THE
CONCISE
KNOWLEDGE
LIBRARY

PHOTOGRAPHY

EDITED BY HENRY P. MASKELL

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A FLOWER STUDY.

Frontispiece.

PHOTOGRAPHY

BY

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E. A. AND G. R. REEVE, H. P. MASKELL,
AND OTHERS

WITH OVER 120 ILLUSTRATIONS

INCLUDING ORIGINAL PHOTOGRAPHS BY THE AUTHORS AND EXAMPLES FROM THE WORK OF J. CRAIG ANNAN, WILL CADBY, ALVIN LANGDON COBURN, REV. D. G. COWAN, M.A., J. W. CHURCH, H. S. CHEAVIN, F.R.M.S., DR. W. M. DANIELS, RUDOLPH DÜHRKOOP, FREDERICK H. EVANS, W. H. ROGERS, T. M. WEAVER, AND MISS R. M. WHITLAW

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PREFACE

In adding a volume on Photography to the Concise Knowledge Library, we have felt that we were dealing with a subject which can only be approached through the avenues of actual practice. This is true about photography, even from the historical point of view. In the beginning it was sponsored by the highest scientific authorities of the time, and leaders of science, from Faraday to Lord Rayleigh, have given of their best to bring it to its present state of perfection. And yet its fundamental processes have to be taken for granted. No chemist by taking thought could have evolved them; they were stumbled upon accidentally by empirics, and it has puzzled the scientific world ever since to explain them adequately.

Similar considerations apply to the popular study of photography. Its results may give pleasure to the million; its methods interest only those who practise them. When we take up a volume on natural history, for instance, we do not necessarily expect to find detailed instructions how to capture wild animals or how to prepare them for the table. But the reader of a work on photography is an actual, or at least prospective, owner of a camera. And this, not merely because the hobby has acquired so widespread a popularity, but because its joys and mysteries are reserved for those who have crossed the threshold of the dark room.

The Concise Knowledge Photography should enable the student to arrive at a creditable proficiency in each department, and suggests the works most suitable for his perusal should he afterwards aspire to become a specialist. The directions have been carefully thought out with a view to meet all ordinary contingencies, but it is obviously impossible to provide against every incidental source of error. One of the virtues of photography as an educative pastime is that it stimulates the observing and reasoning faculties. To cite an example, he who essays the gum bichromate process and uses a brush to spread the sensitised gum will, it is hoped, recollect that the substance which becomes insoluble on the paper will ruin his brush, if he allows it to dry unwashed. The formulæ selected are those which experience has proved to be useful. Some old friends may be missed, but, we hope, not regretted ; amongst them the uranium intensifier, and that cheap but unreliable method of toning printing out papers by adding a mineral acid to the fixing bath.

One sad destiny awaits every work on photography. It will, all too soon, cease to be up-to-date. Just as we are preparing for press, Dr. Mees and Mr. Welborne Piper have communicated to the Royal Photographic Society some hitherto unrecognised facts regarding hydroquinone developers. While sulphite has been proved a source of fog with this particular agent, it appears that a developer containing only caustic soda and hydroquinone, provided the latter is in large excess, will give soft gradations with comparatively under-exposed plates. A useful variation of Dr. Eder's rehalogenation formula on page 192, has just been introduced, in which ammonium chloride is substituted for the bromide. This formula may also be applied for softening and toning bromide or gaslight papers. Fortunately for the reader who wishes to keep abreast of the times, the photographic press is exceptionally well conducted, and the latest information will be found summarised in the current *British Photographic Almanack*. As long as we possess a bookshelf the volumes of this almanack will find an honoured place thereon. We had reason to prize them as a reliable source of information in the old days, when books on photography were few and far between; although we must not forget Mr. E. J. Wall's excellent *Photographic Annual*.

The appointment of Sir Benjamin Stone as official photographer for the Coronation of King George V., must not pass unnoticed here. This is almost the first public recognition of photography for the purposes of historical record.

By the kind permission of the editor of the *Photographic Journal*, we are enabled to include photo-micrographs of the principal screens employed in screen-plate colour photography, and also the diagrams of Mr. A. E. Salt's shutter-testing apparatus, both having originally accompanied lectures or communications to the Royal Photographic Society. The view in New York, by Mr. Alvin Langdon Coburn, appears by the courtesy of Messrs. Duckworth, the publishers of *New York*. Full of atmosphere and originality, this study serves to prove how well adapted is a camera picture to receive the impress of a vigorous and poetic mind. It not only tells us of the towering mass of the Park Row Building, but also suggests effectively the enterprise and industrial forces at work in the great modern city where it sprang into being.

In the selection and arrangement of illustrations we have been fortunately able to depend throughout on the advice of Mr. Roger Ingpen. We must also thank the many contributors and others who assisted in the work of revising the proof sheets, and trust that such technical errors as escaped correction are neither numerous nor important.

CONTENTS

ILLUSTRATIONS

COLOURED PLATES

HALF-TONE ILLUSTRATIONS

ILLUSTRATIONS INCLUDED IN THE TEXT

W. H Rogers.

A WOODLAND PATH.

[p. 1

CONCISE PHOTOGRAPHY

CHAPTER I

INTRODUCTORY AND HISTORICAL

PHOTOGRAPHY, the most widely practised and most versatile of the pictorial arts, is also the youngest. Seventy years ago its very name was unknown, and only a few crude principles existed in the transactions of learned societies. And yet its history might be traced back for many generations. To no single individual belongs the honour of the invention. A long chain of discoveries, made by workers at periods long distant from each other, extends right down to our own day; the sum of these combined makes up photography as now practised.

In vain may we seek to find who first observed that certain chemical substances are changed in colour or decomposed by the action of light. The fact was not unknown to the ancients. It is mentioned by Paracelsus. Boyle is usually given credit for having described some of these changes in terms of modern science. Thomas Wedgwood, about 1791, applied the idea to practice by coating paper with nitrate of silver and placing on it various objects, such as fern-leaves, etc.; when exposed to light the objects were shown in outline on a blackened ground. Sir Humphry Davy published the results of these investigations in 1802, but no method of fixing the image satisfactorily was then known. A few years later Nicéphore Niepce, a French experimenter, made similar sun-pictures on glass and metal plates with bitumen dissolved in petroleum, and also with guaiacum, which became insoluble on exposure to light ; these "heliographs" were permanent. An early example made in 1824, a copy of a portrait of Cardinal d'Amboise, may be seen in the museum at Chalons-sur-Saône.

John Baptist Porta, in the seventeenth book of his *Magia Naturalis*, published about 1550, directs how to make a small aperture in the shutter of a perfectly dark room ; the light from this opening, falling on a white screen, gave an image of the external landscape, but reversed. He afterwards improved this image by inserting a small convex lens in the opening. Hence grew up the camera obscura of our grandfathers.

The legend runs that about the year 1820 a lady called to consult one of the leading men of science in Paris. She complained that her husband had been seized with the strange idea that the beautiful but fleeting pictures seen in the camera obscura could be made permanent. All the remonstrances of his friends were vain. What she desired to know was, whether there was the slightest hope of his succeeding in a project which was gradually absorbing all his means, or whether it must be treated as a mere delusion. The great man temporised with his fair visitor—which was just as well—for the name of her husband was Daguerre, and his strange idea was a few years later to become a fact of everyday knowledge.

Daguerre became acquainted with Niepce, and a partnership was arranged between the two. Niepce died in 1833, and Daguerre purchased from his son the right to omit any mention of him in connection with the process, known as Daguerreotype, which he published in 1839. It consisted in subjecting a surface of metallic silver (obtained in practice by thickly plating with silver a sheet of copper) to the fumes of iodine. The thin film of silver iodide thus obtained was sensitive to light, and was exposed in the camera. The image became visible by the aid of mercury vapour, and was then fixed in common salt, until Sir John Herschel advised the adoption of hyposulphite of soda. Altogether this year 1839 was a significant one. On the 7th of January, M. Arago communicated the news of Daguerre's success to the Académie des Sciences, and on the 25th of the same month Faraday described to the members of the Royal Institution Fox Talbot's "Method of Photogenic Drawing."

The practical difference between the two inventions was that the Daguerrotype presented a finished picture on metal in the lights and shades of nature, but one which could not be copied without going through the whole expensive process over again. Talbot's process produced a paper negative in which the lights appeared reversed—the whites as black and the blacks as white. From this any number of copies were made, with the colour-shades correctly rendered, by simply placing the negative in contact with a fresh piece of the prepared paper in a printing frame. The sensitive salts were chloride and iodide of silver, and a solution of gallic acid was used in development. Afterwards the paper was rendered more transparent by the application of white wax. This process continued to find favour till about 1855, when it was supplanted by the collodion wet plate. Meanwhile, albumen paper for securing finer gradation in printing, and the first recorded method of photo-etching on metal had also been introduced by Fox Talbot.

That Photography, even under these elementary conditions, had already enlisted the sympathies of a considerable body of workers was shown when the Photographic Society of London was founded in 1853 with Sir Charles Eastlake as president; it is now an incorporated body, and known as the Royal Photographic Society of Great Britain. A year later the first number of the *British Journal of Photography* saw the light.

In 1851 Frederick Scott Archer published the details of his invention, which shortly afterwards was to come into general use as the wet-plate process. Glass replaced silvered copper or paper as a support for the sensitive salts; and the vehicle for these salts was a film of collodion. The effect of these changes was that a much shorter exposure to light was possible to secure a picture; either a positive or negative result might be obtained; and the crispness of effect and delicacy of detail far surpassed either the Talbotype or the Daguerrotype.

We need not here enter into the details of the wet-plate process, which is still very frequently adopted for photo-mechanical work, and is described in a later chapter of this book. For the ordinary photographer it was attended with many very serious drawbacks. The pouring of the iodised collodion on to the glass plate in such a way as to form an even, homogeneous surface was a very delicate operation, involving no little deftness and skill. The silver bath was an expensive item, requiring to be constantly watched, and liable to get out of order in all sorts of unaccountable ways. All the preparations had to be gone through within a few minutes of exposure. So that the photographer of land-scapes was compelled to burden himself with a huge parcel of paraphernalia, including a portable dark room or developing tent, bottles of solutions, and dishes. Not more than one or two exposures were possible during a day's excursion. The time of exposure, though less than with Daguerrotypes, was still very far from short, and required of the sitter for a portrait an enormous amount of patience and self-control. Then, again, the whole business was very messy and em-barrassing, especially for the amateur. He was a "marked man," with indelible stains on face and hands. Dribblings of silver nitrate leaked out of his dark slide on to clothes, carpets, and furniture, to the distress of all good housewives.

But they were giants in those days. The wet-plate period is generally regarded as the Golden Age of photography. Nearly all the valuable subsidiary processes had their origin during its sway. The amount of good work done was enormous. Perhaps because of the many difficulties and the conscientiousness and care essential at every stage, it enlisted in its service a strenuous, resourceful race of operators, and undoubtedly much of their work, particularly that of the late

Francis Bedford, Vernon Heath, H. P. Robinson, and W. England (the two last of whom have, of course, lived to illustrate the newer methods) will compare for brilliancy and fine detail with any produced at the present day. The wet plate died hard. Years after the ready-made dry plate had become an ordinary article of commerce leading professional firms were still adhering to the older rival.

Dr. R. L. Maddox, of Southampton, is generally regarded as the inventor of the dry plate. An account of his experiments in this direction appeared in the *British Journal of Photography* in 1871. With its introduction the names of I. Burgess, R. Kennett, and C. Bennett must also be associated. Some old experts still contend that its advent marks the commencement of an age of degeneration. Certainly the last two decades of the nineteenth century witnessed a vast revolution to the profit of all interested commercially in the manufacture and supply of things photographic. From an academic pursuit for the few, and a difficult and expensive trade, photography was suddenly transformed into a pursuit for the million, commending itself readily to the man whose purse is slender and hours of leisure few in number. The gelatine film, whether on glass or celluloid, is ready for instant use, and a supply can be carried in apparatus of small compass and light weight. After exposure it may be packed away for development whenever convenient, even at the end of a lengthy tour. The subsequent processes have all been simplified, and involve no specialist's knowledge of chemistry or any other science beyond common sense. Fresh supplies are obtainable in the smallest country town ; dark rooms are to be found almost in every street. So much has been done by the manufacturer to make the path plain towards success that, with a little artistic instinct, the merest tyro will sometimes attain a result that the professional might envy.

Even more significant is the manner in which photography, since the invention of the dry film, has extended its operations for the advancement of science, and for the delight and instruction of every class of the community. The most ordinary photograph is a record of something, stimulating the faculty of observation, memorising for future use more than can be perceived at a casual glance. Architect and engineer obtain by its aid more accurate and useful ideas of buildings and machinery than could be conveyed by any but the most laboriously prepared drawings. A weekly report of work in progress may be comprised in one or two snapshots. Scarcely less useful is the camera in the hands of the detective, or the medical specialist. Its revelations of wild nature in its living haunts are the delight of the naturalist; the astronomer finds it indispensable; and in connection with the X-rays the dry plate has even introduced the scientific investigator to a knowledge of the unseen.

Thanks to the dry plate we find in our daily newspapers faithful pictures of events that took place only a few hours before. We can step into a cinematograph theatre and see these happenings in their actual details and surroundings, with all the living movements, just as if we were present at the time and place of their occurrence. It is safe to prophesy that, in the course of a few years, satisfactory photographs in the veritable colours of nature will be an everyday matter; without the dry plate not one of the many steps already reached in this direction could have been attempted.

Most of the creators of modern photography are still with us, and it is invidious to particularise. The roll of honour would have to be a very long one, and in the attempt to compile it, some would certainly be forgotten who ought to be found inscribed upon it. We only dare mention here the veteran Sir W. de W. Abney, whose investigations in almost every branch are invaluable, and who may specially be termed the father of the many processes involving the bichromates; Dr. J. M. Eder, the famous chemist and inventor of many new developers; Mr. W. Willis, who with Captain Pizzighelli perfected the platinotype process; and Sir J. W. Swan, who rendered the carbon process popular. So fascinating a study was certain to attract the attention of the greatest minds; each has been content to add his own contribution to the general fund of knowledge, often without seeking for any recognition or reward beyond the pleasure incidental to the pursuit itself.

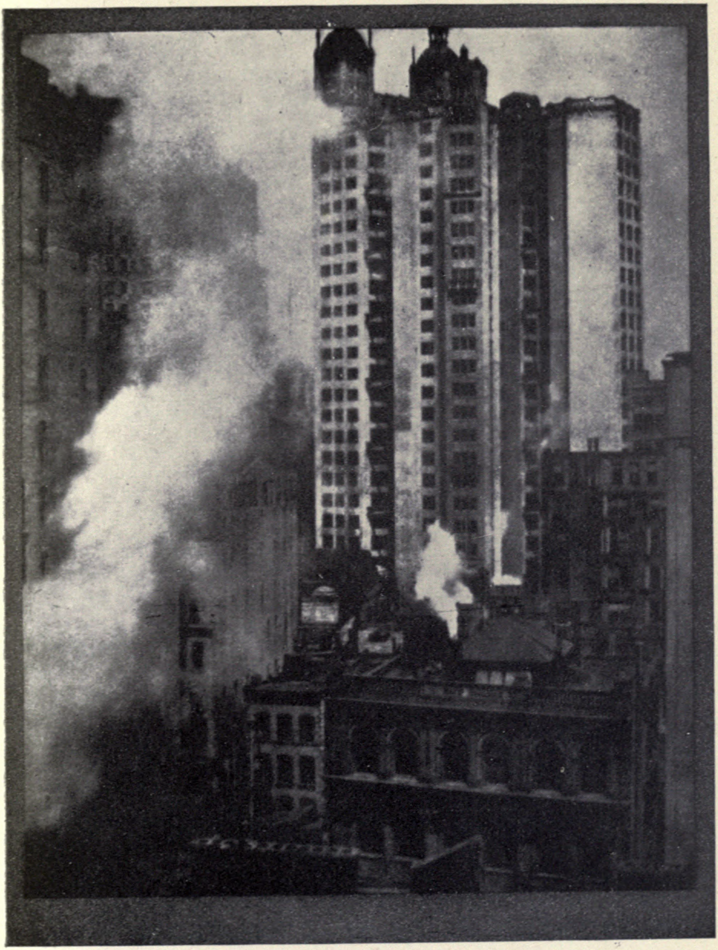
The question is often asked, What is Photography? Ought it to be described either as an art or a science? Many will contend that, setting aside the gum-bichromate and oil processes (in which the photographic image becomes little more than a basis for the work of hand and brush), a photograph is a mere mechanical reproduction from first to last. True it is, that manufacturing enterprise has so simplified each stage and so perfected apparatus that the beginner may produce a passable print, by just pressing a button, and following certain prescribed directions with ready-made solutions. But this does not affect the claim of photography in the hands of its more qualified exponents to a place among the recognised pictorial arts. Art has been defined as nature interpreted by the individual. Like other arts photography has its limitations. But in the selection and arrangement of his subject, variation of exposure, manner of development, etc., there are opportunities for the specialist and even for the genius. Two operators given the same point of view may produce vastly different results, and yet each be meritorious. That there are mechanical operations must be admitted, but throughout they are capable of control and may be influenced to produce the effect which the craftsman has in view. Work of the kind we refer to entails as much judgment, originality, and patience as a water-colour painting and has almost the same conventional restrictions; differing from the latter very little except that copies, by means of the original negative, may be more easily obtained.

On the other hand the photograph need not always be a faithful representation of existing fact. We have known a few heaps of sand on a kitchen table, with the artful aid of flour dredger, some moss, and a toy chalet, become a very characteristic example of Swiss Alpine scenery when interpreted through the camera. An ingenious piece of apparatus, called a duplicator, enables the plate to be exposed in two successive portions with very startling consequences. We do not feel justified in deciding that there is no such thing as a genuine "spirit" photograph: but experts seem unable to devise any test which cannot be evaded by those who are bent on proving that these manifestations are not supernatural in character. The photographs submitted in evidence by the two contending parties in litigation about "ancient lights" have been known to differ considerably as regards the apparent proportion of adjacent buildings. All these may be deliberate sophistications. With the best intentions the photographer will sometimes find that his result does not convey an exact idea of his subject; and that indeed instruments of precision and a worker of scientific knowledge are required in order to obtain accuracy of this description.

No doubt it is its facilities for the reproduction of originals with accuracy and minute detail that render photography invaluable as the handmaid of science and nearly all the arts. And on this side it becomes itself a science of the first order, levying contributions on the higher departments of chemistry, physics, and mathematics. Just as the constructor may be an architect or an engineer, so the art photographer and the photo-mechanic stand side by side. We are apt to depreciate the photo-mechanical worker because his productions are destined to be multiplied and sold at the cheapest prices; they are the copies of another's original. Even the oil painter or the artist in black and white hardly realises the science as well as the skill involved in the processes, reproducing with such fidelity brush marks and pencil lines which were aforetime travestied by wood-engravers and lithographers. The power to enlarge or reduce a subject in more exact proportion than the human artificer can possibly attempt; to rule, for instance, the lines of a glass screen to the fineness of upwards of $\frac{1}{1000}$ of an inch, whereas mechanical instruments have failed to reach $\frac{1}{400}$: these are triumphs only to be understood at their true value in the workshop or the laboratory.

In the more popular applications of photography the evil and the good are intermingled. The vulgar and tasteless picture-postcard is multiplied as well as the masterpieces of Raphael and Sir Joshua Reynolds. Each man's taste is ministered to impartially. The million find an efficient substitute for what was once the luxury of the rich and cultured. No age can boast the possession of more portrait-painters than can be counted on the fingers, and their works fetch a high price; the poorest can procure a photograph recalling in some way the features of the loved ones who have gone to distant lands, or into the unknown; the lineaments of the criminal flying from justice are scattered abroad so that he can find no corner to escape recognition. The hand-camera fiend invades our privacy everywhere; nothing is sacred in his eyes. But the same much-abused instrument gives the city toiler a delightful occupation for his winter evenings, when he finishes off and arranges his little collection. Artless and uninteresting most of them may seem to the superior critic; but they are to their owner a priceless record of his travels, replete with pleasant memories of rambles on the breezy moors, or by the sunny sea-shore. And they may prove the prelude to better things. Perchance he will specialise in the study of some branch of art or natural history as he acquires the habits of observation which photography inevitably stimulates in every man of good will. Not long ago we listened with the greatest interest to a lecture on the habits of the spider given in a rural camera club by a jobbing gardener. While photographing autumn flowers for mere amusement he had suddenly discovered the optical illusion which renders at least half a spider's web always invisible to the argus-eyed fly. This set him thinking, with results by which his audience profited exceedingly.

In short, the province of photography is too comprehensive for definition. It is all things to all men. According to the individual it may acquire the spaciousness of true art, will submit to the faithful service of accurate record, or, yet again, hazard its reputation on the chance pressure of a button. Better still, we may describe it as a bond of fellowship, restoring those truer conditions which prevailed among the mediæval craftsmen, when the fine arts were not separated from the higher mechanical arts, nor were those who practised them. And so we must leave it, hoping that our readers' ambition is to attach themselves to one or other of the two earlier classes, which, each in their own way, promote their own edification and the advantage of their fellow men.



Alvin L. Coburn.

THE PARK ROW BUILDING, NEW YORK.

p. 10]

CHAPTER II

THE DARK ROOM

PHOTOGRAPHY is perhaps unique among the sciences for the variety and many degrees of the votaries it attracts, from the simple amateur who is content to develop and print two or three dozen plates a year, to the serious worker who devotes many hours each day and the contents of a well-filled purse to his favourite hobby. We have to consider, on the one hand, the barest essentials required by the more elementary class of camera users; and, on the other hand, the ideal arrangements for efficiency and comfort.

Much excellent work can be done where the family bathroom is adapted for occasional use as a dark-room. A lock-up cupboard will serve for dishes and chemicals. The bath itself forms a capital trough wherein plates and papers may lie in soak while awaiting further treatment. It is a mistake to suppose that photographic chemicals, especially considering the dilute form in which they are invariably applied, have any evil effect upon bath enamel. Any ordinary carpenter will construct a movable light-tight screen to cover up the window. In fact, the bathroom possesses so many incidental advantages, especially for cleanliness, that it is hardly wise to desert it for any other contrivance, unless one's operations have become so extended that they interfere with the more legitimate uses of the apartment.

The dark room should be lofty, well ventilated, and certainly never less than six feet square in area. Cupboards under the stairs are quite unsuitable except for the casual changing of plates. The temperature of solutions is a very important factor. Confined rooms soon get hot and stuffy; perspiration is by no means a desirable addition to developers; and many a picture has been ruined by the heat of a lamp set too close to the developing dish. There should be a good window giving plenty of daylight when necessary, so that from time to time accumulations of dust and dirt may be removed. In practice this window will be closed with a tightly fitting shutter excluding every particle of daylight. No arrangement of ruby glass and canary fabric

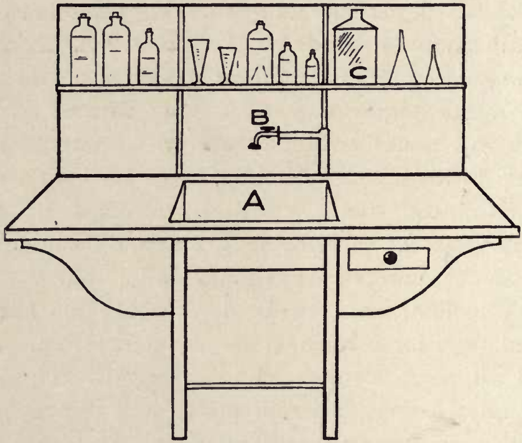


FIG. I.—DEVELOPING-TABLE AND SINK.

will quite serve the purposes of modern isochromatic photography.

The furniture of the dark room will consist of a table and a sink with water laid on. A convenient arrangement in which these two necessaries are combined is shown in the figure. A is the sink, say 24 × 15 in. and 3½ in. deep. B is a swing trap above it, fitted with a rose or rubber tube, enabling a plate to be flooded with water without risk of injuring the film. At C is the lamp placed over the right-hand section where developing and changing of plates are always carried on. To ensure clean and accurate methods the left-hand wing of the table will always be reserved for the fixing tank or dish. Above and around are numerous shelves for such chemicals and measures as are likely to be wanted at short notice. The sink itself may be of stoneware or lead-lined. In the latter case the lead lining might be extended over the two projecting tables. The height of table should be such that the operator can sit comfortably at work and not have to stoop continually. Even if the arrangement is beyond the abilities of the local carpenter, something similar can be procured for a few pounds from any of the leading firms.

Dark-room Lamps.—Every imaginable pattern of dark-room lamp has been placed on the market, and with some of these efficiency is not always commensurate with the price. We have developed many thousands of plates and films with the aid of pyramid nightlights in an ordinary hock bottle costing one shilling. When oil is the illuminant it would be advisable to see the pattern of lamp in use before purchasing; many such lamps have a disconcerting way of bubbling when the surroundings of the burner get heated. If much work is done we recommend a lamp of similar kind to that illustrated, in which no direct rays of light can possibly reach the plate. Indeed, a lamp on this principle is almost indispensable with ortho-chromatic and colour-sensitive plates. As a further precaution we would suggest that this lamp should be placed on a shelf above the developing table. In this way the whole of the dark room will be fairly well illuminated, so that there will be no need to grope along the shelves for anything forgotten, and yet the risk of fogging plates will be minimised. The source of light may be either electricity, gas, hard wax candles, or oil; but if the latter is employed the burner must

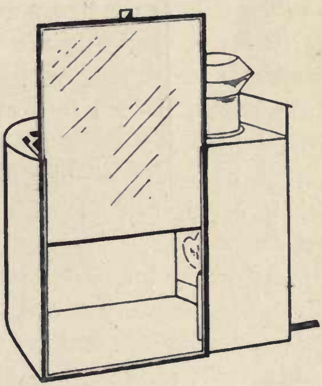


FIG. 2.—SAFE LAMP FOR DARK ROOM.

be a good one and capable of being regulated from outside. The glass fronts are interchangeable, orange-yellow and ruby being usually employed, though ruby is now often replaced by other tints, equally non-actinic in practice, and less trying to the eyesight. For ortho-chromatic plates even ruby glass allows too much light at the red and yellow end of the spectrum to be transmitted, and it is necessary to qualify it with methyl-violet or to employ one or other of the "safe light" screens manufactured by Messrs. Wratten & Wainwright. Paper screens have to be replaced very frequently, as they fade in the damp atmosphere of the dark room.

It is not very difficult to improvise a portable red lamp for use when changing plates on a holiday. A sheet of ruby paper, pinned into cylinder form round a night light, will serve fairly well. If no ruby paper is available a trial might be made of blotting paper soaked in red ink, and, when dried, rubbed with vaseline or butter to render it translucent.

At proper intervals the safety of the dark room and lamp should be carefully tested. Place a plate in the dark slide. Lay the slide on the developing table, and half withdraw the shutter. After about a minute and a half develop the plate in the usual manner; and if within three or four minutes it becomes discoloured there is urgent need for reform.

A series of glass measures, varying in size from a quarter-ounce (marked with minims) and a two-ounce (marked with drams) to a ten-ounce, or even a pint measure when enlargements are attempted, should stand on a convenient shelf with a glass funnel close beside them. For developing and fixing dishes in the smaller sizes earthenware is the best material. For larger sizes we prefer enamelled steel, as they may be stacked out of the way when not in use without fear of breakage. Draining racks for plates are a most useful adjunct, especially the square pattern, which may be lifted from a fixing tank into a washing-trough, and thence taken out to dry without the necessity of separate handling. Weights and scales, filtering papers, packets of plates, and dry chemicals are best stored in some cupboard protected from damp, and not in the dark room. The following chemicals should, however, always be readily accessible, in addition to the developing, etc., solutions favoured:

Alum, 10 per cent. solution.
Potassium bromide, 10 per cent. solution.
Nitric acid.
Ammonia, ·880.
Formalin.

The bottles should be etched, or bear indestructible labels; and in the case of the three latter a small bottle is preferable for safe and easy handling. If a large bottle of either of the two last happened to get broken, the dark room would be rendered untenable for a lengthy period.

CHAPTER III

THE CAMERA

FOR outdoor and landscape photography the type of camera, to be used on a stand and technically known as a "Field Camera," should be of fairly light construction; but at the same time sufficiently strong and compact to bear occasional rough usage with equanimity. It is no longer the fashion to carry into the field instruments of the whole-plate or 10×8 in. size; cheap and expeditious methods of enlarging have changed all this; and the featherweight patterns of a dozen years ago are now unnecessary. The half-plate ($6\frac{1}{2} \times 4\frac{3}{4}$ in.) may now be regarded as the limit for direct printing, and many operators are content with the convenient 5×4 in. and quarter-plate ($4\frac{1}{4} \times 3\frac{1}{4}$ in.). Of course we will not deny the advantages of the whole plate and 10×8 in. cameras to those who make a speciality of architecture.

Extension of Camera.—In choosing a camera one of the first essentials is to see that it will provide for the various lenses likely to be used in it. There must be double extension, focussing by rackwork sufficiently to allow of the back or front combination of the rectilinear lens being used alone, when the central features of the view are at a considerable distance. In the case of a half-plate instrument the extension necessary will be from 16 to 18 inches. On the other hand, provision must be made, by a telescopic form of baseboard or otherwise, for a wide-angle lens of about 5 inches. If the baseboard is long, the lower part of the view is liable to be cut off. Modern patterns provide hinges and spring catch, so that the baseboard can drop down over the tripod legs.

Miss R. M. Whitlaw.

THE ARMENIAN MONASTERY ON THE ISLAND OF ST. LAZZARO, VENICE.

Swing Back.—It is frequently necessary in order to secure some particular view, especially in a confined space, to point the camera upwards or downwards. If, however, the plate is left in this position, the result would be a picture with the lines absurdly distorted. This difficulty is obviated by the use of the swing back fitted with a level, enabling the dark slide to preserve the perpendicular whatever the angle at which the camera is tilted. Some cameras have also a side-swing, but this is rarely required.

Rising and Swing Front.—This valuable modern invention almost does away with the necessity of the swing back. The camera itself need not be moved out of the perpendicular while the lens is raised or lowered and pointed in the required direction. Bellows of extremely tapering pattern are unsuitable for use with the rising front, as a portion of the picture may be intercepted, and this form of bellows must be fitted with a ring or tape on one of the central folds to draw the bellows forward when using a lens of short focus. A changing back enables the advantages of swing back and rising front to be applied to both upright and horizontal shaped views.

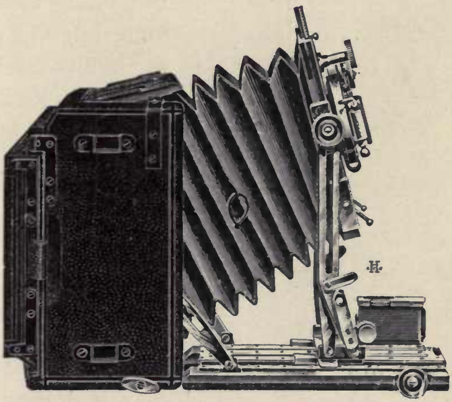


FIG. 3.—THE SANDERSON CAMERA, SHOWING SWING FRONT.

The accompanying figure shows a newly introduced pattern of rising front, in which however much the lens is raised it swings on its optical centre, so that the centre of the circle of illumination is always opposite the centre of the plate. No danger need therefore be apprehended, when the front is tilted to get in objects that are extremely high, that the plate will be unevenly covered and that corners will be in consequence left unexposed.

From time to time camera and bellows must be examined to see that there is no leakage of light. The inside of the bellows and surrounding woodwork ought to be dusted occasionally, and any trace of shininess owing to wear cured by a coat of dead black varnish. Light reflected from the lens on to the bellows is a frequent cause of fogged plates. Leather bellows have a tendency to split if not occasionally varnished outside. For hot climates teak is the best material, and every angle in the woodwork should be protected with brass binding; Russian leather bellows will resist for a long time the attacks of white ants and such-like enterprising insect life.

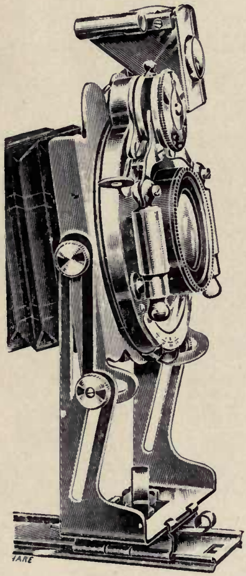


FIG. 4.
THE TUDOR RISING AND SWING FRONT.

Focussing Screen. — The screen should be of finely ground glass. In old-fashioned cameras the glass is often of a bluish tint, and this was no mean advantage, as the operator was less likely to be misled by the colours of his landscape which failed to reproduce themselves on his monotone print. The ground-glass side of the focussing screen and the film of the plate in the dark slide must be in accurate register. If any doubt exists on this point it may be settled by putting the screen into one of the dark slides and focussing the object, then compare the result with the ground glass in its usual position. When the slides are of the solid pattern the test must be made by careful measurement.

Plate and Film Holders.—Three double-dark slides are usually supplied by camera makers to fit with the camera into a satchel or travelling-case, and the pattern of instrument selected will probably determine that of the plate holders, whether of book or solid form with leather-hinged shutters folding back when opened, or with celluloid shutters wholly withdrawn during exposure. The two great disadvantages of the celluloid shutters are (1) that the material has a marvellous attraction for particles of dust, so that plates can never be kept in the slides for longer than a few hours at a time and (2) the danger of breakage while the shutter is resting in the coat pocket or elsewhere during exposure. Metal is occasionally substituted for the celluloid; if it will not break, it will bend out of shape under pressure. Dark slides of all patterns require overhauling at times. The velvet in the light traps becomes dry or frayed, and shrinkage will take place with the very best material. Avoid all "bag" changing boxes. They have brought the changing box into disrepute. But a very reliable one for twelve plates is made on the automatic slide principle, the fresh plate or film being brought into position by simply drawing out the telescopic inner body and pushing it home again.

Daylight Changing.—During the last twenty-five years we have tried many ingenious mechanical contrivances which professed to replace the exposed plates in the dark slide with new ones ready for fresh exposures. Some of them, after much coaxing and shaking before they would work at all, ended by replacing the original plate in the slide to receive a fresh and quite superfluous image upon it. The others fogged one or both the plates in transit. The modern daylight envelope system, however, seems to accomplish the reloading process with a fair degree of safety and certainty, and is not at all difficult to master. Large numbers of these envelopes may be carried in the pocket. Users of films may avail themselves of the improved film pack or rolls of cartridge film. But, as these cannot usually be developed until the entire package is exhausted, they are more properly considered in the section on Hand Cameras.

The Tripod.—The height of the eye averages about 5 ft. 6 in., and the stand at full length ought therefore to be capable of raising the camera base-board to five feet from the ground with the legs spread out. The form which is most portable is not always the most rigid, and the fact that pictures frequently have to be taken while a strong gale is blowing must be borne in mind. An elastic belt drawn round the legs will help to prevent vibration under such circumstances. Wooden stands are, on the whole, most reliable and the sliding pattern is most easily adjusted to various heights. It is important that the screw adjustments should not be removable, or they will drop out and be lost. The new metal tubular tripods of brass and aluminium are very convenient—closing to about fifteen inches to fit a small leather case—and in practice some of these will prove sufficiently rigid for small cameras. The metal heads should be covered with a layer of felt or thin leather.

Spirit Levels.—Even when the view comprises merely open landscape or groups it is most desirable that the focussing screen and dark slide should be accurately vertical. For ordinary purposes a watch hung by its chain beside the camera will serve the purposes of a plummet in gauging the upright position, but a proper level is part of the equipment of every serious worker. The small round levels are good enough for hand cameras; for the field camera we prefer the mason's level, which has both horizontal and vertical bubbles.

Instantaneous Shutters.—Fast plates and large diaphragms are the order of the day, and the range of work will be circumscribed indeed if exposures have always to be given by means of the lens cap. Such exposures must be haphazard if they are timed with a watch, and are of less period than, say, two or three seconds; whereas the average exposure required for landscape in good light is a small fraction of a second. The forms of shutter available may be divided into four classes according to their position, and the manner in which they work. (1) The focal plane close to the plate. (2) In front of the lens. (3) Behind the lens. (4) The diaphragm shutter between the components of the doublet.

Focal-plane Shutters.—The focal plane shutter is attached to the camera immediately in front of the focussing screen and dark slide. Some ingenuity is required in fixing it on field cameras as it must form part of the swing back. Theoretically it is the very best kind of shutter for photographing very rapidly moving objects. Its construction has been brought to the very highest perfection, and for very short exposures it works with much less loss of light than others. In principle it consists of a roller blind with an adjustable slit which is caused to travel with great speed across the surface of the plate. For exposures varying between $\frac{1}{60}$ and $\frac{1}{700}$ sec. no shutter can compare for efficiency with the focal plane. In practice the operator will more frequently give $\frac{1}{50}$ to $\frac{1}{10}$, as full exposure of the plate is the first consideration. At such moderate speeds (and still more, of course, with $\frac{1}{2}$ sec. or 1 sec.) focal plane shutters are not recommended, owing to their tendency to jerk and cause vibration in the camera.

Shutter behind the Lens.—The Thornton Pickard type of roller-blind shutter is still often supplied with field cameras fixed on the sliding front, and the lens flange screwed on to it. Though sometimes regarded as old-fashioned this is a very reliable piece of apparatus, very durable, and in practice we have found the speeds from $\frac{1}{15}$ to $\frac{1}{90}$ sec. fairly accurate. It is not, however, noiseless; and no provision is made for lower speeds such as $\frac{1}{2}$ sec.

Shutter in front of Lens.—The shutter just mentioned is often employed as a movable cap to be placed on the lens just before exposure. The blind will not always exclude bright light for any length of time, and care should be taken not to open the slide until the last moment. There are also one or two good pneumatic shutters made to rise and fall in a manner giving fuller exposure to the foreground than to the sky—often a great *desideratum* in landscape work: but the range of speed is necessarily limited.

Diaphragm Shutters.—Of these there are many approved types: the "Koilos," "Sector," and "Automat"—to mention only a few; and the moderately priced "Unicum," which is probably more widely used than any other by amateur photographers throughout the world. There is no doubt that the consensus of opinion would be in favour of this kind of shutter for nearly all classes of work. It is equally serviceable for high speeds, half-seconds, and time exposures. It works noiselessly, and without the least danger of vibration, whether released by pneumatic or hand pressure. Many patterns are "self-setting," and the higher qualities give a range varying from $\frac{1}{300}$ to 1 sec. If any fault is to be found it is that the speed markings are sometimes quite arbitrary, and need to be tested.

Messrs. Ross & Co.'s "Multispeed" shutter, introduced last year, is a much more complicated instrument, and marks an entirely new departure in diaphragm shutters. It seems to combine all the advantages of the best between-lens shutters when working at useful low speeds as $\frac{1}{2}$, $\frac{1}{4}$, and $\frac{1}{5}$ sec., and is at the same time capable of the highest speeds attainable by the focal-plane shutter; and this without the danger of lateral distortion, which will unexpectedly manifest itself at times in focal-plane exposures.

Testing the Speed of Shutters.—For a small fee many of the leading firms undertake the testing of shutter speeds. Sir W. Abney has devised a rough-and-ready method, which may commend itself to enterprising readers. A small silvered bead is attached to the rim of a bicycle front wheel on which there is a cyclometer. The wheel is caused to rotate, say about three times a second when the machine is upturned. The speed may be judged by the click of the cyclometer, the number of clicks in each second being counted. If the sun shines on the bead, and an exposure be given in the camera, taking in the revolving wheel, an opaque circular line will give the track of the bead. For example, suppose the image on the plate shows a segment of 78°, and the wheel was rotating 3·7 times a second. The time of exposure was therefore $\frac{78}{3{\cdot}7 \times 360}$ or $\frac{1}{17}$ sec.

A more elaborate method for testing the efficiency and speed of a shutter was communicated to the Royal Photographic Society last year by Mr. E. A. Salt, and is illustrated in the accompanying figure. The apparatus records durations of exposure down to about $\frac{1}{100}$ sec. On the right is a light-tight box or camera fitted with a lens, L, in sliding box for focussing. On the left is an incandescent burner illuminating a slit, S, in the board, CC′, shown in section, with front view immediately below. This illuminated slit is

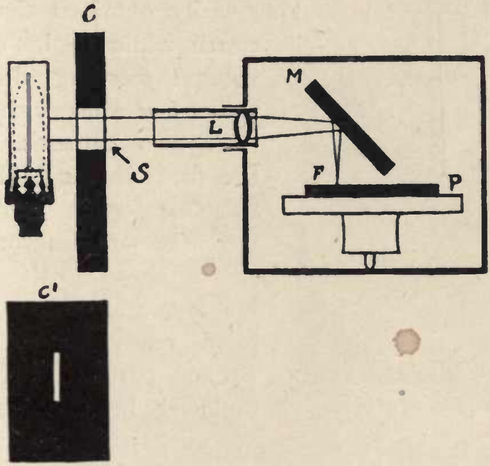


FIG. 5.

focussed on a dry plate, P, by means of a silvered mirror, M, set at an angle of 45°. The dry plate is supported on a carrier capable of rotation at definite speeds. The shutter is placed in front of the slit. On the release of the shutter a point of light is first recorded on the rotating plate, F, broadening into a circular band representing full aperture, and tailing off again into a point on the completion of the exposure. By applying the developed plate to a home-made protractor on glass (secured by copying a drawing in the camera) the number of degrees covered can be read off, and, deducting the width of the slit image, the duration of exposure is ascertained. The second figure shows the form of protractor adopted. In order to avoid crowding, it is divided into 125 divisions only, each division in practice being read as representing 4°. With the motor revolving twice a second each degree will therefore indicate $\frac{1}{1000}$ sec. A special spring motor, sold by Messrs. George Adams & Co., for driving gramaphones, is used to rotate the plate, which is rigidly held in a carrier of simple design. At two revolutions per second this motor runs with great accuracy.

Home-made Cameras.—All photographic apparatus is now so readily accessible and so easily obtained that it is not worth while to include in this volume working drawings for those few who wish to make their own cameras. Some of the firms in the Midlands publish catalogues containing all the necessary information, with sheets showing the brasswork, bellows, and other parts supplied ready for the purpose. Broken parts may generally be replaced in this way in case of mishap. The home-made camera need not be a very elaborate instrument; the only absolute necessity for taking photographs is a light-tight chamber with some means of focussing the lens. A box, with a groove at one end for the dark slide, and of the length just sufficient for the lens when focussed at infinity, will do a lot of good work; the lens may slide out in a "focussing jacket" or a brass tube, when objects nearer the camera than, say, 20 ft. have to be considered. Of course, many views cannot be attempted without the rising or swing front.

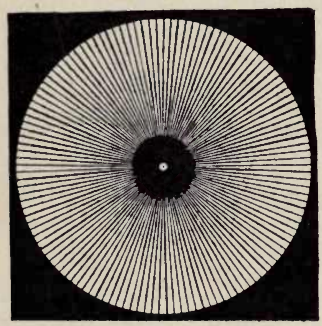


FIG. 6.—THE PROTRACTOR.

Hand and Stand Cameras.—Now that the rising and swing front has been adapted to do the work formerly accomplished by means of the swing back, it would seem that the old-fashioned field camera will gradually drop out of use. A new type of universal camera finds favour from its portability, variety of movements, and ready adaptability, either for instantaneous snapshots or for well-considered compositions focussed upon the ground-glass screen. We should advise the reader to turn to the chapter on Hand Cameras, in order to see whether any of these types will meet his requirements.

CHAPTER IV

THE OPTICS OF PHOTOGRAPHY

THE lens is the only part of a camera which a person of average mechanical skill cannot make for himself. A good carpenter can make the camera body, dark slides, and stand, and anybody with a taste for mechanism can construct some kind of shutter. Every one taking up photography must, however, *buy* a lens if good work is to be done. Instructions are sometimes given in photographic books as to how a lens can be made; but mere perusal of these working directions is sufficient to show their absurdity for the ordinary photographer, who has neither unlimited wealth nor a very large amount of spare time. A knowledge of the fundamental differences between various types of lenses is essential to the photographer who desires to spend his money to the best advantage. Some knowledge of the properties of a lens is necessary also, if it is to be used intelligently.

It may be thought that the early photographic workers found excellent lenses ready for use, since the telescope is a comparatively old invention; but this was not so. The objective of a telescope is designed to bring only axial rays to a focus, and has a very small field of view. A normal angle of view for a lens used in photography is from 40 to 60 degrees; it must bring to a focus not only axial rays, but also oblique rays. As a telescope objective was of little use, opticians had to devise a lens which would form an accurate reproduction on a plane surface of a plane object situated at right angles to the lens axis, and at the same time have a fairly large field of view. Many lenses were soon constructed which would do this; but the amount of light they allowed to reach the sensitive plate was comparatively small, and the exposure had to be fairly long. It is only within the last twenty years that lenses have been constructed which will accurately reproduce a plane object on a plane surface, and at the same time allow sufficient light to pass to permit of the plate being fully exposed in a space of time measured in fractions of a second.

Refraction.—The formation of an image by a lens depends on that property of the material composing it which is called Refraction. When a ray of light passes from one medium to another its direction is changed, unless this direction is

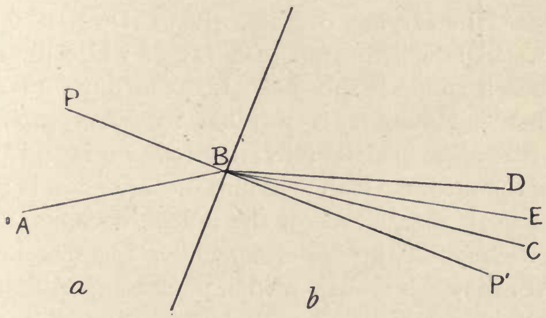


FIG. 7.

normal to the surface separating the media. Refraction is the term applied to such changing of direction. The amount of change depends on the media and on the colour of the light. In Fig. 7 a ray of blue light, AB, is shown passing from a medium, *a*, to another medium, *b*, and its new direction as BC. The rays AB, BC are, however, in the same plane as the normal to the surface of separation at B. If the blue ray is replaced by a red ray, its direction is changed to a lesser extent, and will be in some such direction as BD. If PP′ is the normal to the surface separating the media *a*, *b* at B, it is found that, whatever be the inclination of the ray AB, the ratio $\frac{\sin \angle ABP}{\sin \angle CBP'}$, is constant. This quantity is called the

Refractive Index of the media *a*, *b* for the blue light under consideration. It is usually denoted μ_b. Similarly, the ratio $\frac{\sin \angle \text{ABP}}{\sin \angle \text{DBP}'}$ or μ_r is constant, and is the Refractive Index for the red light under consideration. Now, if we are to be able to compare different glasses with respect to their refracting power, it is obvious that they must be examined as to their effect on light of a definite colour. In optics it is customary to use the light from a sodium flame which is approximately monochromatic. The refractive index for light of this colour is *the* refractive index for any media, and is denoted μ. The refracted ray corresponding to this value is shown at BE.

Dispersion.—If AB is a ray of white light, its constituents are refracted in varying degrees, giving rise to the familiar spectrum. This splitting up of a ray of white light into its constituents is called Dispersion. If the medium *b* is replaced by another medium, it is possible to select such a new medium that although the refractive index μ is still the same as that of the medium *b*, the amount of dispersion is different. That is to say that, although the ray BE occupies the same position, the rays BC, BD are either closer together or farther apart. We may select such media, possessing a high refractive index in combination with low dispersive power, and *vice versa.* This is of great importance in photographic optics.

Lenses.—A lens is a portion of a refracting medium bounded by spherical surfaces. The refracting medium is usually glass; but other materials, such as quartz, etc., are sometimes used. Various lenses are shown in Fig. 8, and a modern photographic lens consists of various combinations of these simple lenses of various kinds of glass. The older lenses were made with Crown and Flint glass, the crown glass having the lower refractive index and the lower dispersive power. For some time it was believed that unless glass could be made possessing high refractive power, but only low dispersive power or *vice versa*, no lens could be constructed which would possess a flat field and be anastigmatic.

Accordingly, the glass-makers set to work and produced such glasses, these being put on the market in 1886. The new glasses are known as Anomalous Glasses, and are indicated in the diagrams throughout this book by horizontal shading thus: . Crown glass is indicated , and flint-glass . Light will always be considered to travel from left to right.

Equivalent Lens.—The modern complex lens can be replaced for purposes of calculation by a single thin lens 1, Fig. 8, which is called the Equivalent Lens. This thin lens

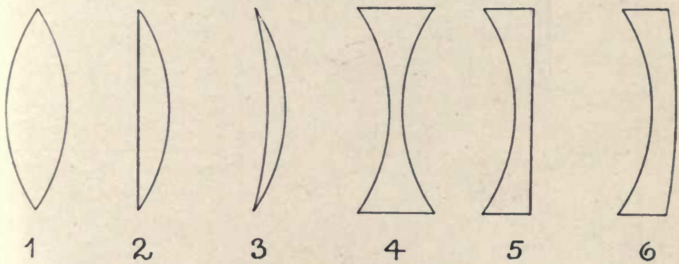


FIG. 8.

is, however, ideal, and possesses no aberrations. It may here be mentioned that the image formed by the lens 1 suffers from various defects known as aberrations; but our *thin* lens is considered as being able to form a plane reproduction of an extended plane object at right angles to its axis. If, therefore, the properties of the lens 1 for narrow axial pencils of light are known, this knowledge can be applied to all pencils, whether oblique centric or oblique excentric.

Formation of Images.—Any one of the lenses 1, 2, 3, Fig. 8, is able to form a reproduction *ba* or image of an object AB, Fig. 9, on the opposite side of the lens, provided that the object AB is more than a certain distance from the lens. Three typical rays from the point A are shown converging to the point *a*. Such lenses are known as Positive or Converging, and can be recognised easily, because they are always thicker at the centre than at the periphery. The lenses 4, 5, 6, Fig. 8, appear to form an image, *ab*, Fig. 10, on the same side of the lens as the object AB. Such an image of course does not exist, and is called Virtual. The lenses are known as Negative or Diverging. They are always thinner at the centre than at the periphery. Negative lenses would appear in themselves to be of little use to the photographer, since no image can be received on a screen. Such lenses are, however, absolutely indispensable to the construction of a good lens, and also form an essential part of a lens which is becoming extremely popular—viz. the Telephoto lens.

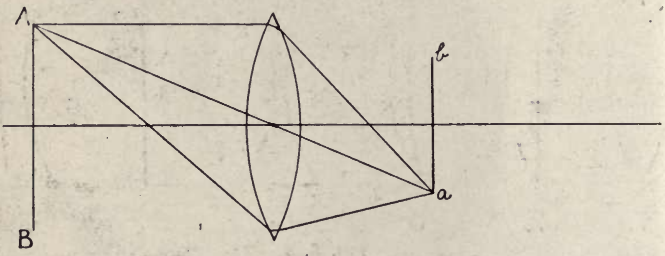


FIG. 9.

Before considering the formula connecting the distances of the object and image from a lens, we must have a clear idea how distances are to be measured. Unfortunately the convention adopted in Photographic Optics is not the same as that adopted in English treatises on general optics. The usual convention in Photographic Optics is adopted here, but the difference must be borne in mind if more advanced information is required from the larger works. The convention is that distances measured from the lens in the same direction as the incident light are positive, and in the opposite direction negative. Thus in Fig. 9 the distance of the image is positive, and the distance of the object negative. In Fig. 10 both distances are negative.

J. Craig Annan.

"GOSSIPS."

p. 32]

In Fig. 11 a biconvex lens, LL′, is shown in cross-section passing through the centres of curvature CC′ of the surfaces LPL′, LP′L′ respectively. The straight line CC′ is called the

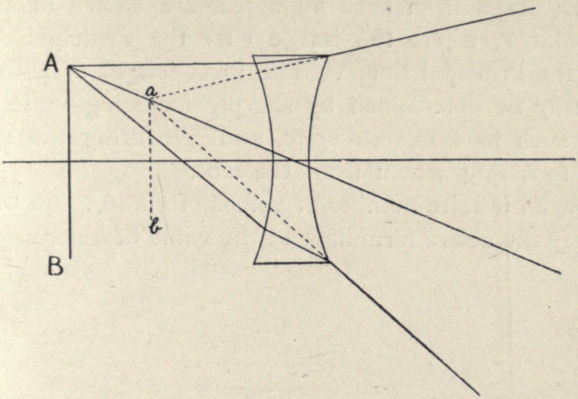


FIG. 10.

Principal Axis of the lens. Let the image of an object, AB, at right angles to this axis be formed at *ba*. Then if the distance of AB from the lens, which is supposed to be

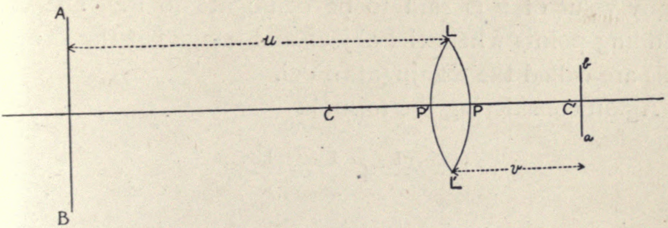


FIG. 11.

infinitely thin, is u, and the distance of the image *ba* is v, it can be shown that

$$\frac{1}{v} + \frac{1}{u} = \text{a constant, denoted } \frac{1}{f}.$$

In this formula the signs of u, v, f have been allowed for, so that it is only necessary to substitute the *numerical* values of the various distances.

The constant f is called the Focal Length of the lens, and is the distance of the image when the object is infinitely remote. Rays from such an object are shown in Fig. 12. The point F, where the image cuts the Principal Axis, is called the Principal Focus. The focal length of a thin lens can easily be determined by sharply focussing some distant object such as a church spire, and measuring the distance of the focussing screen from the lens.

Now an infinite number of values of u and v can be found to satisfy the above formula, and the value of u corresponding

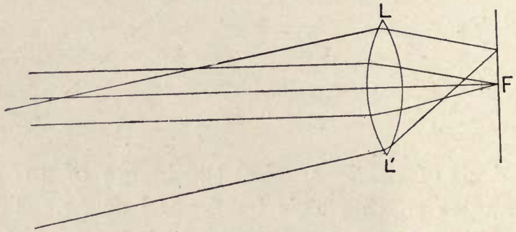


FIG. 12.

to any value of v is said to be conjugate to it. The corresponding points where the object and image cut the Principal Axis are called the Conjugate Foci.

Again considering the formula

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

we see that as u increases, v decreases, so that as the object recedes from the lens the image approaches it. When u is less than f a virtual image is formed, but with this we are not concerned.

It can also be shown that the relative sizes of image and object are in the ratio $v:u$, so that the magnification or reduction is $\frac{v}{u}$.

The solution of some examples will make clear the use of these formulæ.

Example 1.—A 6 in. lens is sharply focussed on an object distant 10 ft. What is the distance of the lens from the plate?

$$\text{Here } f = \tfrac{1}{2} \text{ (6 in. is } \tfrac{1}{2} \text{ ft.)}$$
$$u = 10$$
and v is required.

Substituting these values in $\dfrac{1}{v} + \dfrac{1}{u} = \dfrac{1}{f}$

$$\text{we have } \frac{1}{v} + \frac{1}{10} = 2,$$

$$\text{so that } \frac{1}{v} = \frac{19}{10}$$

$$\text{and } v = \tfrac{10}{19} \text{ ft.}$$

Example 2.—It is desired to enlarge from quarter-plate to whole-plate with a 6 in. lens. What must be the distance of the paper and negative respectively from the lens?

In this case the magnification is 2, so that

$$\frac{v}{u} = 2.$$

$$\text{Substituting in } \frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

$$\text{we have } \frac{1}{2u} + \frac{1}{u} = 2,$$

$$\text{so that } \frac{3}{2u} = 2$$

$$\text{and } u = \tfrac{3}{4} \text{ ft.}$$
$$v = 1\tfrac{1}{2} \text{ ft.}$$

Example 2 is another form of the frequently occurring question in which it is desired to know whether a lens of given focus can be used in a studio of certain length to obtain portraits of a particular size.

Field of View.—The angle of view included by a lens of focal length f when used with a plate whose longer side is n can easily be found by drawing a right-angled triangle, in which the sides subtending the right angle are f and $\frac{n}{2}$. The angle opposite the side of length $\frac{n}{2}$ is half the angle of view, and its value can easily be ascertained by measurement with a protractor. When the focal length of a lens is the same or less than the shorter side of the plate it is used with, it is a wide-angle lens for that plate. Obviously it could be used on a smaller plate, and would not then include such a large field of view. A normal angle of view would be included by a lens of focal length about equal to the diagonal of the plate. Lenses of longer relative focal length are known as long-focus or narrow-angle lenses. It must be remembered that the resulting picture will be the same if it is taken with a wide-angle, medium-angle, or narrow-angle lens of the same focal length on the same plate. The wide-angle and medium-angle lenses can, however, be used with larger plates, and so have a more extended field of usefulness. As an example it may be mentioned that a 6 in. lens can be obtained which will sharply cover a whole plate at full aperture. Such a lens is, however, of suitable focal length for use on a 5 × 4 in. plate as a medium-angle lens. The medium-angle 6 in. lens recommended for a 5 × 4 in. plate will, however, not be suitable for use on a whole plate, because it will not illuminate it all over. The angle of the cone of rays transmitted by different lenses of the same focal length is not the same, owing to the different constructions and mountings employed. That transmitted by the 6 in. wide-angle lens is much greater than the angle of the cone of rays transmitted by the medium-angle lens. (It may here be mentioned that the perspective of a picture becomes more pleasing as the focal length of the lens increases.

CHAPTER V

THE OPTICS OF PHOTOGRAPHY (*continued*)

Principal Planes.—It was stated in the last chapter that for purposes of calculation a thick lens can be replaced by a single thin lens of negligible thickness. Now, no single point can be found at which such a lens could be situated, but it is possible to find two points at each of which the lens must be imagined to be situated. These points are shown at P, P′, Fig. 13, and the planes through them at right angles to the

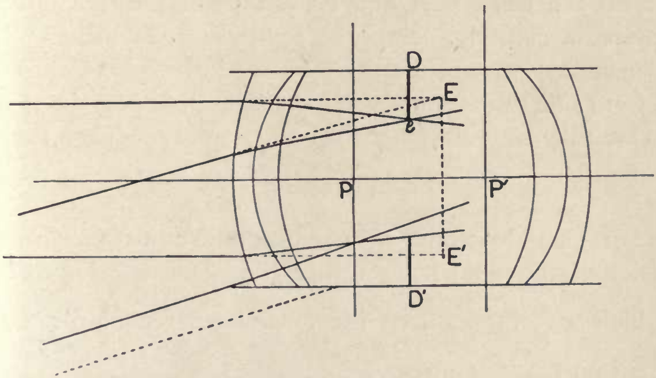


FIG. 13.

Principal Axis are called Principal Planes. The distances u of the objects are measured from the point P, and the distances v of the images from the point P′. We must therefore imagine the thin lens as shifting instantaneously from P to P′ as the light passes through it. The focal length is measured from the point P′. A simple and yet accurate method of determining the position of P′ is given in the next paragraph.

Determination of the Focal Length of a Thick Lens.—It is always desirable to know the *exact* focal length of a lens. An idea finds currency that it would be sufficiently accurate to measure the distance of the focal plane from the diaphragm, DD′; but whilst this may do for the rectilinear type of lens, it is not sufficiently accurate for some anastigmats, and of course quite wrong for lenses like the Bis-Telar, in which P′ is outside the lens. The Back Focus, which is the distance of the focal plane from the back surface of the lens, is equally inaccurate. The following method is one of the simplest yet suggested.

Focus the lens on a distant object, and note the position of any suitable point on the moving part of the baseboard with respect to any suitable point on the fixed part. Now sharply focus on a scale placed sufficiently near the camera to give a large image. The selected point on the moving part of the baseboard will have changed its position with respect to the point on the fixed part, and its *change* of position must be measured accurately. Suppose it has moved e inches. It is also necessary to measure the size of the image of the scale, and from this to determine the magnification or reduction as the case may be. Suppose the reduction is r. Then the

$$\text{Focal length} = \frac{e}{r}.$$

The lens should now be focussed on a distant object, and the position of the point P′, or rather the plane passing through it, which is $\frac{e}{r}$ inches from the focussing screen, indicated by a mark on the lens mount.

Measurement of the Effective Aperture of a Lens.—All lenses are fitted with means for varying at will the amount of light passing through them. In a good lens this should take the form of the Iris Diaphragm, which will be familiar to all photographers. The *effective* aperture of such a diaphragm for a doublet cannot be determined by unscrewing the front combination, and accurately measuring the diameter of the opening in the diaphragm. The reason for this is shown in

Fig. 13. In that figure the extreme rays parallel to the Principal Axis are shown as just clearing the diaphragm after refraction. Clearly the diameter of this cylinder of rays *before* refraction is the *effective* aperture of the diaphragm. Another ray has also been shown which just clears the diaphragm, and the intersection E of the original direction of this ray with the original direction of the extreme parallel ray is also shown. This point E can be regarded as the Virtual Image of the point *e* on the diaphragm formed by the front component of the lens. If the complete virtual image EE′ is obtained, we get what is called the Entrance Pupil of the system. Similarly the virtual image of the diaphragm formed by the back combination is known as the Exit Pupil. When we measure the effective aperture of a lens we are really measuring the diameter of these pupils. To find the effective aperture the lens must first be sharply focussed on a distant object. The focussing screen is then removed, and replaced by a piece of card which prevents any light entering the camera except through a small perforated hole at its centre. The camera is now taken into a room in which the only source of illumination is a candle flame, and the flame is placed close to the perforation. A finely divided scale is placed touching the lens mount, and the diameter of the cylindrical beam of light passing through the lens measured. This value is then usually expressed in terms of the focal length f, e.g. if it is 2 inches, and the focal length is 8 inches, it would be $f/\frac{8}{2}$, *i.e.* $f/4$. The value so obtained should correspond with that indicated by the pointer on the diaphragm. A recent test on a cheap lens showed that the aperture marked $f/8$ was in reality $f/16$. This result is exceptionally bad.

Depth of Field.—In addition to limiting the amount of light passing through the lens, the diaphragm performs the very important duty of controlling the definition. From the last paragraph it is evident that it is not the size of the actual aperture, but the size of the entrance pupil, etc., that we have to consider, so in Fig. 14 the pupils only are shown. The lens is supposed to be sharply focussed on the plane AB, and the image to be formed at *ba*. Now consider any other point, P, on any plane, e.g. on a plane more distant from the lens, as in Fig. 14. The cone of rays from this point will cut the plane AB in a circle XY, and this circle will be reproduced as a circle *yx* on the image plane *ba*. The circle on the image plane is called the Circle of Confusion due to the point P. Now it is agreed that circles of less diameter than $\frac{1}{100}$ inch may be considered as points, so that if our circle on the image plane is less than this value, we shall have the distant plane containing P in focus at the same time as the plane AB. Obviously, however, there is a limit to the position of this plane on each side of the plane AB. The distance apart of

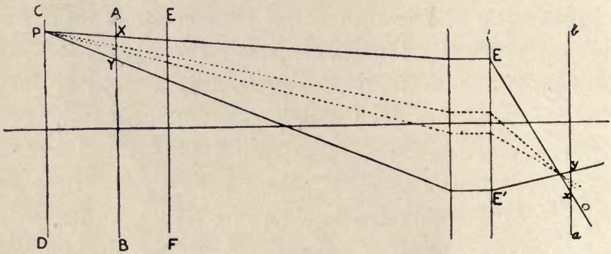


FIG. 14.

these limiting planes, CD, EF, is called the Depth of Field for that aperture. By reducing the size of the aperture we increase the distance apart of these planes. The effect is shown in dotted lines in Fig. 14. The depth of field for a lens of known focal length can be very easily calculated for any aperture; but, before giving the formula, we must consider what is known as Hyperfocal Distance. From consideration of Fig. 8 it will be obvious that when sharp focus is secured on a very distant object, other objects much nearer to the lens are also in focus. The distance of the nearest plane to the lens which is in focus is called the Hyperfocal Distance, and is usually denoted by H. It can be shown that

$$H = \frac{100F^2}{12f} \text{ ft.}$$

F being the focal length in inches, f the aperture (8, 11, 16, and so on).

Now the distance of the farthest sharp plane from the lens when sharp focus is secured on a plane distant u feet can be shown to be

$$\frac{u\text{H}}{\text{H} - u} \text{ approximately.}$$

and the distance of the near plane

$$\frac{u\text{H}}{\text{H} + u} \text{ approximately.}$$

A knowledge of the distance of these planes is invaluable to the hand-camera user, and many cameras are now fitted with an index which enables them to be very easily read off from a scale. It is also possible to buy scales calculated for lenses of four common focal lengths.

The solution of an example will perhaps help to an understanding of the use of these formulæ.

A 6 in. lens is sharply focussed on an object 20 ft. away. What will be the Depth of Field at F8?

We must first calculate H.

$$\text{Now H} = \frac{100\text{F}^2}{12f} \text{ ft.}$$

Here $\text{F} = 6, f = 8$, so that $\text{H} = \frac{100 \times 6 \times 6}{12 \times 8} \text{ ft.}$

$$= \frac{300}{8} \text{ ft.}$$

Distance of far plane is $\frac{u\text{H}}{\text{H} - u} = \frac{20 \times \frac{300}{8}}{\frac{300}{8} - 20} \text{ ft.}$

$$= 43 \text{ ft. (approximately).}$$

Distance of near plane is $\frac{u\text{H}}{\text{H} + u} = 13$ ft.

So that Depth of Field is $(43 - 13)$ ft., *i.e.* 30 ft.

With respect to fixed-focus cameras it will now be obvious that the lens should be set for sharp focus on an object at the Hyperfocal Distance for the largest aperture of the lens.

Depth of Focus.—Again referring to Fig. 14, it will be understood that the plane AB will not only be sharply reproduced on the plane *ba*, but also on planes lying on either side of it. The distance apart of the extreme planes on which sharp focus is obtained is called the Depth of Focus for the aperture in use. Depth of Focus is not a large quantity unless very minute apertures are used; and when that is so, Diffraction is very likely to occur, and the fine definition is accordingly destroyed. It is periodically pointed out by writers in the photographic press that by using a very small stop any ordinary lens can be used as a so-called wide-angle lens. Suppose the depth of focus of a 6 in. lens at F 300 is 4 inches. Then this lens could be used as a lens of 4 in. focal length, which would include a much larger field of view. It could also be used as a lens of focal length 8 inches, which would include a much smaller field of view. The reader can try the effect of placing a piece of very finely perforated card against the ordinary diaphragm, and then making a series of exposures with the lens at varying distances from the plate. The results will probably not be satisfactory. As a guide it may be mentioned that when the screen is v inches from the lens, and the aperture is a inches, the depth of focus is approximately

$$\frac{v}{50a}$$

The screen can therefore be moved $\frac{v}{100a}$ inches on either side of the position in which the sharpest definition is obtained.

Equality of Illumination.—A lens is said to equally illuminate a plate when the same amount of light is incident on unit areas at the centre and margin of the plate. No lens does this. With many lenses it is found that the plate is not uniformly illuminated at large apertures, but that the illumination apparently becomes uniform when the aperture is decreased. The reason for this can be understood from Fig. 13, in which a good part of the oblique cylinder of rays is cut off by the lens mount. When the aperture is reduced sufficiently, all the rays of the oblique cylinder enter the lens, and take part in the formation of the image. It will be seen that even then the cross-sectional areas of the axial and oblique cylinders are unequal, but it is found in practice that the equality of illumination is not influenced very much by this, unless the lens is used as a wide-angle lens. With wide-angle lenses the illumination will always fall off towards the edges of the plate.

CHAPTER VI

THE OPTICS OF PHOTOGRAPHY (*continued*)

A GOOD photographic lens, as was explained above, consists of several single lenses of varying refractive and dispersive powers. We must now consider why it is necessary to use several single lenses to obtain a perfect image. A perfect image cannot be formed by a single lens, since such a lens does not cause all the light rays coming from a given point on the object to pass through a single focal point. This defect in the action of a single lens is called Aberration, and can be considered under two headings, viz. (i) Chromatic Aberration, (ii) Spherical Aberration. The image formed has additional defects which are considered under the various headings below.

Chromatic Aberration.—This defect is caused by the splitting up of a ray of white light into its components when it is refracted. It has already been illustrated in Fig. 7. When the axial cone of white light AB, Fig. 15, is incident on the lens LL′, it is obvious that the various coloured components of the ray are brought to different foci. These foci are shown at exaggerated distances apart in the figure, V being the point where the violet rays cut the axis, B the point where the blue rays cut, and so on. If a focussing screen is placed at R it will be in the focal plane of the red rays, so that there will be a sharply defined red image. This image has, however, violet, blue, etc., images superposed, and these images are blurred. Now, in the early days of photography, the blue rays were the rays which caused chemical action in the photographic plate, and the red and orange rays caused no chemical action at all. If, therefore, a sensitive plate was placed at V, a sharply defined image should have been formed on it. The rays which affect the eye are the yellow, orange, etc., so that, when focussing, the screen would be placed at O. It is, therefore, necessary

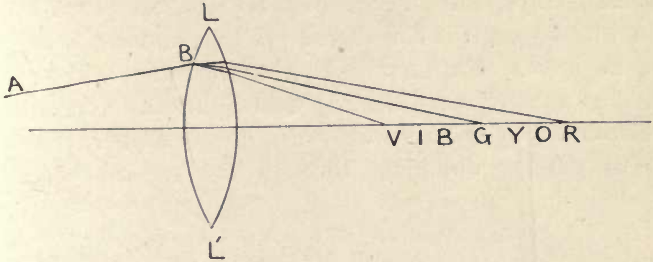


FIG. 15.

to shift the screen through the distance OV, such distance being easily calculated. This distance is known as the correction for chemical focus. In these days of panchromatic plates all the rays would cause chemical action, so that the resulting image would be blurred.

Spherical Aberration.—This defect is due to the shape of the single lens; the surfaces of a lens are spherical, it is

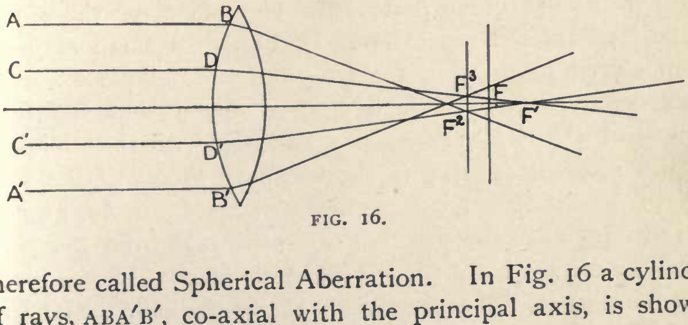


FIG. 16.

therefore called Spherical Aberration. In Fig. 16 a cylinder of rays, ABA′B′, co-axial with the principal axis, is shown. The rays AB, A′B′ are brought to a focus at F^2, but the rays CD, C′D′ are brought to a focus at F′. At the position F^3, between F′ and F^2, the circles of confusion will have a minimum size. If all the rays parallel to the principal axis are considered, it is possible to find a point F where the circles of confusion due to all the rays have the minimum effect. This is the point where the focussing screen should be placed. The amount of Spherical Aberration present is measured by the distance between the foci for marginal and axial rays, i.e. $F'F^2$ in Fig. 16. For a positive lens, as in this figure, it is considered positive, and for a negative lens, negative. Chromatic Aberration must not be overlooked as a factor when dealing with Spherical Aberration.

Curvature of Field.—We must now consider the effect of rays passing obliquely through the central portion of

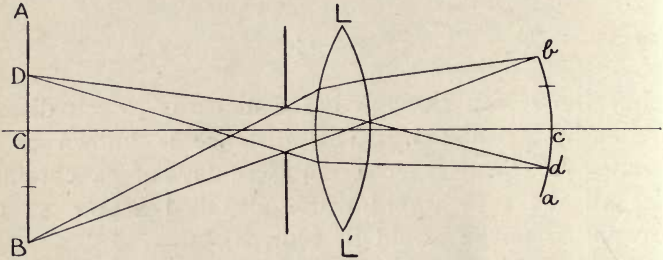


FIG. 17.

a single lens, and also the effect of those passing obliquely through its marginal portions. The effect of these rays is best considered separately. In Fig. 17 a small stop has been placed in front of the lens and the oblique excentric rays are excluded. Now it can be shown that the focal length of a lens for centric pencils varies with the obliquity of the incident pencil; as the obliquity increases, the focal length decreases. If we consider a plane object, AB, Fig. 17, at right angles to the principal axis, the rays from the point C will be focussed at *c* (where the circle of confusion is least), and the rays from B at *b* which is nearer the lens. The focal surface is therefore curved.

Distortion.—We will once more refer to Fig. 17 and consider rays from the middle point, D, of AC. These rays are brought to a focus at *d*, but *d* is not midway between *ac*. With the stop in the position shown the distance of *d* from *c* is greater than its distance from *a*. The image is therefore distorted.

Astigmatism.—This error is caused by the rays passing through the marginal portions of the lens, and only occurs when the lens is used with a fairly large stop. The nature

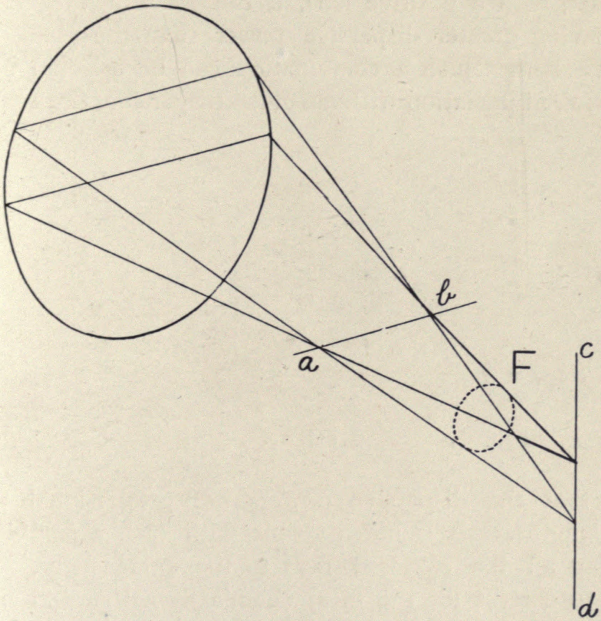


FIG. 18.

of this defect is shown in Fig. 18 in which is shown part of a pencil of rays after refraction. The refracted rays pass through two mutually perpendicular lines *ab*, *cd*, known respectively as the First and Second Focal Lines. Between these lines at some position F, a section through the pencil is approximately circular. This section is called the Circle of Least Confusion, and is the position for the focussing screen. The circles of least confusion for a series of pencils lie on a curved surface, and this must also be considered with the curvature of field caused by oblique centric pencils. Astigmatism is measured by the distance between the lines *ab*, *cd*.

The various defects of a single lens having been indicated, we will see how they can be remedied.

Correction of the Defects of a Single Lens.—Chromatic Aberration is corrected by combining a negative lens, 2, Fig. 19*a*, with a positive lens, 1, the glass of the negative lens having greater dispersive power than the glass of the positive lens. Such a combination can be selected to give the required deviation without much dispersion, the condition

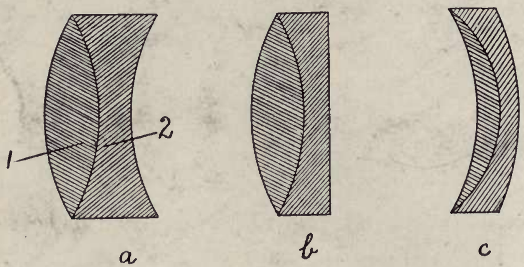


FIG. 19.

being that the dispersive powers are proportional to the focal lengths. It is not possible with such a combination to bring all the coloured rays to the same focus, so it is usual to correct for the most chemically active and visually affective. If more than two lenses are used with a corresponding variety of glasses, it is possible to obtain a combination which is approximately corrected for all colours.

Spherical Aberration is corrected by varying the shape of the components of the achromatic combination, it being necessary to select two lenses in which the positive error of the one equals the negative error of the other. The correction is, however, not perfect. The most common forms of single achromatic lenses are shown in Figs. 19*a*, 19*b*; but the form shown in Fig. 19*c* is better corrected, and can

Rudolph Dührkoop, F.R.P.S.

PORTRAIT STUDY.

p. 48]

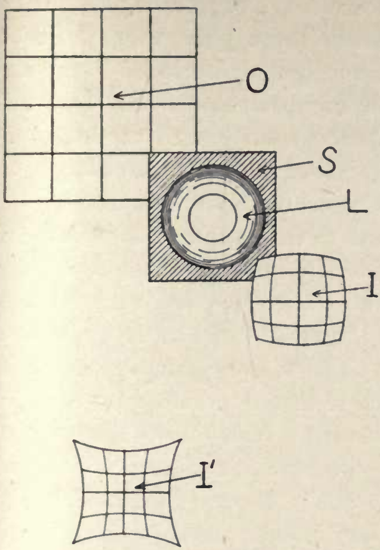


FIG. 20.

be used at a larger aperture. The use of a stop with a single achromatic lens is a necessity, and it must be of such size and position that the centre of the image is only formed by centric pencils, and the margins of the image by oblique excentric pencils. Single achromatic lenses of only two components and medium focus can be designed to cover sharply a quarter plate at F11. More complex single achromatic lenses can also be corrected for astigmatism. Distortion is corrected by placing two single achromatic lenses co-axial as shown in Fig. 21 with a stop between them. If the stop S is placed between the lens L and the object O, as in Fig. 20, the image I is shaped as shown; but, if the stop S is placed between the lens L and the image I, the image takes the shape shown at I′, Fig. 20. Obviously if two single achromatic lenses are placed as in Fig. 21 with a stop between them, the distortion created by the front lens is nullified by the opposite distortion created by the back lens. Such a lens is said to be Orthoscopic or Rectilinear. They are usually constructed to work at F8; but some are made to work at F5·8 and are particularly useful for portraiture. These large-

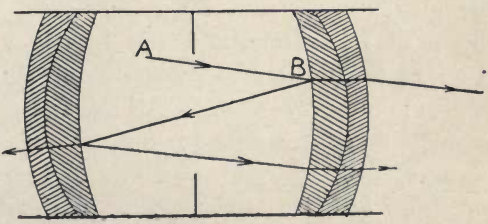


FIG. 21.

apertured rectilinears are known as Euryscopes, Biplanats, etc., but, when used on a fairly large plate they must be stopped down to give good marginal definition. They are usually mounted so that one component can be removed, leaving a lens of about double the focal length of the combination. The use of a longer focus lens is advantageous in portraiture, and in some classes of landscape work.

Anastigmat.—We now come to that type of lens known generally as the Anastigmat, which indicates that it is free from astigmatism. The forms of this lens are very varied, and it is only possible here to illustrate three varieties, which may be regarded as typical. There is a general idea that Anastigmatic lenses were only rendered possible by the use of the Jena glasses introduced in 1886. This idea is erroneous; several modern anastigmats are made with glasses which were in use before this time. Nevertheless the introduction of this kind of glass gave a great impetus to lens construction, and it is very largely used at the present time. The form shown in Fig. 22 employs one of the new glasses as the back component. Such lenses can only be used in combination, since each component is not separately corrected. They are thus single-focus lenses. In the form shown in Fig. 23, the front component corrects spherical aberration and back component astigmatism. As both components are free from chromatic aberration, they can be used separately, and the lens is a three-foci lens. In Fig. 24 is shown a more complex lens, each component of which is fully corrected. All the anastigmats shown employ cemented combinations; but, many are made in which numerous air spaces occur. Since there is a certain amount of light lost by reflection at each air-glass surface, the efficiency of such a lens is less than one of the same

FIG. 22.

aperture but comprising only cemented surfaces. This will be understood from Fig. 21, in which a ray AB incident on the front surface of the back component is shown as partly refracted and partly reflected. The reflected ray when incident on the back surface of the front component is partly refracted out into the air, and partly reflected back to the back component. A part of this reflected ray is refracted and with neighbouring rays forms another image. This image must be some distance from the plate, so that the circle of confusion at the plate is very large. The circles of confusion of the various rays overlap and the general effect is simply a degradation of the brilliance of the image. Such degradation is not very noticeable when only one air surface occurs; but, it has a cumulative effect for each air surface. It will also be understood that many rays will be reflected on to the lens mount and there absorbed. If the image formed by the reflected rays is in the plane of the plate, the lens is useless.

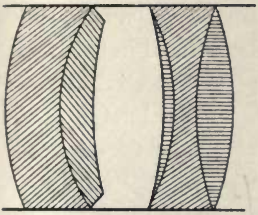


FIG. 23.

No general statement of the methods employed for correcting astigmatism, and at the same time curvature of field, can very readily be given. It may, however, be mentioned that, if the "old" glasses are used exclusively, air spaces are bound to occur. When "new" glasses are used as well, it is possible to form them into cemented combinations with only the one air space as in the form shown in Fig. 24.

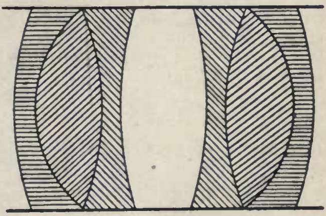


FIG. 24.

Petzval Lens.—Some special forms of lenses will now be considered. The Petzval portrait lens, Fig. 25, has been in use for sixty years, not only as a portrait lens, but also as a projection lens. It works at a large aperture; but, is of short focus and has a very small field of view. If it is stopped down, flare is very likely to be caused. Several improvements on the form shown have been made. Perhaps the most notable is that in which the elements of the back component are mounted so that they can be separated at will. Any desired amount of diffusion of focus can be caused in this way.

Another lens of long standing is the so-called Orthoscopic lens of Voigtlander, produced in 1857. This lens was of fairly long focal length, and yet did not require a corresponding amount of camera extension. The point P′ in Fig. 13 was some distance in front of the lens, so that a lens of 10 in. focal length might only require a camera extension of 5 inches. This property of the lens did not, however, receive much attention, and only when telephotography became popular was it brought to the front. Lenses having the same property are now on the market, being sold by the Busch Optical Company under the name Bis-Telar.

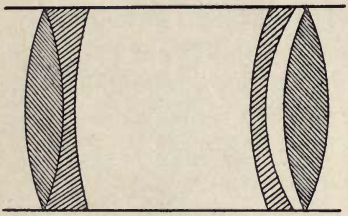


FIG. 25.

In photographic work it is often found necessary to use a lens of shorter or longer focus than the one usually employed. Any lens can be converted into a lens of shorter or longer focus by placing an appropriate lens co-axial with it. The amount of change of the focal length varies with the separation of the lenses. The focal length, F, of a combination of two lenses of focal lengths f^1, f^2 at a distance d apart is

$$\frac{f' f^2}{f' + f^2 - d}.$$

Thus if we have convergent lenses of focal lengths 10 and 5 inches at a distance apart of 1 inch, the focal length of the combination is

$$\frac{10 \times 5}{10 + 5 - 1} \text{ in., i.e. } 3\tfrac{4}{7} \text{ in.}$$

The lens employed for altering the focal length is called a Supplementary Lens, and sets of such lenses suitable for use with lenses of common focal lengths are made by several opticians. They are sold under the names "Portrait attachment," "wide-angle attachment," etc., and, since they are cheap, are very useful to the worker who does not wish to buy a large number of expensive lenses.

Telephoto Lens.—The ordinary Telephoto combinatior consists of a positive and negative lens, the latter being placed between the positive lens and the plate. Such a combination is shown in Fig. 20. The position of the negative lens has well-defined limits. It must never be

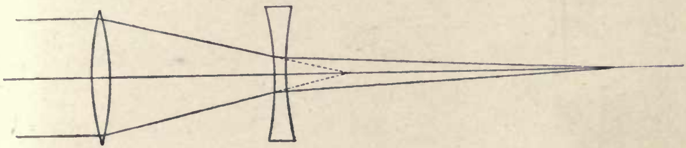


FIG. 26.

nearer the positive lens than the difference of the focal lengths, and never farther away than the focal length of the positive lens. Thus supposing we have a positive lens of 8 in. focal length, and a negative lens of 3 in. focal length; then, to use this pair as a telephoto combination we can place the negative lens anywhere between 5 and 8 inches from the positive lens. The formula given above applies to such a combination, due regard being paid to signs. If the positive and negative lenses are complex, then d is the distance between the nearest *principal planes of the lenses.* The most useful thing to know when using a telephoto combination is the amount of camera extension required for a certain magnification. The extension required can then very readily be found, for if the magnification is n, and the focal length of the negative lens is f, it is

$$(n - 1)f.$$

It will be seen from Fig. 26 that the function of the negative lens is to make the angle of the cone of rays transmitted smaller. This alteration of the angle of the cone of rays without corresponding alteration in the camera extension has a very important effect when the lens axis is not horizontal as in photographing some elevated architectural detail. For full information on this point the reader is referred to the chapters on Architectural Photography.

For the more advanced study of photographic optics the reader may be referred to *Photographic Optics and Colour Photography*, by Lindsay Johnson; or to the work on Optics by Lionel Laurence.

CHAPTER VII

ON SELECTING A LENS

IN the preceding chapter some account has been given of the various types of lenses and their distinguishing characteristics, so that the reader is now in a position to decide on the lens he is going to purchase. Some additional remarks will, however, be of interest.

Opticians say that the very best lens a person can afford is the one that should be purchased. That is what any one would expect them to say in their own interests. To choose a lens in that way is absurd, and it is much more important to consider the kind of work you are likely to use it for. You can then select the cheapest lens which will do such work efficiently. There are many photographers in existence who have taken up photography simply as a means of artistic expression. The aim of many of these photographers is the production of those extremely blurred, featureless pictures which adorn (?) the walls of our chief exhibitions, and these photographers produce nothing else. I could instance one worker, who whilst he has a very expensive anastigmat, produces nothing but badly defined pictures from his exquisitely defined negatives. Such pictures may be artistic, but with that we are not concerned. We are only interested in the means of production. Pictures of this type can very readily be produced by the single non-achromatic lens which can be purchased for a few pence. Therefore it seems a sheer waste of money to spend pounds on an anastigmat.

If the single non-achromatic lens is used, all the tedious after-processes, such as interposing chiffon between the plate and the paper, or racking the lens forwards and backwards when enlarging, can be dispensed with.

Single Lenses.—A single achromatic lens will fulfil the requirements of the landscape worker and portraitist. As illustrated by Fig. 20 these lenses give a distorted image, but, this will not be noticeable when photographing trees and the like. The image given by such a lens is very brilliant, since it has no air spaces, and if it is used as a narrow-angle lens, the field will be sufficiently flat to give good results without considerably reducing the aperture. This lens also may be considered as possessing considerable depth of field due to its curvature of field. The nearer an object is to the lens (which is focussed for a distant object) the nearer is the line in which the focal surface for that object cuts the plate, to the bottom of the plate. So that if the objects in the foreground are not very large, sharp focus may be obtained on both foreground and distance at a large aperture.

Rectilinear Doublets.—For the worker who wishes to do general work, and to whom price is a consideration, a rapid rectilinear can be recommended. Such a lens is available for architecture, and other subjects in which distortion is not permissible. The definition is good at full aperture (usually F8) excepting at the edges of the plate. Good definition can be obtained all over the plate by slightly reducing the aperture; but, if a fairly long-focus lens is used, e.g. a 6 in. lens on a quarter plate, good definition will be obtained all over at full aperture. Rectilinears are made with an aperture of F5·8, and although such lenses are extremely useful in portraiture, where rapidity is essential, they are no better than the ordinary rectilinear for general work, owing to the amount of stopping down required to give good definition all over the plate. A rectilinear is composed of two symmetrical components, each of which can be used separately. Since the focal lengths of the components are equal, such a lens gives only two focal lengths.

Anastigmats.—The anastigmat will cover sharply the plate it is listed for at full aperture. When it is remembered that the full aperture for some of them is F3·5, and that the usual aperture is F6, it will be seen how very valuable they are to the photographer. A good anastigmat can now be obtained for very little more than the price asked for a new rapid rectilinear. The latter lens can, however, be obtained in a shutter at almost nominal prices second-hand. It must be remembered that *the* feature of the anastigmat is its ability to cover sharply at *large apertures*. When stopped down, it is no better than the ordinary rectilinear, so that if the worker is not going to do much hand-camera work where rapidity is essential he might very profitably buy a second-hand rectilinear. There is, however, one important difference between the anastigmat and rectilinear. An anastigmat listed for a quarter plate would probably cover sharply a 5 × 4 in. plate at full aperture, and a much larger plate at a small aperture. A rectilinear listed for a quarter plate would not cover sharply a much larger plate even with a small stop. It will be obvious that the former lens is of great use to the architectural photographer, who frequently has to use considerable rise of the camera front.

An anastigmat is also of great use when focussing in some poorly lit building, since at F6 the illumination of the focussing screen will be nearly twice as great as at F8 which is the usual aperture of the rectilinear. Moreover the photographer has only to stop down to secure depth of field, and not to secure good marginal definition. To the screen-plate colour photographer, a large-apertured anastigmat is of great use, and it is also indispensable to the copyist whose time is valuable. Now, there are many varieties of anastigmats. Some do not permit the components to be used separately. Others permit the use of the components, and since they are often very highly corrected and of unequal focal lengths, three good lenses are contained in one. Preference should be given to the latter type of lens, which will be found extremely useful.

The lens for the photographer who has plenty of money to spend on his hobby is an anastigmat which will cover sharply at full aperture a much larger plate than that for which it is sold. As an example, it may be of interest to know that a 6 in. anastigmat can be obtained which will cover a 10 × 8in. plate at full aperture, viz. F6·3. Now a lens of focal length 6 in. is normally used on a 5 × 4 in. plate, so that the aforementioned lens would permit the maximum use of the rising front when used with a 5 × 4 in. camera. In cameras made with the so-called "universal" movements such a lens is essential, if good use is to be made of these movements. The maximum rise of front can be used at *full* aperture, and this is extremely useful to the architectural photographer where a stand camera cannot be erected on account of traffic, etc. It may be objected to the use of such a lens that a large part of the light it transmits is incident on the interior of the bellows from whence it is reflected to the plate. If this occurs it can easily be remedied by using a hood on the lens; but, care must be taken to see that no part of the picture is cut off by it. Caution is especially necessary when using the rising front. Hoods are made which are adjustable in length, and though expensive are undoubtedly the most useful, since their length can be adjusted to suit the amount of rise of front in use. A hood can be made very simply from an old pill box by knocking out the bottom, and giving the interior a coating of dead black. A 3 foci anastigmat used normally so as to include an angle of view from 50° to 60°, but which may be used equally well to include an angle of view of 90° is the best lens for all-round work, and all who can afford such a lens should purchase one. Such a lens is very useful to the worker possessing more than one camera, as he can use the lens as a wide-angle lens on his large camera, and as a normal-angle lens on the small one. In general, bear in mind what work the lens is required for. Do not get the 3 foci anastigmat if fuzzy pictures are your only desire.

Focal Length.—When the type of lens is decided, the next thing to settle is the focal length. As the focal length increases, the perspective becomes more pleasing, and it has been found that a focal length of from one-third to one-half as long again as the longest side of the plate, is about the most useful length for all-round work. If the lens is to be bought new go to a reputable optician, and he will probably give you some good advice as to the make to select. Lenses by reputable makers are nearly all of good quality; but, some makers have a reputation for better workmanship. When the lens is obtained, the *actual* focal length should be determined in the manner already explained. The effective aperture should also be determined, and if there is much discrepancy between the marked figure and that obtained by experiment, the lens should be returned, as it is worth considerably less than the price paid for it. The lens should also be tested for flare in the following way. The lens is taken into a room illuminated by a single candle, and the image of the flame sharply focussed on the centre of the focussing screen. The camera is now rotated so that the image of the flame moves towards the edge of the screen. If flare is present a bright spot will appear on the opposite side of the centre of the screen.

Testing second-hand Lenses.—When buying a lens second-hand, greater care is necessary, and the lens should be obtained on approval before it is purchased. Even if the lens is marked with the name of a reputable maker, it should still be tested thoroughly, for unscrupulous dealers have been known to engrave cheap unknown lenses with the name of a good maker. The lens should first be tested for colour by looking through it at a piece of white paper. If there is a yellowish tinge, the lens should be rejected, as such a colour makes a considerable difference in the efficiency of the lens. The lens should then be tested for flare, and the above-mentioned test will also show whether spherical aberration is present. If it is, the image of the flame will not remain sharp as it approaches the edge of the screen. The next test is for chromatic aberration, and perhaps the best test is the following, recommended by the late Traill Taylor. A row of numbered cards is placed co-axial with the lens and at a distance of a foot or so apart. From the camera the cards appear as a fan, and the lens is sharply focussed on, say, number 8. A plate is exposed, and if on development, card No. 8 is not sharp, the lens is not corrected for colour. If the lens is alleged to be an anastigmat, a further test is necessary. An object should be focussed at full aperture, and the camera rotated until the image of the object approaches the edge of the screen. If both vertical and horizontal lines are still defined sharply the lens is free from astigmatism. If they are both blurred, or one set sharply defined and the other set blurred, the lens is not free from astigmatism, and should be returned or a considerably lower price paid for it.

Rev. D. G. Cowan, M.A.

CHÂTEAU D'OEX.

CHAPTER VIII

OUTDOOR PHOTOGRAPHY: FOCUSSING THE IMAGE

In whatever section he may afterwards specialise, the beginner should always pass through a course in landscape work. The incidental difficulties are few and arise in so regular a succession, that a result worthy of being shown to critical friends may often be achieved after a few lessons.

Focussing the View.—Having arrived at the scene of action, the lens is opened by removing the cap. If it is fitted with an automatic shutter the indicator must be turned to "time," and the lever pressed once. Then, with the aid of a focussing cloth of some opaque material, such as black cotton velvet, we examine the image thrown on the focussing screen, racking the front backwards and forwards till it appears fairly sharp. (The iris diaphragm of the lens must be at its widest, *f*/8 or *f*/6·5, in order that this can be satisfactorily done.) If we only want practice in development it would suffice at this point to stop down the lens to, say, *f*/11, reset the shutter, place the dark slide in the camera and expose the plate. But if a picture of technical value is desired, there are a number of further details deserving of consideration.

It is presumed that we have some purpose in our mind which impels us to choose this particular spot. The scene before us either contains something worthy of record, or possesses qualities that appeal to us as beautiful or educative. In other words, we intend the future print to convey some definite idea.

(1) What is the essential feature in our picture?—e.g. a

tree, a cottage, a river bank, or a water mill within reasonable distance. This must be settled, and then (still with the lens aperture at its widest) this feature must be brought into sharpest focus. We endeavour with the lens to follow the natural instinct of the observer who will unconsciously focus his eyes on this same object.

(2) Is the foreground necessary? If it is, the stop in the lens must be reduced or the focussing adjusted until it appears reasonably sharp. The contributor of "In a Green Valley," has boldly ignored his foreground and focussed for the middle distance with a large stop. His picture would have gained, we think, by racking out till the leaves on the hedge had become crisp and bright. If the foreground is uninteresting we may avoid it by raising the front until the lens soars above it, or by so moving the camera as to cut off a hedge, fence, or tree trunk, that would otherwise obtrude into the scene. Fences and hedges are sometimes distorted into absurd proportions if too near the lens.

If the chief feature of the picture is a long way off, and no intermediate objects deserve attention or force themselves into the line of vision, the front combination of an RR lens may be unscrewed and the camera racked out to the necessary double extension, the exposure, of course, being increased proportionally. A smaller stop will be necessary with the single lens than with the doublet.

Mountain Scenery.—On the contrary, if a view is taken from the top of a hill over the valley beneath, or of distant mountains, all idea of scale and proportion will be lost unless some object in the foreground is shown in focus. Without some such standard of comparison (serving also to indicate clearly the position of the observer) the slopes of the hillside will have become unaccountably flattened out in the print; very often the effect conveyed will be that of an immense plain.

General Notes.—The subject of pictorial composition in landscape is dealt with in another chapter, but one or two common faults may be mentioned here. Roads, small rivers, etc., are often taken "broadside" in such a way that the resulting picture is divided off from end to end by horizontal streaks of light colour. The edges of the picture, right and left, always deserve careful examination in the focussing screen to see that no detail exciting curiosity is abruptly cut off. Beware of waste paper, old tin cans, and other

Lionel West.

IN A GREEN VALLEY.

rubbish in the foreground. The camera will invariably record such articles with hideous fidelity. If figures are introduced, they must not be so near the camera as to divert attention from the essential elements of the composition, nor, on the other hand, so far off as to appear insignificant dots. Well-chosen figures in the right position and in good focus give scale and interest to the composition. Otherwise they are a source of confusion.

Know also that the camera, trim and dainty though it may look in its brass fittings and polished rosewood, is destitute of brain power; and that the most expensive lens is only a glass eye capable of a meaningless stare. Any expression of intelligence must come from the man behind it. It is worth while for the beginner to spend hours in studying landscape as interpreted on the focussing screen. He will acquire by this method a knowledge of the limitations of his instrument, and also a habit of close observation which is even more valuable. Masses of light and shade, well disposed, are of more importance than small objects, and in judging this general effect of light and shade it is a benefit in disguise that the picture on the focussing screen appears upside down.

Except for certain architectural subjects, minute definition of detail all over the print is not often desirable. In ordinary landscape the lens should not be stopped down below *f*/16, and *f*/11 is generally better than *f*/16 with the doublet lens.

Clouds.—Nearly all landscapes containing a wide expanse of sky require mitigation by the printing in of clouds, and a stock of cloud negatives to serve on various occasions is part of the work of the landscape artist. Contrary to general opinion, we do not advise that such clouds should be taken from near the sun. It is true that these are often extremely picturesque and brightly coloured, but they give an unreal effect when introduced into the average landscape taken by an operator with his back to the sun. The best clouds are found in the afternoon and low down in the sky, near the horizon. Cirrus and fleecy clouds floating on a blue sky demand the yellow screen (q.v.) or must be snapped very quickly on a slow-process plate. For grey masses of cloud the screen should be dispensed with, and a fast exposure be made with a small stop.

Natural Clouds.—It is occasionally worth while to preserve the actual clouds in the landscape which we are photographing. A sky shade-shutter will give a much shorter exposure to the sky than to the foreground; good results have also been produced with the graded light filter in spite of the severe criticism attending its introduction. Some workers tilt the dish during the latter part of development in such a way that chemical action is retarded in the upper part of the plate. But all these contrivances are only applicable to seascapes, marsh land, or open prairie, where the horizon line is not broken up by trees or buildings. The best plan of all is to expose the plate in the usual manner, and then, without shifting the camera, give a second plate one-fourth

HARTFIELD. NATURAL CLOUDS OF NEGATIVE.

the exposure for the clouds. Both plates will be in the same register, so that the printing in of the clouds will present no difficulty when the features of the landscape have been blocked out.

It is an advantage to employ films for the preparation of cloud negatives. They can then be easily reversed according to the lighting of the picture in which they are to be introduced.

Moonlight Effects.—Most of the so-called "moonlight pictures" are taken by a very rapid exposure to the setting sun when surrounded with clouds. In mountain scenery, or with the sea or a lake in the foreground the illusion is often very skilfully accomplished. Genuine moonlight pictures require a long exposure half an hour and upwards. The luminary herself must not be attempted—that is as part of a landscape. During the period of exposure she will have traversed a considerable part of the plate and her path will be represented by a broad white band.

Night Photography.—Street scenes after dark may easily be taken on a backed orthochromatic or panchromatic plate and, if lighted by arc lamps, the exposure will not much exceed 2 minutes at *f*/8; incandescent gas may require as much as 10 minutes. Figures must be put in afterwards, if desirable at all. The most successful efforts of this kind, however, are obtained by focussing and giving partial exposure during the day time, but not while the sun is shining, or the shadows will spoil the effect. When the lamps are lit a further exposure may be given for, say, two minutes.

For flashlight outdoor pictures the following mixture may be tried, but it must not be used indoors as the fumes are acrid and poisonous:

Magnesium powder	30 gr.
Chlorate of Potash	45 gr.
Sulphide of Antimony	10 gr.

The chlorate of potash must be ground to a powder before mixing; it explodes on friction with other substances in a mortar. Keep carefully in a dry place, and ignite with a long taper at a distance of six feet from the camera or any other person.

Lightning.—The camera must be focussed by scale, at infinity. For sheet lightning the centre of the lens will be pointed at near the horizon with the camera level, as the effect to be aimed at is an illuminated landscape. For forked lightning point the camera upwards in the direction of the storm, including only just enough ground (the top of trees or roof of buildings) to show which is the top of the picture. Remove the cap just before the flash is expected;

a minute too soon is of no consequence, but cover the lens directly the flash is over to prevent fogging by any afterflash.

Water.—Fast flowing streams usually require a very rapid exposure. Still water, unless there are good shadows or knots of reed, either appears as a white patch or muddy and dull. We have found it a good plan to create ripples with a stone upon the surface of the pond just before exposing.

Alpine Scenery and Snow.—The yellow screen is of no service whatever for these subjects wherein form, light, and shade are the chief characteristics. The ordinary maxim, "Expose for the shadows and let the high lights take care of themselves," will not answer above the snow line. According to Mr. Donald M'Leish, who in this class of work has been eminently successful, the contrasts are too enormous. The high lights require much more attention than is usual, and we must rely upon after-treatment for bringing out detail in the shadows. A comparatively small stop should be used. For ordinary winter snow scenes, however, when there are dark tree trunks or cottages in the foreground, a longer exposure may be tried. The best effects are often obtainable towards evening if the weather is not too misty. Trees and shrubs covered with hoar frost must have extremely short exposures; and if the ground is covered with snow the lack of contrast in the distant background will tend to ruin the result. Sometimes it is possible to get the frosted bough against a leaden coloured sky. In fact a "London Particular" is the great opportunity for the seeker after hoar-frost pictures, if he can choose his moment when the mist has begun to lift.

It is worthy of remark that Dr. C. Atkin Swan, unlike most Alpine workers, finds that as a rule his exposures in the higher altitudes are very little shorter than those at sea-level; and he employs a yellow light filter of low multiplying factor.

Choice of Plate.—There is considerable variety of opinion as to the speed of the plate suitable for landscape work, chiefly because it has only been of recent years that plates combining high speed with the other qualities desired have been easy to obtain. Comparing various makers, we find some labelling a plate "landscape" which is only marked as of rapidity 40 on the Hurter and Driffield scale. Others recommended for the purpose by their manufacturers vary from 100–200. What we need is a plate giving a considerable amount of gradation and latitude, with medium rapidity. Very seldom in the course of the year does a day occur when the air is quite still. At least there will be a light breeze stirring the foliage, and prolonged exposures are undesirable. Beginners may be content with a plate marked at rapidity 100–125, and then, when they graduate in the use of the yellow screen, adopt the isochromatic high-speed types, which can be used for short exposures almost throughout the year. We would not discourage the learner who cares to practise with the slow photo-mechanical plate which will allow of lens caps exposures with a large stop, and can be manipulated in the dark room under yellow light. He will then tread in the steps of his fathers, with a plate capable of giving almost the same effects as the old wet plate.

Halation.—In photographs of the interior of buildings a window facing the camera is often found to be surrounded by a misty white fog which obscures its form, sometimes rendering its details invisible. This phenomenon is termed halation, and is caused by the bright rays of light reflected upon the sensitive film from the back of the dark slide, after passing through the glass support. In certain conditions of light, halation will occur also in outdoor pictures, especially where trees and roofs stand out in sharp contrast against the sky. To avoid this disfigurement the dark slides must be packed with cartridge paper stained a dead black with Stephens' Ebony Stain, or better still the plates may be "backed." The makers supply most brands ready backed at a slight extra charge, and some receipts for backing will be found amongst our miscellaneous formulæ.

J. Craig Annan.

THE WATERFALL.

[p. 71

CHAPTER IX

THE LAWS OF PICTORIAL COMPOSITION

ALTHOUGH we are concerned in this chapter entirely with what are generally spoken of as the "laws" of composition, we must warn the reader, at the very beginning, against the danger of overestimating their importance. A short time ago, at the conclusion of an address upon this subject, the President of a photographic society dolefully declared that in future he should be positively afraid to take a photo for fear of breaking the "laws" we had referred to.

Let us say, then, emphatically, that no work of art can be produced in blind obedience to law, however good such laws may be. "Laws were made for slaves." If, after much practice and many honourable failures, you do not come to know what to do instinctively, without thinking about any laws, you might as well turn your attention to some other subject better suited to your natural abilities or, at any rate, pursue photography for purposes other than pictorial. Besides, many if not all the laws of composition are being constantly broken with complete success, while pictures made in abject fear of the rules always look it—trammelled, conventional, made-up.

Mr. Craig Annan's picture, "The Waterfall," is a capital case in point. Astonishingly beautiful, it treats all the rules with perfect contempt. Its qualities wholly depend upon Mr. Annan's powers of perception and taste. Very few artists, with their almost unlimited opportunities of rearranging the subject, could have expressed so much sheer loveliness. That is what cannot be explained. That is above and beyond all rules; that is Art.

This, of course, is not an argument in favour of ignorance, but it is a very necessary warning lest theoretical principles are allowed to become masters rather than servants. The golden rule in art, to which there can never be any worthy exception, is this: Do as you like; go on doing as you like, and eventually, if it is in you, your appreciation of the beautiful will come out in your picture.

A word concerning the history of these laws will emphasise the point. Few people seem to realise that practice comes before theory. Laws, after all, are only generalisations upon facts. It was constantly observed that in the majority of great pictures the same things were invariably done, and theories were advanced to account for these facts. The theories proved to be so workable that they have been adopted as principles. It very often happens that the artist is quite unconscious that he is obeying any laws. He is doing what he likes. Ruskin discovered the principles upon which Turner's pictures were based. Turner is said to have remarked that Ruskin seemed to know a great deal more about the pictures than *he* did! The theories had followed, not preceded, the practice. But there the principles are, and providing they are not allowed to unduly obtrude themselves they should be completely understood.

Repetition.—A composition is an arrangement—a bringing together of the parts in an orderly manner so as to produce a unified whole. The simplest and most elementary form of

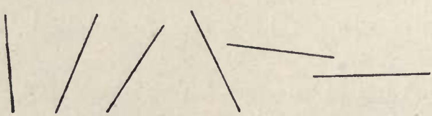


FIG. 27.

arrangement is repetition—the association of like things. Here (Fig. 27) are some straight lines. They are not in the least associated. Each lies in a different direction.

In Fig. 28 one of these lines (the upright one) is repeated. All the lines are the same length and upright. They are at equal distances from one another and that distance is equal

FIG. 28.

to the length of the lines. That is the simplest possible form of repetition. There is order, if nothing else.

Variety.—But the eye quickly tires. It always begins by associating like things; then it looks for differences. It desires variety as well as repetition. In Fig. 29 the want is somewhat satisfied. There is just as much repetition as

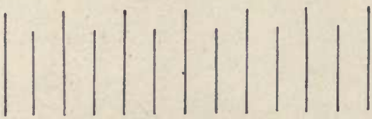
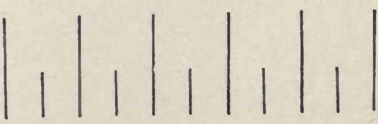


FIG. 29.

before, but in addition we have an alternation of long and short lines, and the distance between the lines is different from the length of either. Without any return to disorder an increase of interest has been created.

Contrast.—In its turn this, too, fails to satisfy. It is weak and inconclusive. Fig. 30 does something to remove that impression. Variety is intensified into contrast. The differences are more decided. With no loss of association or interest there is a gain in strength.



Concentration.—Once more interest is short-lived. The pattern lacks purpose. It might go on for ever without any object. So Fig. 31 brings into the composition the great unifying principle, Concentration:

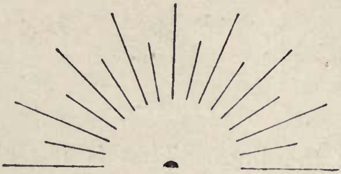


FIG. 31.

All the lines now converge, so that, if produced, they would meet at one point. That is their purpose—to direct the eye to a point of rest.

The Laws Applied.—Now to apply these principles to landscape. The accompanying sketches illustrate what we mean. Fig. 32 is about as helpless and unpicturesque as could

FIG. 32

well be imagined. The four "lines"—viz. the contour of the hill, the path across the field, the trunk of the tree, and its shadow on the grass, all go in different directions. The result is complete confusion. The eye cannot rest anywhere, because it is being constantly dragged away from any one part to nowhere in particular by one or another of these disconnected lines.

If nothing else can be said for it, Fig. 33 contains some

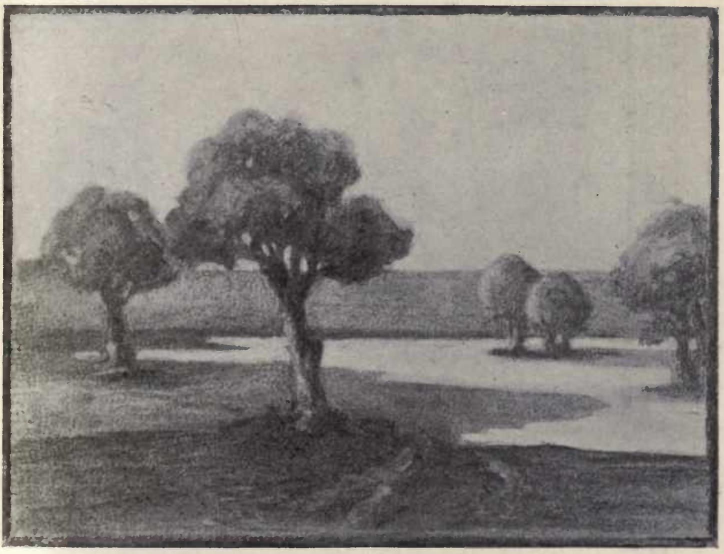


FIG. 33.

evidences of order. The same kind of tree is repeated, and their direction (upright) is also similar, thus repeating the upright sides of the picture. The distant parts of the landscape now consist of more or less horizontal lines, repeating top and bottom of the picture: there are two almost parallel paths, while the outlines of the shadows have a good deal of similarity. The differences in the sizes of the trees mean the inclusion of some variety. But the improvement of Fig. 33 over Fig. 32 is almost entirely due to repetition. Still, the result is decidedly dull.

Fig. 34 is undoubtedly better. There is a deal of difference in the shape as well as the size of the trees. The principal one is not so near the middle of the picture. The horizon has been lowered, so that the two parts of the picture which it divides are less equal. The background has been lowered to give a greater effect of distance. All this, together with the introduction of several and varied clouds, give a distinct

FIG. 34.

effect of interest, movement, and vivacity. Such is the influence of variety when allied to repetition.

In Fig. 35 everything is sacrificed to obtain the most powerful effect of contrast. The principal tree has been made much larger, and, together with the strip of dark foreground, stands out in bold relief against the rest of the picture, which has been made relatively small and faint. The horizon has been lowered still more to give most positive difference between the size of sky and ground, and to make the tree look higher and more imposing. Undoubtedly the effect is striking, but the game is given away—all the means by which the result is achieved are evident at a single glance. The picture has only one thing to say, and says it with a shout.

Fig. 36 combines all the foregoing principles without making any one of them unduly prominent, and is clearly superior to any of the other sketches. To use a phrase

FIG. 35.

common among artists, it has been "pulled together." Everywhere there is a sense of arrangement without it being too obvious. The large tree is still the most prominent feature at the first glance, but the real centre of attraction is the little group consisting of a sunlit cottage and trees enclosed by light clouds. To this part all the lines of the picture are directed—in particular the paths, the wedge-shaped mass of trees on the left, and a branch near the top of the large tree. The great change which has been brought about is due to concentration.

Subtlety.—So the process is very simple: repeat, vary, contract, concentrate, and the thing is done—a work of art! Sad to say, it does not follow. If the picture has been thus mechanically made and contains nothing else, it will be no more a work of art than my diagrams. Because the means by which it has been produced will be perfectly obvious, and the obvious in art is always the sorriest blunder. You lose the game when you lay your cards on the table.

FIG. 36.

All other things being equal, the beauty of a picture is in proportion to its subtlety.

"That is all very well," we fancy you will say, "for the artist who can do what he likes with the scene in front of him; pull down churches, sweep away mountains, grow trees, or build bridges as his fancy may dictate. A big stone in the foreground, or a telegraph pole in the middle of the view would make an otherwise eligible view impossible for the photographer—a painful fact, and must be accepted.

But, on the other hand, there is much to choose from, and, in the hands of those who possess the necessary taste and skill, a great deal can be done between the squeezing of the bulb and the mounting of the print. Anyway, the following suggestions should do something to lighten the undoubtedly heavy load of difficulties.

Choose, for preference, a simple subject. Resist the ever-present temptation to "get in" this or that, because it happens to be interesting in itself. You are not out to secure an illustrated record of a place, but to make a picture. In fact, don't think of what is in front of you as a place at all. Regard it simply as a combination of line, light, and shade. Your highest aim should be to express an emotion rather than to represent a place. A cathedral in unsuitable light and with unsuitable surroundings would make an execrable picture, while, in a favourable light, and in a satisfactory position, it would be possible to get a superb result from a pigsty.

By a simple subject we do not necessarily mean a subject with very few objects in it, but a subject containing simple masses of light and shade. A huge city, making one mass of shade against a light sky, would be more simple than a village street, cut up with bright lights and dark shadows.

Choose a subject having some feature (that is to say, feature of light or shade), more prominent than the rest, and to which the other parts are pleasantly related. As a rule, if this feature is comparatively near, focus upon it. If it is not sufficiently important in nature for your purpose, use the utmost resources of the camera to make it so. At all times have no concern for the mechanical exactness of the machine when it interferes with the perfection of the artistic result. And never fall into the fatal error of regarding nature as too perfect to be manipulated. Nature has no patience with those who grovel abjectly before her.

Remember that the camera is not human, that it has no taste, and that it sees more as if it were a fly with a million eyes. The "sharp" negatives, so beloved of the photographer plus nothing, are as much evidences of the ignorance of the manipulator as of the perfection of the machine. Make the result as nearly as possible as *you* see it, while looking in one direction, usually in the direction of the principal feature. If you do this you will see the view as a whole without being irritated by a mass of complicated details. But if you give a thousand separate glances at a thousand different parts of the scene you will see it in much the same way as the camera, but the sum of these glances will not give you a good picture. As likely as not it will give you nine hundred and ninety-nine bad ones.

This, we know, is the bone of contention, over which photographers are divided into two opposing camps—the manipulators and the artists. The manipulator's objection is well exposed by the word "fuzziness"—the deliberate blurring of certain, or it may be all, parts of the picture. In many cases, we unhesitatingly admit that the objection is completely justified. One generally finds a few examples of the kind referred to, in most photographic exhibitions—combinations of meaningless blurs with wildly sentimental titles. But they do not constitute an argument in favour of uniform sharpness; they merely show that the perpetrators of freak photographs do not know what the artists are aiming at. The artist looks at a scene and gathers certain impressions. He tries to record these impressions—that is all. Finding that the camera cannot achieve his object unaided he comes to its assistance. He is quite fearless; he will stop at nothing in order to attain his object. Now that object is generally attained by blotting out a considerable amount of detail that the unimpressionable lens will, if left to itself, inevitably record.

For a long time past we have been trying to discover exactly why the manipulators still object, in spite of the perfectly plain reasons which the artists give for their method of procedure, and have only quite recently discovered it. A member of the former school put the point of view in the following words:—"I quite agree that a certain amount of

T. M. Weaver.

FAR FROM THE MADDING CROWD.

p. 80]

obliteration of detail makes a photograph more like a picture; but what satisfies me in a picture does not satisfy me in a photograph. I expect something else in a photograph." That puts the matter in a nutshell. The two schools have different aims, and set up different standards. Very well; let each go in its own chosen direction, realising that the other is bound for another destination. If the manipulator aims at securing all that the most delicately constructed camera can be made to record, let him get the finest possible machine, become a complete master of every technical intricacy, and go on his way rejoicing.

There remains another argument, or, rather, it is the same one put in a more subtle way. It is this: that there are some things which the camera can do better than (to quote Mr. Bernard Shaw) "that clumsy instrument, the human hand." Therefore, it is argued, the special province of the camera is to concentrate upon those things in which its powers of execution are naturally superior. Very seductive but very shallow. In the first place, in what way is the camera superior to the hand? We have heard it said, in the rendering of tone values. That is not so. It is quite true that in many cases the artist cannot get perfect tone values, because the range in Nature is greater than in pigments—the contrast in Nature, between the highest lights and the deepest darks is often greater than the difference between white and black paints. How does that fact demonstrate the superiority of the camera? The photographer has nothing but pigments to print with!

But what about the rendering of detail? Even there the human hand could do it, if necessary, though of course with infinite pains. But why do it, when it inevitably spoils the picture? The argument, you see, is just the same as the former one. What the objectors want is a photograph, not a picture. Well and good; let them get what they want. But they really must not call it Art!

One more suggestion. Regard as an essential part of your education visits to picture galleries. Whenever you get into difficulties with any particular part of your pictures (you are certain, as all painters are, to find foregrounds the bugbear) go and notice how the artist tackles the problem, and then see to what extent you can do something of the same kind.

Finally, beware of prejudices in Art. Preferences we must have or fail, but prejudice—the artist's besetting sin—results in nothing but blindness and stagnation. Shun as though he were plague-stricken, the man who speaks of every new thing as the work of a crank, and upon whose lips is ever that blessed word "legitimate."

The delightful photograph by Mr. T. M. Weaver, "Far from the Madding Crowd," illustrates what we have been driving at far more admirably, because with more subtlety, than the sketches. Let us analyse it. First as to Repetition. There is the large arch echoed on the left-hand side by two small ones; the large one alone would have been unbearable. A painter would probably have brought them farther into the picture and made them rather large. Then there are the three trees leaning inwards and almost parallel. But there is no unpleasantness, because the trees vary so much: one is leafless; another has the stem considerably broken up with foliage; and the right-hand one is nearly lost. Also the tone of each is slightly different. Still, they would have given a nasty "lean" to the picture were it not corrected by the many upright lines, notably of the large window and the lamp-post. The prominence of the large arch would have made one's eyes swirl round at the top of the picture, but this again is counteracted by the horizontal lines which have an admirable steadying effect. Notice, too, how aptly the rays of light are broken by a branch of the left tree running firmly across it. Just here there is a piece of charming subtlety displayed. See how the line of that branch is continued by the foliage lower down on the left-hand side, directing the eye towards the little archway, and clustering at the back of the lamp so as to take away its geometric shape. But the picture is perhaps most notable in its contrasts of light and shade. The dark shadow of the near arch greatly enhances the soft atmospheric effect of the rest, while the quiet, low tone of the house gains immensely by being contrasted with the dancing lights on the ground, and particularly on account of the bright lights on the seated figures. The concentration is altogether happy. Those long rays of light would have been distressingly obvious, if they had been strongly marked, and if there had been no other concentrating lines. But there are the joints in the stonework of the arch, the positive line of the principal tree, and (happiest touch of all) the shadow of a branch trailing across the pavement, all leading the eye gently but inevitably to the figures, which, though exceedingly small, thereby become the essential feature of the whole picture.

CHAPTER X

OUTDOOR PHOTOGRAPHY: EXPOSURE

WE are now ready to insert in the camera the dark slide (duly loaded with plates film side outwards), and to withdraw the shutter. Dark slides containing plates should be protected from the direct rays of the sun, and it is a good rule to keep the focussing-cloth over the back of the camera and slide during exposure. Now the delicate question arises, for what length of time shall we expose the plate?

Ninety-nine out of every hundred photographers believe that they are born with a heaven-sent faculty of judging the time of exposure without the aid of meters or artificial calculations, or at least that they can correct any error in exposure during development. And we must admit that this faith is apparently justified in their works. We know of men with the experience of many years who are daily exposing several plates under all kinds of conditions—interiors, groups, portraits, and landscapes—and they invariably obtain results of technical excellence. The real truth is that modern dry plates permit of enormous latitude. There is a certain minimum exposure for each subject. Any period exceeding that minimum up to possibly thirty times will produce a negative in some degree representative of the subject. An example of this is shown on the page opposite. No. 1 of the two plates received $\frac{1}{15}$ sec. exposure; No. 2 received 1 sec. in each case at *f*/16. They were taken on a roll of Ensign film, which was passed through a pyro developer for 4 minutes, and then fixed and finished off without any separation of the views. Had No. 1 been

EXPOSURE $\frac{1}{16}$ SECOND.

EXPOSURE 1 SECOND.

allowed to remain in the developer for two minutes, and No. 2 treated as an over-exposure with additional bromide, the difference between them would have been more difficult to gauge. As it is, No. 2 takes twice as long in printing as No. 1. The differences between the prints have almost disappeared in engraving.

But these casual methods of working are not satisfactory to the serious worker. It is necessary to know as nearly as possible the *normal* exposure for our particular view. We may vary it considerably, but we shall do so with deliberate motive, for it is in the variation of exposure that we can exercise more control than at any other stage over the ultimate result. Herein the artist can rise above the mere mechanic.

Normal exposure depends upon three principal factors:

(1) The lens and its diaphragm.

(2) The speed of the plate.

(3) The quality of light available.

And we might add a fourth, the distribution of high lights, half-tones, and shadows over the picture. For instance a picture consisting entirely of high lights, such as clouds, may only require about one-sixth the exposure given to an ordinary open landscape.

The Lens.—As a general rule, with each stage that the aperture of the lens is reduced the exposure must be doubled. The stops marked on most lenses are respectively *f*/6·5, *f*/8, *f*/11, *f*/16, *f*/22, *f*/32, *f*/44, and *f*/64. If we take *f*/8 as our standard, then for *f*/11 the exposure must be double, and for *f*/16 fourfold. Some high-class lenses are naturally much more rapid in action than others of lower market value, but this difference is more apparent in dull weather than when the light is good.

Speed of the Plate.—Most makers stamp their plates with a number showing the actual degree of sensitivity of the batch, obtained by the Hurter and Driffield test. But the accuracy of the standard in comparing the speed value of various plates has been brought into question. Were the

Hurter and Driffield method always applied with the same standard light by each maker, it would be enough to regard the speed number given as deciding this factor. In practice it is *fairly* correct. Most of the pocket exposure books provide a list brought up to date of the plates and films on the market, showing their actual speed as tested by independent means. A simple way of testing the speed value for our own purposes is to choose a view in which the features and lighting are well balanced, say a row of elm trees in the middle distance. The camera must be clamped tightly to a table or a stand rigid enough to remain firm while the dark slide is manipulated. The horizontal picture will be the one required.

On looking at the exposure table on p. 91 we find that the normal exposure given for the particular conditions of light is, say, $\frac{1}{15}$ sec. Withdrawing the slide-shutter, we expose for half that time, or $\frac{1}{30}$ sec.; then, replacing the shutter of the slide over one quarter of the plate, we expose again for another $\frac{1}{30}$; pushing it in again to halfway, a third exposure is given, and then a final, with the result that we have secured on one plate a record of four exposures for $\frac{1}{30}$, $\frac{1}{15}$, $\frac{1}{10}$, and about $\frac{1}{8}$ sec. respectively. On developing these for a fixed time we shall be able to decide from which of these exposures we can obtain the relative factor for this brand of plates.

Quality of Light.—The chemical intensity of the light is, unlike the other factors, a variable one, and quite independent of the will of the operator. Conditions of atmosphere, geographical latitude, and the season of the year have to be considered, as well as the altitude of the sun above the horizon. The most intense light is present on a sunny, clear day for about an hour before noon; afterwards the evaporation caused by the heat of the sun intercepts a portion of the light. The lower the sun is in the heavens, the thicker and denser the layers of atmosphere through which his rays have to pass. Clouds and mist seriously decrease the amount of available light; dull, heavy clouds reduce it sometimes to about one-eighth that of a clear day at the same time of year.

Actinometer.—A simple actinometer for measuring the chemical intensity of light at a particular time may be devised as follows: Soak a piece of bromide paper of any good make in a 10 per cent. solution of potassium nitrate. This operation and the subsequent drying must, of course, take place in yellow light. Take a manilla thick envelope and cut a small hole about ½ inch square in one face of it. Expose a slip of this specially prepared paper to reflected light for a period sufficient to give it a definite blue tint, then with water-colour or pencil surround the square aperture with a border exactly matching this tint. A constant fraction of the time which the sensitive paper takes in reaching the tint will be the exposure required.

To use this actinometer we must first get a standard exposure. Suppose that on a certain day we find that the paper takes two minutes to reach this tint, and that the correct exposure at *f*/16 is found to be one second. From these data we can write a memorandum as follows in the outside of the cartridge envelope.

Time of exposure per minute taken by the paper in reaching tint, given in seconds:

f/5·6	$\frac{1}{15}$ sec.
f/8	$\frac{1}{8}$ "
f/11	$\frac{1}{4}$ "
f/16	$\frac{1}{2}$ "
f/22	1 "
f/32	2 "

This is a very rough-and-ready form of actinometer, but quite sufficient for ordinary practice. There are many excellent instruments of more convenient and durable form to be had at low prices, and they contain a very large amount of information helpful to the student. Actinometers should not be exposed to direct sunlight, because detail in the shadows is the chief aim in most exposures; just within the shadow of the operator himself will suffice.

Exposure Tables.—These must always be calculated for the latitude of the place, the variation at different times of the year not being constant. For instance, according to Spitaler's Tables the intensity of the light during the month of January at 40° and 50° latitude differs as 80 : 22 ; in April as 361 : 288 ; and in June only as 469 : 432. The observer should keep an exposure diary in which the time, nature of subject, and character of the light are carefully noted down for future guidance.

The following tables are only intended as a foundation for the reader to work upon. They represent the experience of some years, and are calculated for a plate registering about 125 on the Hurter and Driffield scale. The time given is the lowest at which detail in the shadow can be secured at *f*/8 when photographing a landscape the foreground of which is well lighted. (Latitude that of Southern England, or 51° 30′.)

Except in dull wintry weather, half these exposures will often suffice for a passable negative. Subjects containing excessive contrast should have a good exposure ; those having few shadows and plenty of half-tones require considerably less. The nearer the object is to the lens, the longer the exposure necessary to give it prominence.

Authorities differ as to the effect of east wind and rain upon the time of exposure. Some contend that a drying wind increases the intensity of the light, because it tends to remove the aqueous vapour which otherwise would intercept a portion of the rays ; others insist on a shorter exposure when the atmosphere is very moist. In practice we have found that with a moist atmosphere the foreground requires a much longer exposure : the background gains in illumination owing to the light reflected by the moist particles in the air. This applies to sea and lake pictures as well as to lucid intervals in wet weather.

Lighting.—Brilliant sunlight does not always produce the most artistic picture ; the gradations are softer and clearer in diffused light. It is rarely advisable to take a picture

	Jan., Feb., Nov., Dec.				March, Sept.				April, August.				May, June, July.				October.			
	A.	B.	C.	D.	A.	B.	C.	D.	A.	B.	C.	D.	A.	B.	C.	D.	A.	B.	C.	D.
7 to 8 .	—	—	—	—	—	—	—	—	1/25	1/15	1/10	1/5	1/35	1/25	1/15	1/10	—	—	—	—
8 to 10.	1/5	1/2	1	—	1/25	1/15	1/10	1/5	1/30	1/25	1/15	1/10	1/50	1/35	1/25	1/15	1/15	1/10	1/5	1/3
10 to 2 .	1/15	1/10	1/5	1/2	1/40	1/30	1/25	1/15	1/50	1/40	1/30	1/15	1/75	1/50	1/35	1/25	1/30	1/25	1/15	1/10
2 to 4 .	uncertain				1/25	1/15	1/10	1/5	1/30	1/25	1/15	1/10	1/50	1/35	1/25	1/15	1/15	1/10	1/5	1/2
4 to 5 .	—	—	—	—	—	—	—	—	1/15	1/10	1/5	1/2	1/30	1/15	1/10	1/5	—	—	—	—
Midday	1/25	1/10	1/5	1/2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

A.—Bright sunshine.

B.—Light clouds on blue sky.

C.—Diffused light, or light heat-mist.

D.—Dull.

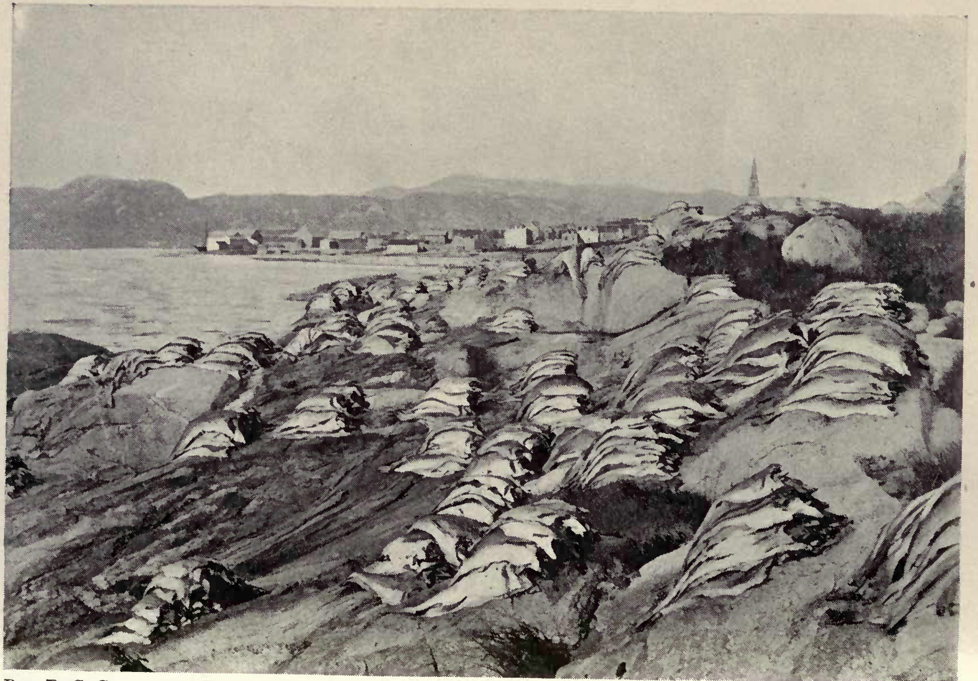
For very dull weather and dark clouds double the exposures for dull.

The afternoon light in winter is of small actinic value, and exposures in the afternoon should be rather longer than those in the morning between 8 and 10.

Detailed Foreground	Double the above exposure.
Dark Foreground	Four times the above exposure.
Seascapes	About one-fourth the above exposure.
Clouds	About one-eighth ,, ,,
Glens, and Woods with no open foreground .	About eight to ten times the above exposure.

against the sun, i.e. with the lens pointing towards the sun in such a way that it has to be shaded to prevent the fogging of the plate. If the light is directly behind the operator, the shadows will tend to be tame and flat. Lighting at an angle is the best for the average picture. A very good general idea of the lighting of a scene, and of how it will look when the colouring is lost on a monotone silver print, will be got by examining it through a square of blue glass.

Maxims for Practice.—Expose for the shadows ; never mind the high lights. When in doubt, over-expose.



Rev. D. G. Cowan, M.A.

COD DRYING WITHIN THE ARCTIC CIRCLE, NORWAY.

CHAPTER XI

DEVELOPMENT OF THE NEGATIVE

SOME thirty years ago, when photography was not very widely understood of the common people, we were passing through the usual ordeal at a *douane* on the German frontier. One luckless tourist had amongst his luggage several boxes of exposed plates; these were ruthlessly opened to the light of day, lest perchance some contraband article might lie concealed between them. The victim protested bitterly about the destruction of his work, and vowed that he would exact heavy compensation from the authorities. The official merely shrugged his shoulders with the remark: "You talk about your pictures; these plates have nothing whatever on them!"

For, when we return once more to the dark room, and examine the plate taken from the camera, it has apparently undergone no change whatever. There is no difference visible between it and the other plates left in the makers' box. An image has been impressed on the creamy surface during the fraction of a second that the rays of sunlight have been admitted, and will remain there for many years if protected carefully from moisture and light. One instant of exposure to daylight will blot it out for ever. No mortal eye will ever see it unless the plate undergoes development in some reagent capable of translating the subsalts into metallic form.

For most of us, development is a process having a charm of its own, an ever-recurring species of romance. We watch our picture, hitherto seen only by the eye of faith, grow gradually from a few faint blurs into full outline and substance. We are conscious of a magical power which has somehow evolved this portrait of our friend, or this study of nature, as it were out of nothing. We can ill spare this source of pleasure; and so, in spite of the fact that many of the advantages once supposed to belong to dish development have been proved to be illusions, the old-fashioned method is likely to die hard.

Composition of Developers.—A developer consists of (1) the reducing agent or developer proper, (2) an accelerator, and (3) a restrainer. The developer itself, being a strong absorbent of oxygen, must, while in solution, be associated with a preservative, usually sulphite of soda, which also serves to prevent stains.

Accelerators.—The majority of developers in common use have an alkaline reaction, and the accelerator employed with them is an alkali, such as potassium hydrate, sodium hydrate, sodium carbonate, or ammonia. The purpose of the accelerator is to set up and maintain the chemical and electrolytic action. Chemically, the alkali combines with the bromine or chlorine of the image to form the corresponding bromide or chloride salt. It was formerly supposed that an excess of the alkaline accelerator reduced contrast in an under-exposed plate, and would "force up" the details of the image; better experience proves that the only result is "fog" over the whole surface.

In certain non-alkaline developers sulphite of soda acts as an accelerator; and with ferrous oxalate the accelerator, hyposulphite of soda, is recommended for a different purpose, viz. the removal of the incidentally formed ferrous salts, which would otherwise retard progress in development.

Restrainers.—The effect of the restrainer, either a bromide or citric salt, is to increase contrast by restraining the action of the developer; this influence will be most marked in the lower tones, those parts which have been least exposed to the action of light, and it is therefore a partial corrective of the faults of over-exposure. With normal exposures no bromide ought to be necessary, or, at least, very little; and in practice we prefer to keep a 10 per cent. solution in a dropping-bottle near at hand, ready for addition to the developer when occasion arises.

Process of Development.—All developers do not act in quite the same way, and we will therefore describe as the typical one, "pyro-soda," variations from this type being noted under the heads of the respective developers. Two solutions will be prepared marked A and B. A consists of pyrogallic acid with its preservative, B of the alkaline accelerator.

Into a glass measure pour 1 oz. of A and 1 oz. of B (cautious workers commence with only a half-quantity of B, adding the remainder when the details of the image have appeared). Two oz. of liquid are sufficient for a quarter-plate, in a *flat*-bottomed dish, and 4 oz. for a half-plate. Do not be niggardly in the use of developer. It is cheap enough if the worker makes up his own solutions.

Lay the plate, film upwards, in the developing dish and pour the solution in a flood over it, so as to ensure it being covered all over at once with as few bubbles as possible. Then rock vigorously backwards and forwards for a few seconds, to remove air-bells. Within about a minute, if the exposure has been correct, the image will begin to appear as a faint discoloration which will be recognisable as the sky in a landscape; or in a portrait the white collar, face, and hands. These high lights go on darkening and become more defined as black patches, and then, still by degrees, the half-tones assume a grey colour, till at last we can recognise all the chief features of the scene, only with the lights reversed. If the plate were to be removed from the developer at this point the image would be so faint as to be of no value whatever; it must remain for a further period, during which, by electrolytic action, the unchanged molecules of silver salts continue to be reduced till the image has penetrated well into the film towards the back.

Under-exposure.—On the other hand, if the image fails to make its appearance, and the full amount of alkali has been added, we must decide that the plate is under-exposed, and therefore not worth troubling about. But if the subject is irreplaceable, and we are content to have a very inferior result rather than none at all, the dish is covered over, say, with a lidless cardboard box of sufficient size to touch the table all round, and so form a thorough protection from light. We may examine at intervals of ten minutes; but if after half an hour a satisfactory image is not well on its way to completion, hope must be abandoned. No means exist of reinforcing a developer to enable it to define detail on an under-exposed plate.

Over-exposure.—If a plate is suspected of being over-exposed 10 drops of bromide should be added to each ounce of the developer before it is poured over the plate; and if the image flashes out quickly the solution must be returned to the measure, and a further quantity added. Some workers, on finding after commencing development that the image flashes out at once instead of gradually, and is therefore over-exposed, remove the plate at once into a weak solution of ammonium citrate (5 grs. to the ounce), and after about a minute wash and replace in the developer. Others wash the plate under the tap, and replace in the developer to which three times the amount of bromide has been meanwhile added. Unless the over-exposure is very serious it need not occasion anxiety, as the resulting negative will print well enough after treatment in a reducing bath. The great mistake of beginners is to *under-develop* over-exposed negatives.

When Development is Complete.—Most classes of plates may be allowed to continue in the developer until the lines of the image are plainly visible on the glass side; but with some thickly coated plates the image never penetrates completely through the film. Another test is the commencement of "fog" on the white margin left by the rebate of the dark slide. When held up against the ruby lamp the sky and other portions which are to appear white in the resulting print should be approaching a solid black, and the details in the shadows well marked.

Factor for Timing Development.—Mr. Alfred Watkins, the inventor of many valuable instruments for securing exactitude in exposure and development, has prepared a table showing the factor necessary to calculate the time when development reaches a degree found by trial to give a sufficient amount of contrast. To use the table, multiply the time which elapses between the immersion of the plate and the first appearance of the image. Thus, if the image when we are using a pyro developer 5 grs. to the ounce appears in 45 secs., development should be complete in just under 5 minutes.

	Factor.
Adurol	5
Amidol (2 gr. per oz.)	18
Diamidophenol	60
Diogen	12
Edinol	20
Eikonogen	9
Glycin (carb. soda)	8
Hydroquinone	$4\frac{1}{2}$ to 5 [1]
Pyro Soda (1 gr. to oz.)	9 to 18 [2]
,, ,, (4 gr. to oz.)	4, 8 [2]
,, ,, (5 gr. to oz.)	$3\frac{1}{4}$, $6\frac{1}{2}$ [2]
Imogen Sulphite	6
Kachin	10
Metol	30
Metol Hydroquinone	14
Ortol	10
Pyrocatechin	10
Quinomet	30
Rodinal	40

Controlling Development.—We have seen that the restrainer increases contrast; we can *diminish* contrast by diluting the developer. Dilution renders the action slower, and incidentally gives the ehance for more detail to appear in the shadows before the high lights have become too dense, and so a softer negative can be obtained. With the normal solutions, if a plate is removed from the developer before the usual time, the contrasts will be very great, and the

[1] The latter figure with minimum amount of Bromide

[2] The latter figure without Bromide.

prints show only ghostly high lights; longer development improves the shadows and gradations; very long development still further levels matters, till in the end the shadows are so filled up that printing becomes well-nigh impossible.

Temperature.—The normal temperature for solutions is 65° Fahr. In hot weather developers should be used much weaker than the usual strength, and in cold weather some means of keeping the dark room warm is very desirable. Some developers—quinol and ortol especially—will work very slowly at a low temperature, and at 55° action practically ceases. But it is a mistake to warm the developer unless the fixing bath and washing water can also be raised to the same temperature.

Fixing Bath.—When development is adjudged complete the plate should be washed in three changes of water, and may then (except in hot weather, or when the gelatine edges show much frilling) be transferred direct to the fixing bath consisting of hyposulphite of soda and water in the proportions of 4 ozs. to the pint. It is an old-fashioned practice to add a few drops of ammonia to the hypo bath. After 5 minutes' immersion in the hypo bath the negative may generally be examined by daylight without serious injury, but fixation will not be complete for at least 10 minutes, or about 3 minutes after all traces of the white bromide of silver have disappeared at the back of the film. The same hypo solution can be used again and again for fixing plates until it becomes discoloured or fixes too slowly; the bottom of the dish must be frequently sponged to remove the black precipitate which collects there. Large firms and clubs collect their stale hypo in a barrel, the contents of which are periodically evaporated, and the residues sent to a refiner, who recovers the silver.

Acid Fixing Bath.—Many workers prefer to the above alkaline bath Prof. Eder's acid bath, which is considered to give greater clearness and brightness. Mix tartaric acid solution (1 to 2) $\frac{3}{8}$ oz. with sodium sulphite solution (1 to 4) $1\frac{1}{4}$ oz., and then add the mixture to each pint of the ordinary hypo bath. Another very good one is made by adding ½ oz. of potassium metabisulphite to each pint of hypo solution.

Washing the Negative.—On removal from the fixing bath the plate is well rinsed under a tap or in several changes of water, and must then lie either in a washing tank or in running water for several hours to remove the last traces of hypo from the film. Hypo left in the film will not only lead to spots, stains, and premature fading of the negative, but may injuriously affect the printing papers placed in contact with it. Or, after an hour's washing, it may be placed in a clearing solution consisting of alum 1 oz., citric acid ½ oz. (or nitric acid 20 drops), water 10 oz. Five minutes will suffice for this before a final washing under a tap, when the plate may be put away in a rack or some other secure place to dry.

Hypo Eliminators.—To obviate the prolonged washing of the negative several preparations have been suggested. Peroxide of hydrogen in a very weak solution, 1 dr. to 10 oz. of water, is one of these, and in such proportions will not injure the image very seriously. Another is percarbonate of potash 25 gr., water 10 oz. Easier than these, and quite as reliable, is to wash the negative (after a rinse under the tap) in five changes of washing water, to each of which just enough permanganate of potash solution or Condy's Fluid has been added to turn the liquid a faint pink. The caution must be given that all hypo eliminators are strong oxydisers, and the greatest care is necessary that they only reach the film after proper mixing, and in the very dilute form recommended.

Drying Negatives rapidly.—That negative has the best chance of turning out satisfactory which is allowed to dry naturally at an even and moderate temperature. But if prints are wanted in a hurry, blot off superfluous moisture with hard hairless blotting paper, or dab with cotton wool, and then flood with good quality methylated spirit. Five minutes will be sufficient for the plate to remain in the spirit. A safer method is five minutes in the formaline bath, the usual proportions being formaline 1 oz., water 20 oz. Afterwards dip in water for a minute, drain off, and if necessary dry near the fire or a foot above a gas flame, keeping it in motion by a swinging movement of the arm.

Frilling.—In warm weather the formaline bath is always advisable, and if signs of frilling appear may be introduced before fixing. The alum clearing bath is sometimes employed to prevent frilling after development and before fixing; but, if so, careful washing is necessary, as alum in contact with hypo produces an insoluble precipitate.

Celluloid Films.—Cut films require a deep dish owing to their habit of curling up and becoming unmanageable. Some films behave so shamefully during development that they must be enclosed in metal or ebonite rims to prevent uneven markings.

Roll Films.—Attach a strong spring clip to each end of the roll for the purpose of handling. Pass the film backwards and forwards through a tray of cold water for about a minute, rendering it equally wet and supple all over without any traces of bubbles or missed edges. Now the strip of film may be transferred to a deep developing dish ready filled with solution, where the same process is repeated, taking care that the film is drawn through with an even motion from end to end and well covered. When the images begin to appear each picture may be cut apart with a pair of shears and developed separately, but, except in cases of obstinate under-exposure or over-exposure, we prefer to keep the roll intact until development is complete, as shown by the appearance of the image at the back or any other test, when the film may be washed in a trough and transferred to the hypo bath to fix at leisure. Most films frill and blister terribly in warm weather, when the first soaking should be in a bath of formaline 1 oz., water 20 oz. Formaline does not interfere with development, but rather increases brilliance and crispness.

Choice of a Developer.—We may accept the conclusion of modern investigators that all developers tend ultimately to reach the same relative gradation of density. But they do not travel by the same road. Some are much slower than others; in some the half-tones appear simultaneously with the high lights; in others the high lights appear long before any other detail is visible. Experience teaches that with certain particular developers it is more easy to secure the

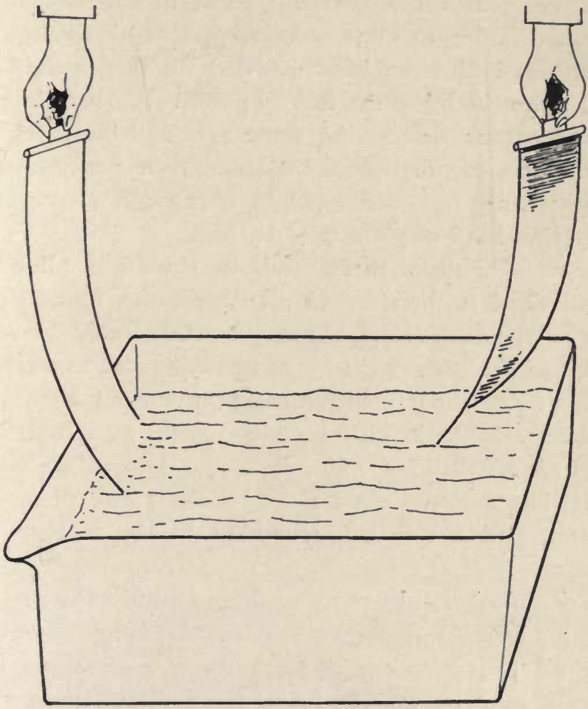


FIG. 37.—DEVELOPING ROLL FILM.

result we happen to be aiming at. Sometimes we wish for a very hard negative, at other times softness is more important; and special printing processes require a special variety of negative to be successful. We are not always content with a scientifically correct negative. The art of photography consists, as Mr. A. J. Anderson points out in a recent work, in its power of expressing with delicacy the effects of light; and with some developers the gradations necessary for that expression cannot possibly be gauged.

Developing Solutions.—A number of formulæ are appended to the notes on developing agents, but of these we would like to remark that the developing formula recommended by the makers is generally to be preferred, unless the worker has experience with these plates. Each maker has his own emulsion, differing in some peculiarity from his rivals, and the presumption is that he has provided for this in the formula printed upon the lid of the box of plates. We very frequently hear an amateur disparaging some excellent brand of plates, and find on enquiry that he thought a ready made up developer must be good enough, because it answered well with another kind of plate used by him.

The water used for these solutions should in all cases be either distilled or boiled. In all developing formulæ, metabisulphite of potash ($K_2 S_2 O_5$) may be substituted for sulphite of soda, and the greater purity of this chemical, as well as the reduction of matter in solution, are points in its favour. The amount necessary will only be one-quarter by weight of that directed for sulphite of soda, or, if for immediate use, one-eighth. The sulphite should be dissolved first, preferably in hot water, and the developer added to the solution when cool.

Stock Solutions.—In most of these formulæ the proportion of water advisable during actual development is indicated. Nearly all the agents will keep for a few weeks, and in practice it may be well to make them up in more concentrated form. For example, with the pyro-soda developer, instead of two solutions of twenty ounces each, the chemicals may be mixed in two five-ounce bottles, and watered down to the proper consistency immediately before using.

Pyrogallic Acid ($C_6H_3(OH)_3$) may now be obtained in concentrated crystalline form, as well as in the snow-white needle flakes, an ounce of which required so enormous a bottle to contain them. It is the oldest of developers, and is still the one used by nine-tenths of the photographic world.

It will admit of infinite modification to adapt it for all purposes, and being very energetic is regarded as the most suitable for open-dish development. The only fault to be found is the stains it frequently leaves, both on negative and hands. We find, however, that these stains are much more easy to remove than the similar discolorations caused by so-called stainless developers. The pyro-ammonia is an old favourite, but is not suitable for very rapid plates, and sometimes produces green fog.

A good formula is:

A.	Pyro	90 gr.
	Sulphite of Soda	1 oz.
	Nitric Acid	3 drops
	Water	15 oz.
B.	Ammonia (·880)	$\frac{1}{8}$ oz.
	Ammonium Bromide	$\frac{1}{8}$ "
	Water	20 "

For development take equal parts of A and B, adding a further proportion of B if found necessary.

Pyro-soda has almost entirely supplanted pyro-ammonia during the last few years. It is cleaner, less liable to fog, and green fog is practically unknown in connection with it. The following, which we have used for some years, is a good all-round formula, which, for some purposes, will allow of dilution:

A.	Pyro	$\frac{1}{4}$ oz.
	Sodium Sulphite	2 "
	Nitric Acid	5 m.
	Water	20 oz.
B.	Sodium Carbonate (crystals)	2 oz.
	Potassium Bromide	60 gr.
	Water	20 oz.

Mix in equal parts at time of using. For instantaneous exposures or for very soft negatives omit the bromide.

A variety of the above may be used with a caustic alkali, substituting for B:

Caustic Potash	100 gr.
(or Caustic Soda	70 gr.)
Water	20 oz.

For use take A, 1 oz.; B, 1 oz.; Water 1 oz.

Pyro-acetone.—Messrs. Lumière, a few years ago, introduced the employment of an aldehyde in place of the alkali. Acetone is the most suitable and most easy to obtain; with pyro and paramidophenol it appears to promote rapid action and at the same time the risk of injury to the film is less than when the strong alkalies are the accelerators.

A.	Pyro	¼ oz.
	Sodium Sulphite	4 ,,
	Water	20 ,,
B.	Acetone	20 m.
	Water (added at time of using)	1 oz.

Take 1 part of A to 2 parts of B. The simplest way is to first pour the developer into the measure, then add the acetone in the proportion of 40 minims to each ounce of A, and fill up the measure to three times the original volume. Metabisulphites or acids must not be used with acetone developers.

Variations in Pyro Formulæ.—It is always a good practice in comparing various developing agents to calculate the quantities dissolved in each ounce of fluid developer. The formulæ for pyro vary most considerably, some giving as much as 8 gr. of pyro to the ounce, others as little as 1¼ gr.; the amount of sulphite varies from 40 gr. to 5 gr., and the alkali in proportion. The formulæ we have given average about 2¾ gr. of pyro; it is therefore not so economical a developer as some of more recent introduction, especially as fresh developer must be employed for each plate, whereas paramidophenol or amidol will develop several plates in succession, with but one to two grains to the ounce. Density of image is, however, less quickly obtained, and the character of negative not so readily controlled.

Pyro Stains.—The deep colour which pyro-developer assumes during action is rather an advantage than otherwise, preventing fog from the lamp during prolonged development. Wash the plates well before fixing, and the acid alum bath will generally remove the last traces of yellow stain, especially if nitric acid is employed. Dip the fingers at the same time in the acid bath. Lemon peel or weak solution of potassium permanganate, followed by a dip into the hypo bath and then a wash with soap and water, are said to be efficacious for the fingers. The stains are easily removed when fresh.

Messrs. Lumière have urged that if the alkaline salts of the tribasic acids, as for instance the phosphates of soda and potash, were employed as accelerators, the danger of stains occurring would be greatly diminished.

Paramidophenol ($C_6H_4NH_2OH$).—This developer is very widely employed under the name of Rodinal, a proprietary article said to consist of a solution of paramidophenol hydrochlorate with sulphite of soda, to which sufficient of a caustic alkali has been added to redissolve the precipitate at first formed. The concentrated solution is cheap, keeps well, and produces a developing agent of considerable range, but slow in acquiring density. The image appears more quickly than with pyro, and details are distinguishable almost at once, but development is not complete for a considerable time. For ordinary use take

Rodinal	1 part
Water	30 parts

For under-exposures or greater detail add more water ; to increase contrast strengthen developer. Bromide acts as a mild restrainer, and may be freely added. The hydrochlorate is generally the salt of paramidophenol preferred, and consists of needle crystals which easily turn a dark colour, but this does not materially affect development. A good stock solution is

Paramidophenol	60 gr.
Sodium Carbonate	2 oz.
Sodium Sulphite	2 oz.
Water	20 oz.

Dilute with from 3 to 5 times the bulk of water before using.

Metol ($C_6H_3OHCH_3NHCH_3$) is a very powerful and energetic developer, producing density very rapidly, and bringing up detail in the shadows almost simultaneously with the high lights. Softer results are obtained for short exposures than with most other. Unfortunately it produces a very painful affection of the skin. Rubber gloves should be used, and the fingers washed immediately after development. The usual formula is :

A.	Metol	¼ oz.
	Sodium Sulphite	2½ ,,
	Water	25 ,,
B.	Sodium Carbonate	2 oz.
	Water	20 ,,

Metol is generally preferable as an addition to hydroquinone or pyro, when it acts as a useful corrective. For an example we will give the Imperial Dry Plate Company's developer of this class (single solution) :

Metol	50 gr.	3.250
Hydroquinone	40 ,,	2.600
Sodium Sulphite	500 ,,	32.500
Potassium Bromide	25 ,,	1.625
Sodium Carbonate	500 ,,	32.500
Water	20 oz.	560

Or for two solutions (Metol Pyro) :

A.	Metol	45 gr.
	Potass. Metabisulphite	120 ,,
	Pyro	55 ,,
	Potass. Bromide	20 ,,
	Water	20 oz
B.	Sodium Carbonate	4 oz.
	Water	20 ,,

Hydroquinone ($C_6H_4(OH)_2$).—Negatives from this developer tend to rather harsh contrasts, detail in the shadows not appearing until the high lights have acquired considerable thickness. Its chief value, especially in solutions with bromide, is for the necessary contrasts when copying prints and drawings, and for some of the photo-engraving processes. When hard negatives are desired, try:

A.	Hydroquinone	40 gr.
	Metabisulphite of Potash	40 "
	Bromide of Potassium	5 "
	Water	10 oz.
B.	Caustic Potash	100 gr.
	Water	10 oz.

Amidol ($C_6H_3OHNH_2HCl.$).—This developer is slightly acid in solution and acts very energetically without any alkali. The image appears almost at once in full detail, but requires long development. It produces good black negatives, and is often recommended for instantaneous work. Amidol does not keep well in solution but a stock solution consisting of

Amidol	80 gr.
Sodium Sulphite	800 "
Water	8 oz.

will keep for a few weeks if well corked. For use dilute 1 part with 4 parts of water. Old amidol developer sometimes leaves serious stains behind it. The best way of all is to make a stock solution of

Sodium Sulphite	1 oz.
Potassium Metabisulphite	$\frac{1}{8}$ "
Water	20 "

and with a horn spoon measure out 5 gr. of dry amidol for every two ounces immediately before using. A very weak solution of citric or acetic acid is a better restrainer for this developer than bromide of potassium.

Diamidophenol ($C_6H_3OH(NH_2)_2$).—A variation of that previously described, as will be seen by the symbol. It will give an excellent black image with good gradations, and is not so likely as amidol to produce stains, but it does sometimes cause inflammation on delicate skins.

Diamidophenol	40 gr.
Metabisulphite of Potash	½ oz.
Sodium Sulphite	2 "
Water	20 "

Or it may be substituted for amidol in the previous formula.

Ortol.—A composite developer introduced by Dr. Hauff, which consists of a mixture of hydroquinone with methyl-ortho-amido-phenol. It acts in a very similar way to pyro but is stainless; the negative produced is somewhat less dense.

A. Ortol	70 gr.
Potassium Metabisulphite	35 "
Water	10 oz.
B. Sodium Carbonate	1 oz.
Potassium Bromide	5 gr.
Sodium Sulphite	1 oz.
Water	10 "

Pyrocatechin ($C_6H_4(OH)_2$).—This developing agent, first introduced by M. Benoist, is the same in its components as hydroquinone, but behaves very differently. It acts energetically at a low temperature, giving a brown, fairly printing negative. On the other hand it is equally useful in hot weather, as the tanning action which it exercises upon the gelatine diminishes the risk of blisters and frilling in the film. The formula given for pyro soda will serve for pyrocatechin with the addition of more water, if required.

A. Pyrocatechin	¼ oz.
Sodium Sulphite	1 "
Water	20 "
B. Sodium Carbonate	1 oz.
Water	10 "

The acid fixing bath is said to be unsuitable for negatives developed with Pyrocatechin.

Eikonogen is not very widely used for plates, but gives clear negatives, full of detail without great density in the high lights, and therefore suitable when bromide enlargements are needed rather than direct printing.

A.	Eikonogen	80 gr.
	Sodium Sulphite	160 „
	Water	5 oz.
B.	Sodium Carbonate	1 oz.
	Water	10 „

Eikonogen is often used in conjunction with hydroquinone, the presence of the latter increasing vigour and contrast. The following formula we have used with great success and especially for the development of Kodak films:

A.	Sodium Sulphite	2 oz.
	Eikonogen	180 gr.
	Hydroquinone	120 „
	Water	20 oz.
B.	Potassium Carbonate	1 oz.
	Water	20 „

Take A 1 part, B 2 parts.

Kachin.—The chief recommendation of this developer is its cleanliness and its success for the development of stale plates, on which it does not produce the usual iridescent markings.

A.	Kachin	¼ oz.
	Sodium Sulphite	1 „
	Citric Acid	20 gr.
	Water	10 oz.
B.	Sodium Carbonate	360 gr.
	Water	10 oz.

For use take 1 part of A and 1 part of B, with from one to two parts of water according to the nature of the exposure. No bromide is required.

There are many other developers of this kind. We may mention adurol, the action of which is very similar to hydroquinone; edinol, sometimes recommended as a clean substitute for pyro and equal to it in range of densities; glycin, slow in action, but very sure and specially adapted for tank development; azol, synthol, imogen sulphite, diphenol, etc., etc.

Those who wish to experiment will find suitable formulæ provided in the ounce packages supplied by the manufacturers.

Ferrous Oxalate, once a great favourite, is now very little used for plates. It gives a very brilliant, sparkling negative, but the resulting prints have often a deadly dull look on most modern papers. The old formula was:

A. Saturated solution of Ferrous Sulphate.
B. Saturated solution of Potassium Oxalate.

Take 1 part of A and 3 parts of B.

Before fixing the plate must pass through three changes of water, to which a few drops of citric-acid solution have been added to remove the otherwise insoluble iron salt. From the peculiarity of its chemical reaction ferrous oxalate is the one chosen for standard tests. We subjoin the formula used by Messrs. Hurter and Driffield:

A.	Potassium oxalate	1 part
	Water	4 parts
B.	Ferrous Sulphate	1 part
	Citric Acid	0·01 part
	Water	3 parts
C	Potassium Bromide	1 part
	Water	100 parts

For use, take A 100 parts, B 25 parts, C 10 parts.

Daylight Development.—In the *British Journal of Photography*, August 27, 1909, a method was described for desensitising plates after exposure by immersion for a minute or two in a 4 per cent. solution of potassium iodide. They may then be brought out into daylight and developed in a metol-hydroquinone developer fully restrained with bromide. As an interesting experiment at the lecture table the process may have its value. But the results will not bear very critical examination, although the solution is said to be sold for the purpose in Germany.

We do not know whether the following combined developing and fixing bath for daylight use, described in the same journal, is permissible by the patent laws. Picrate of soda or of magnesia forms the colouring agent, the first-named being the more soluble.

Magnesium Picrate	81 parts
Sodium Sulphite (anhydrous)	544 parts
Sodium Hyposulphite (hypo)	250 parts
Diamidophenol	125 parts

This powdered mixture is dissolved in water to the extent of about 20 gr. per ounce, and the exposed plate or print having been placed in it in the dark, the further operation may be continued in daylight or other actinic light. The credit of the proposal is due to MM. F. Jeannot and M. R. Bremner.

CHAPTER XII

TIME DEVELOPMENT

In our last chapter we stated that most of the advantages formerly attributed to development in the open dish were now proved to be illusory. For a clear understanding of the system which is taking its place with a considerable body of photographers, we shall have to recapitulate to some extent.

The key-note for a successful negative is correct exposure, and the accompaniment must be correct development. The question will then arise, What is correct exposure, and what is correct development? Correct exposure is that which will produce the rendering of the subject that the photographer requires; and the correct development, that which will produce the amount of contrast required by the printing process to be used. Theoretically there is only one correct exposure, but in practice there is a large amount of latitude, or, in other words, the falsification of the tones, which is the result of incorrect exposure, is so slight that it is negligible so long as the variation of exposure is kept within the latitude of the plate or film; and it is by this means that photographers can produce negatives and prints to suit their requirements.

Latitude of Exposure.—There is no difficulty in obtaining both correct exposure and correct development if the photographer works systematically. Both can be easily calculated. The principal thing necessary is to understand the action of the exposure on the sensitive plate, so as to fully realise the method of developing by time, which is practically developing by calculation. To obtain an absolutely correct rendering of any subject the exposure must be exact, because any other exposure will render the half-tones false. But there is a large amount of latitude before the false tones produced by incorrect exposure become discernible. This latitude is much less on the under side of correct exposure than on the over side—many films and plates to-day allow a latitude of about one-half on the under side, and four times on the over side.

The simplest way of studying the effect of exposure on the half-tones is to work with one half-tone, a shadow, and a high light as follows:

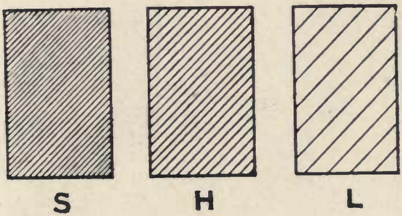


FIG. 38.
S = Shadow, H = Half-tone, L = High-light.

The half-tone is exactly half-way between the shadow and high light; that is, the reflective power of the half-tone is to be double that of the shadow and half that of the high light.

Correct Exposure.—If these were exposed on three separate plates in the same ratio as the reflective power, and developed together in the same developer for the same length of time, the result would be three identical negatives, as the difference in the reflective power in each tone would be equalised by the different exposures. On the other hand, if these three tones were exposed on one plate with a single exposure, and that was correct, we should get three tones in exactly the same ratio as the original, whether the plate was developed for either a flat or a contrasty negative. That is, if the density of each tone was measured, the half-tone would be in the centre of the other two, irrespective of whether the shadow and high light were very close together or very wide apart.

Figs. 39–41 represent a section of a developed plate of the three tones. The deposit would of course be considerably greater on L than on S. Fig. 39 is a section of a correctly exposed plate, giving the steps between each tone exactly the same as in the original. The dotted line touching the point of each tone, being straight, denotes that the exposure had been correct.

Incorrect Exposure.—Fig. 40 is a section of an under-exposed plate, developed so that the shadow and high light

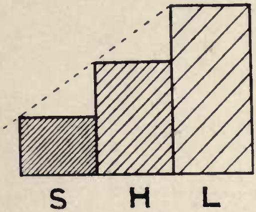


FIG. 39.

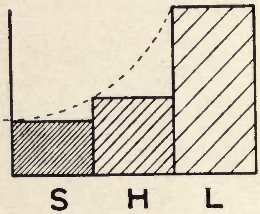


FIG. 40.

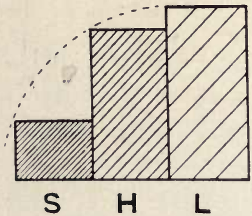


FIG. 41.

are the same as in the correctly exposed plate. Now it will be seen that the half-tone has not got the same value, and that instead of being in the centre it is much nearer to the shadow; and the more considerable the under-exposure the nearer will it approach to the shadow. A line drawn touching the points of each tone will no longer be straight, but concave—a concave line represents under-exposure.

Fig. 41 is an over-exposed plate with the shadow and high light developed to the same degree as in the previous cases. And now we find that the half-tone is much nearer to the high light. The line becomes convex, a sure representation of over-exposure.

When the wrong exposure has placed the half-tone out of its true position it is impossible to put it back with the developer. An incorrect exposure is always an incorrect exposure, however the development has been carried out. The idea that any developer can develop up the shadows and at the same time hold back the high light is a fallacy. To do this the developer would have to produce a negative and positive effect at the same time, which is contrary to all chemical laws. Photographers have been taught, and the impression is deeply rooted, that incorrect exposures can be corrected by the developer, whereas the only thing that can be done is to develop for more or less contrast. It is impossible, however, to divert either the concave or convex lines of incorrect exposure into the straight line of correct exposure.

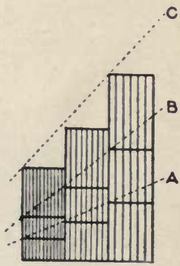


FIG. 42.

When we come to the conclusion that it is impossible to correct one half-tone in a picture to any great extent, what is the good of trying to correct the numerous half-tones in our negatives?

Contrast.—The only control the photographer has in the development of negatives is the amount of contrast; and the easiest way to exercise this is simply by altering the time of development—the longer the development the greater the contrast.

Fig. 42 represents the section of a correctly exposed plate, with short, medium, and long development. The difference in the lines A B C, is the shallowness or steepness of the contrast obtained by the varying time of development. The negative having had correct exposure the half-tone is in the centre in each case, although the outer tones vary considerably; A, B, and C might all be good negatives for different purposes.

A.—A soft negative with little contrast, suitable for enlargements on bromide paper of a large size.

B.—A good all-round negative.

C.—A negative with more contrast, suitable for carbon printing.

Altering the strength or the composition of the developer is equivalent to altering the time of development, which would produce exactly the same effect.

The development of either an under-exposure (Fig. 43) or an over-exposure (Fig. 44) proceeds in exactly the same way as a correct exposure; that is, each tone will develop in the

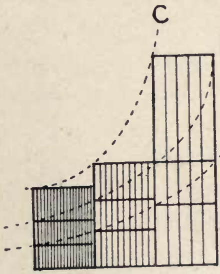


FIG. 43.

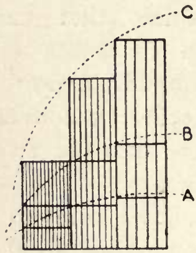


FIG. 44.

ratio decided by the exposure. If development is continued long enough to double the deposit on the shadow, the deposit on the high light and the half-tone will be doubled also.

Fig. 43 shows three stages in development of an under-exposed plate: A, development for a short time; B, the development continued until the deposit in the shadow has been doubled; C, continued development until the deposit on B has been doubled; and in each case the deposit on the high-light and half-tone has also been doubled. The exposure having placed the half-tone much nearer to the shadow, it remains in that position, whether the negative is flat as in A, or contrasty as in C.

Fig. 44 shows the same three stages of development in an over-exposed plate; only that in this case the half-tone has been placed by the exposure nearer to the high light. We get practically the same result in both cases, with the exception that the displacement of the half-tone is towards the shadow with under-exposure and towards the high light with over-exposure.

In Figs. 43 and 44 the development has been carried on so that the density of the shadow and high light may correspond to those of correct exposure (Fig. 42); but it will be seen that in both cases the half-tone is untruthfully rendered. And when the half-tone has been placed in this false position it remains there in whatever way it may have been developed. The only control the photographer has is to decide how far he will carry development, and by this means he can determine the amount of contrast obtainable in the negative. This degree of contrast should be regulated according to the medium to be used for printing; some processes require a soft negative, while others require one with more contrast.

Density.—The density of a negative has very little effect on the printing value, except to increase the time actually occupied in printing, whereas the contrast is the governing factor for a good print. Developing negatives to a certain density is a fallacy, although photographers have been invariably taught that this is the correct method. It is far better to develop for a certain contrast. Many have the idea that density and contrast are synonymous, whereas they are totally different; the density of a negative is practically the thickness of the deposit, while contrast is the distance between the high light and shadow. It is possible to have a dense negative with little contrast, or a thin negative with plenty of contrast. If four plates of the same batch were exposed on a subject each receiving a different exposure (within the latitude of the plate) and developed together in the same developer for the same length of time, the result would be four negatives of different density, but all would have the same contrast. They would all give equal prints, but the time of printing would vary according to the density. The negative which received the longest exposure would be denser than the others and take longer to print. On the other hand, if these negatives were developed in the dark room, and development had been stopped when each reached the same density, they would all have different contrasts. And in this case it would be impossible to get equal prints. Some negatives would give flatter prints than the others, although each would take about the same time to print.

Therefore the exposure does not only decide the relations of the tones, but the density of the negative, and the development decides the contrast between the tones. And as the determination of this contrast is the only means of control the photographer has, there is no necessity to watch the process of development, which can be just as well carried out by calculation.

The necessary factors are a standard developer, a standard quantity of water, a standard temperature, and a standard time. Any variation in the first three factors can be corrected by altering the last. A strong or a warm developer acts more quickly than a cold or weak one, but this can be corrected by altering the time of development. The amount of contrast is also regulated in the same way, so that everything required can be obtained by altering the time of development.

Time development can be carried out in an open dish; but a tank is far preferable, as the dark room need only be used for loading the tank. With films and the Kodak developing tank, the dark room can be done away with entirely, as this system allows of the film being placed in the developer while the photographer is in ordinary daylight.

If all the factors are carefully adjusted when developing in the tank by time, the best possible result will be obtained, whether the exposure has been correct or incorrect; and this system entirely removes the temptation to over-develop under-exposures and to under-develop over-exposures, which is usually done when development is carried out by ocular observations. With under-exposures photographers continue the development, hoping to get more detail in the shadows, and make the negatives so hard that they are spoilt and will only yield prints of a soot and whitewash character. Over-exposures are dense and opaque in the high lights long before development is complete. Hence there is a tendency to take them out of the developer too soon; and this practice is so general that it is usually understood that the thin negative is the result of over-exposure, whereas it is due to under-development. Errors in development are often confused with errors in exposure: which leads to doubt where the fault really lies. But when all negatives are developed for the same time, and the other factors kept normal, there will be no error in development. Consequently, the errors in exposure are easily located, and time development teaches correct exposure in the simplest way.

Developers.—Nearly all developers are available, but it must be remembered that variations of temperature have not the same effect on all. The normal time is usually calculated for 65° Fahr.; the time given must be increased by one-half in the case of pyro, and about doubled with rodinal, metolquinol or glycin if the temperature of the solutions has fallen to 55°. The Kodak formula is as follows:

Stock Solutions.

A.	Pyrogallic Acid	1 oz.
	Sulphuric Acid	20 minims.
	Water	28 oz.
B.	Sulphite of Soda (cryst.)	6 oz.
	Carbonate of Soda (cryst.)	4 "
	Water	to 28 "

For development take 1½ oz. of each and make up to 20 oz. with water. Time of development is 10 minutes at temperature 65° Fahr.

Glycin is a great favourite, and Fuerst's formula gives a very clean negative, allowing for reasonable latitude before the half-tones become unprintable.

Stock Solution.

Hot water	10 oz.
Sodium Sulphite	1½ ,,
Potassium Carbonate	3 ,,
Glycin	240 gr.

Use a 20 oz. measure in mixing, and add the glycin slowly to prevent excessive effervescence. For use make each ounce up to four ounces with water. The tank must be carefully washed before use with this developer, as any trace of hypo will produce bad stains. An alternative is the metolquinol formula in the last chapter. Some of the original advocates of time development advocated rodinal and similar formulæ so diluted that twelve or more hours were required; in fact, that plates should be put into the tank overnight and found in the morning correctly developed. Such prolonged development has no good effect on the gelatine of the plate, and will often result in silver fog. For the benefit of experimenters we give Bothamley's formula for one-hour development at 65°.

Glycin	46 gr.
Sodium Sulphite	46 gr.
Water	70 oz.

Developing and Fixing Combined. (V. Cremier).

Diamidophenol	15 gr.
Sodium Sulphite	150 gr.
Hypo (20 per cent. solution, 4 oz. to the pint)	2¾ drams.
Water	3½ oz.

Fixation is said to be complete in about fifteen minutes, but with many varieties of plates a second fixing bath will be necessary and may be given in daylight.

CHAPTER XIII

THE CHEMICAL THEORY OF EXPOSURE AND DEVELOPMENT

NOT lightly have we approached the task of writing an account of the chemical changes involved during the exposure and subsequent development of the ordinary dry plate. At the very start we are baffled. The latent image is invisible, and though, without doubt, it contains less bromine than the ordinary bromide of silver, still the loss of weight is so small that all the efforts of chemists in devising more and more ingenious methods for detecting this loss have hitherto been fruitless. The unhappy chemist is deprived of his balance, the one wholly reliable source of evidence. He can only fall back on indirect methods of reasoning, based on analogy. And he finds no analogy to help him. He dare not point to the compounds of silver with fluorine, for his brethren would at once send him an elementary text book on the non-metals, with a blue-pencilled paragraph to the effect that the lowest member of a family of elements always differs so widely from the other members, that no analogies can safely be drawn from its behaviour.

Defeated here, a gleam of hope flashes across his mind. He remembers that there is gelatine on a photographic plate. But this fitful gleam vanishes at once, leaving him in utter darkness. We do not know anything about gelatine. Most Organic Chemistry books are silent concerning gelatine: others give only a few lines, which tell him very little more than every carpenter knows. Humbly he goes to the gelatine manufacturer and asks him for information. But the manufacturer knows no more about gelatine than the chemist does—the manufacturer, in fact, cannot depend on two batches of gelatine made under identical conditions, turning out alike.

The Latent Image.—Only one positive statement can be made concerning the latent image, that a smell of bromine accompanies its formation ; and one conclusion may apparently be safely drawn. From the smell of bromine emitted by a plate after an exposure to light, we conclude that a certain amount of dissociation of the silver bromide has taken place. Two theories are current in explanation of this. The first theory states that half the bromine splits off, leaving a substance more complex in structure than the original silver bromide.

$$4AgBr = Ag_4Br_2 + Br_2$$
$$4AgBr = 2Ag_2Br + Br_2$$

Similarly, with the chloride and the iodide of silver, and to these hypothetical halides have been given two names—(1) sub-halides, (2) photo salts. According to the second theory, all the bromine leaves the silver bromide, leaving a latent image of metallic silver in one of its allotropic forms. $2AgBr = 2Ag + Br_2$. Neither of these theories can be proved. Such a substance as $(Ag_2Br)_n$ [1] has never been prepared, nor does the chemistry of silver point to its existence. A fluoride of the constitution $(Ag_2F)_n$ is known. But fluorine is often a diad, whereas the valency of the other three halogens is always an odd number.

On the other hand, the substance forming the latent image seems to differ very widely in properties from any allotropic form of silver yet prepared. To cite only one difference : dilute nitric acid does not destroy the latent image, even on warming the solution.[2]

The fact that bromine water does destroy the latent image

[1] Possessing the properties of the latent image.

[2] All the allotropes of silver are unstable, passing readily into the ordinary form, which is dissolved by nitric acid.

points equally well, either to the presence of metallic silver, or of the sub-halide.

$$Ag + Br = AgBr$$
$$Ag_4Br_2 + Br_2 = 4AgBr$$

Nor does it help matters forward very much for the supporters of either theory to maintain that the properties of silver sub-bromide, or of silver, are profoundly modified by the presence of gelatine. This is doubtless true. But if we ask the theorist "what next?" he has no other resource, owing to his ignorance concerning gelatine, than to invent for it a number of properties, which seem to him to fit in with his theory. We will leave him to it.

On the whole, as Luther has shown, the metallic silver theory is simpler. The cardinal objection to the sub-halide theory is that it began life as a blind guess, which gained currency by reason of its plausibility.

To conclude, we can only assert of the latent image that it consists of some unknown substance, which is acted on by the developer at a different rate to the unchanged silver halide, and on that account acts as a catalyst. We cannot say whether it is acted on more, or less, rapidly, but shall find this point merely enhances the pleasure of sketching the theory of development.

Action of Light on the Plate.—Before proceeding to discuss development, we should like to clear the air a little as to the chemical effect of light. The actinic power of light is so often spoken of as if it were something not-to-have-been-expected, some new manifestation of energy. And this while two facts concerning light are common knowledge. We have but to mention the name of Clerk Maxwell and the reader at once remembers that light is an electrical phenomenon.

One expects some chemical change to take place when an electrical disturbance is propagated through an ionised solution.[1]

[1] Research has shown part of the silver halide on the photographic film to be in solid solution, and slightly ionised.

The other well-known fact is that heat is developed when light is absorbed by a medium. This local heating will have two effects. It will first increase the number of free ions, thereby aiding electrolysis. Secondly, it will tend to vaporise any bromine or iodine that may be liberated, and by thus removing it from the sphere of chemical action, render recombination with the silver impossible.

Development of the Image.—It has been shown that it is necessary to formulate two theories of development, since we do not know whether the unchanged or the changed silver compounds on the plate are attacked the more rapidly by the developer. The general law which has been found to apply in all such cases is that the less active substance is unaffected, whilst the more active one is attacked at an increased rate, which increase is directly proportioned to the difference in chemical activity between the two substances. On the supposition that the photo salt is attacked less rapidly than the unchanged silver halide, the simplest explanation of development lies along the lines laid down by Desalme.[1]

Desalme's *Theory of Development* is electrolytic. It is found that whenever two substances that differ either chemically or physically, are placed in electrical contact, a difference of potential is set up between them. (In the case of an exposed plate this potential difference between

[1] We will assume the reader to be familiar with the concept of ions and will adopt the ionic mode of expressing chemical change. We must therefore mention what ions are present in the developing solution.

The film supplies bromidions and argentions. (The solubility of the halides of silver, though too small to be detected by the balance, is proved by the increase in the conductivity of water in which they are shaken up, and the number of ions present in unit volume, estimated by measuring this increase.) Be it remembered that equilibrium will be established in the case of a solid in contact with water when the number of free ions in solution reaches a definite value; and if any be removed, a fresh number will immediately enter into solution to restore equilibrium.

The alkaline hydrates will yield sodions (or potassions) and hydroxidions. Alkaline carbonates and even phosphates also yield these ions, owing to the hydrolysis occurring when they enter into solution.

$$Na_2CO_3 + H_2O = NaOH + NaHCO_3$$
$$Na_3PO_4 + H_2O = NaOH + Na_2HPO_4$$

the photo-salt[1] and the unchanged AgX[2] will be increased by the action of the electrolyte.)

If this E. M. F. be high enough electrolysis will commence. But, immediately, owing to the accumulation of anions and cations in opposite regions, an equal back E. M. F. will spring into existence, and cause polarisation. Electrolysis ceases. To re-establish it, a depolariser is needed. It will be enough to remove the bromidion, by causing it to enter into chemical combination.

It has generally been assumed that the bromidion combines with the developer. This is true in the case of ferrous oxalate:

$$3(COO)_2Fe + 3AgX = FeX_3 + (COO)_3Fe_2 + 3Ag$$

but untrue for the usual organic developers. It was thought that the halogen attacks the organic developer, forming a halogen substitution compound, with liberation of HX, which was neutralised by the alkali, whereby the action of HX on the silver of the image was prevented. But if this were so, then we should find that bodies which react most readily with the halogens (such as the monohydrophenols) would make very good developers; but such is not the case, these compounds do not develop. Furthermore, if the bromidion combined with the developer, we should expect unsaturated compounds, such as cinnamic acid $C_6H_5 \cdot CH : CH \cdot COOH$ which adds on bromine directly to form $C_6H_5 \cdot CHBr \cdot CHBr \cdot COOH$, without evolution of HBr, would develop without alkali. Such compounds do not develop.

Since therefore, no HX is liberated, the alkali must play another part. On running our eye over a list of organic developers we find aromatic compounds containing at least two hydroxyl groups, or both hydroxyl and amido groups, joined directly to the benzene nucleus, and are

[1] By which we mean the substance, whatever it may be, forming the latent image.

[2] X is used indifferently to indicate chlorine, bromine, or iodine, and x for the ion.

struck by the fact that such compounds are sensitive to hydroxidion.

We now see daylight. Hydroxidion combines with the developer and loses its charge. The sodion to which it was joined is now free to react with the bromidion:

$$\overset{+}{Na} + \overset{+}{Ag}\overset{-}{Br} = \overset{+}{Na}\overset{-}{Br} + \overset{+}{Ag}$$

and the argention liberated will turn into metallic silver:

$$\overset{+}{Ag} \longrightarrow Ag.$$

Alternative Theory of Development.—If we assume that the photo salts are attacked more readily than the unchanged AgX, then the chemistry of the process appears simpler, though the final products are the same. The first action will be the disappearance of the photo salt. Heat will be liberated.[1] This heat will be taken up by the neighbouring particles of AgX, and the action of the developer on those particles will be hastened in proportion to the amount of heat received (which will depend on the local amount of photo salt) in obedience to the law that the rate of a chemical change is doubled (roughly) for every rise of 10°C in temperature. Thermo-chemical calculations show that the action of the developing solution on AgX is exothermic.[2] Once started, it will go on of itself, at an increasing rate, the photo salt merely imparting an initial acceleration.

Meanwhile, however, heat is travelling along the film by conduction, and by local convection currents, and hence as development proceeds the action slowly spreads to other parts of the plate, and will ultimately involve the whole film. In this light the solution of the problem regarding the action of the photo salt is as simple as the starting of

[1] Thus, suppose a certain change requires 5 minutes for a completion at 0°C. At 100° it will proceed $2^{\frac{100}{10}} = 1024$ times as fast and be complete in about $\frac{3}{10}$ seconds.

[2] The weight of matter involved and the exothermic surplus are too small to cause any noticeable rise of temperature of the developing bath.

a furnace by the aid of a safety match; though the chemical changes are more involved.

Fixing.—When development is complete, the unchanged AgX must be removed, for two reasons: It is opaque. It darkens on exposure to light, becoming still more opaque. The AgX goes into solution when the plate is immersed in a solution of sodium thiosulphate—known as "hypo"—(the fixing bath).

The action of $Na_2S_2O_3$ on AgX is not exactly known. We quote, however, some English text-books.

$$Na_2S_2O_3 + 2AgX = Ag_2S_2O_3 + 2NaX.$$

Silver thiosulphate is sparingly soluble in water, but readily soluble in $Na_2S_2O_3$ solution.

$$Na_2S_2O_3 + Ag_2S_2O_3 = Na_2S_2O_3 \cdot Ag_2S_2O_3.$$

These equations are close enough for the photographer's purpose, for they show why a second immersion in "hypo" diminishes the time necessary for washing.

It is of the utmost importance that all the S_2O_3 radicle be removed from the film. Thiosulphates are slowly attacked by carbon dioxide from the air, with liberation of finely divided sulphur, and also of sulphur dioxide.

$$Na_2S_2O_3 + CO_2 + H_2O = Na_2CO_3 + S + SO_2.$$

This sulphur will combine with the silver and lessen its opacity. Any sulphur dioxide remaining in the substance of the film will also go through a number of chemical changes, none of which will do any good, either to the image or to the gelatine.

Action of the Sulphite.—The chief function of sodium sulphite in solutions of organic developers, is to prevent stains on the film. Stains are the result of secondary reactions undergone by the compounds formed when aromatic developers are attacked by hydroxyl; these bye-products tend to oxidise and then undergo condensation, with the consequent formation of dyes. The ordinary action of sodium sulphite keeps these dyes in the leuco condition—in which state they are colourless—thereby preventing stains. It has generally been thought that the sole action of sodium sulphite was to prevent weakening of the developer, owing to the superior avidity with which it will take up any oxygen going into solution from the air. And it was pointed out that alkaline pyrogallol, which absorbs oxygen very rapidly, requires the largest quantity of sulphite, whereas ferrous oxalate, which absorbs little oxygen, requires none. But though it thus enables a developer to "keep" better, this fact is of quite minor importance in comparison with its action in preventing stains.

Printing in Silver.—With the ordinary daylight printing paper, the basis of which is silver chloride, exposure is very long, and the image (probably ?) consists of metallic silver. From the reddish colour of an untoned print one would suggest that the silver was in the form of one or more of its allotropic modifications. Toning consists in the partial replacement of the silver image by a gold one, according to the equation:

$$AuCl + Ag = AgCl + Au.$$

The change of colour is explained by the bluish tinge of very finely divided gold. The gold solution must be very dilute, and in practice some substance, usually an organic sodium salt, is added to prevent the destruction of the silver (or subchloride) image.

The theory of the fixation of prints is the same as that of negatives, the removal of the unchanged AgX. In fixing these prints it is advisable to use a slightly alkaline solution of thiosulphate. This body is unstable in the presence of acids, sulphur being liberated, which will combine with the silver and spoil the print.

Besides these printing-out papers there are also on the market a wide variety of "bromide" and "gaslight" papers. These are exposed and developed in the same way as negatives. The image is ordinary silver in one or more of its allotropic modifications: whence the multiplicity of shades obtainable.

Printing in Platinum.—We breathe a sigh of relief in turning to the platinotype process. Here we are on firmer ground. Two very simple chemical changes underlie this process. The first is the reduction of ferric salts to the ferrous state by the action of light; and the second, the re-oxidation of the ferrous salt at the expense of the acid radicle in combination with platinum, the platinum thus precipitated in the metallic form building up the image. Details vary with different makes of paper; we need only describe the simplest process. A paper containing a mixture of ferric oxalate and potassium chloroplatinate[1] is exposed to light behind a negative in a printing frame. Local reduction of the ferric oxalate takes place in accordance with the equation:

$$(COO)_6Fe_2 = 2(COO)_2Fe + 2CO_2.$$

No further change can now take place in the dark so long as the paper is dry, for the ferrous oxalate and the platinum salt cannot react in the solid state. They will do so, however, the instant they enter into solution.

Such papers, therefore, are developed by immersion in water.[2]

$$6(COO)_2Fe + 3K_2PtCl_4 = 3Pt + 2(COO)_6Fe_2 + 2FeCl_3 + 6KCl.$$

This change, occurring *at the moment of solution*, the platinum is deposited in the pores of the paper. Fixation takes place by the solution of all the salts left in the paper. But a little dilute hydrochloric acid must be used in the washing water, to prevent the hydrolysis of ferric salts, especially chloride, which occurs in neutral solution.

$$FeCl_3 + 3H_2O = Fe(OH)_3 + 3HCl.$$

[1] K_2PtCl_4 is readily soluble. The simpler body $PtCl_2$ is unsuitable, because sparingly soluble in water.

[2] A solution of potassium oxalate is, nowadays, always employed in the developer.—Ed.

This ferric hydrate (in a colloidal state), would adhere to the paper and produce red stains. Excess of HCl prevents its formation, or if already present redissolves it.

$$Fe(OH)_3 + 3HCl = FeCl_3 + 3H_2O.$$

Carbon Prints.—These printing papers are coated with gelatine containing bichromate. The action of light on potassium bichromate in the presence of easily oxidisable organic matter, such as gelatine, may be summarised in the equation

$$K_2Cr_2O_7 = K_2O + Cr_2O_3 + 3O.$$

Potassium bichromate is not sensitive to light when alone, and, in contact with organic matter the action takes place, curiously enough, more rapidly in the dry state than when moist. The effect of this chemical change is twofold. The Cr_2O_3 reacts with the gelatine to form a dark opaque substance.[1] The gelatine in contact with this dark substance becomes insoluble. The developer is hot water, which dissolves out the unchanged gelatine, leaving the insoluble portions as a raised image.

Chemical Manipulation.—In conclusion, a word of warning to the reader whose knowledge of chemistry is still in the elementary stages, may not come amiss. Many of the leading operations in photography are delicate, and require conscientiousness and care. They are performed by very minute quantities of the reagents. An average developing formula contains only two to three grains of pyrogallol to the ounce of water ; with some other developers the proportion is finer still : for instance, effective work may be done with a solution containing only $\frac{1}{4}$ grain of paramidophenol to the ounce. A toning solution contains very frequently $\frac{1}{8}$ to $\frac{1}{10}$ of a grain of gold in each ounce of water, together with two or three grains

[1] It was formerly supposed that oxygen liberated in the nascent state, had a charring action on the gelatine. Dr. Eder, as well as MM. Lumière and Seyewetz, has shown by convincing experiments that the gelatine is not oxidised, and may be recovered by digestion either with very dilute sulphuric acid (1 in 1,000) or an alkali in the case of chrome alum.

of a moderately alkaline salt. Needless to say how completely the desired effect may be rendered impossible if these are allowed to come in contact with the saturated solutions in the fixing bath, or the ferrous oxalate developer. A few grains of amidol, blowing as dust about the room, may settle on printing-out paper and make whole sheets worthless. Dishes and measures must be kept scrupulously clean, and rinsed after use ; and the fingers that have been dipped in fixing baths or bichromate sensitisers must not handle plates, silver papers, or toning prints until they have been very carefully washed and dried. Ordinary tap-water often contains sufficient alkaline matter or other impurities to entirely alter the action of a toning bath, and should, therefore, be avoided for such purposes.

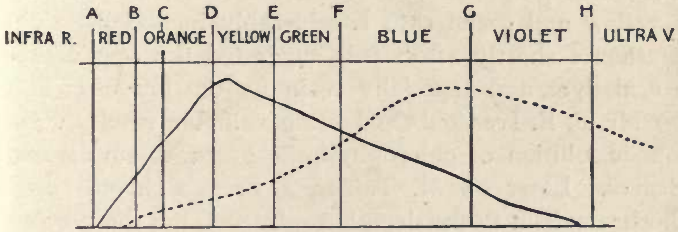
Among works dealing more fully with the chemistry of photography may be mentioned those of Dr. Eder and Prof. Meldola ; also Chapman Jones' *Science and Practice of Photography* ; and on the special subject of dry plates and development, Sheppard and Mees' *Investigations on the Theory of the Photographic Process.*

CHAPTER XIV

ORTHOCHROMATIC PHOTOGRAPHY

WHEN the pioneers of photography began to turn their attention to landscape and decorative work they discovered a very serious defect in their productions as either records of facts or as interpretations of nature as they saw it. The rendering of colour was entirely misleading. They did not, of course, anticipate that the bright hues of nature would arrange themselves automatically upon the finished print. But they had expected to find some such relative shading of objects seen by the eye as is expressed by the varying depths of tone in an etching or steel engraving. This is just what the photographic image failed to do. The colour values appeared as a confused muddle. A dark-blue ribbon in a maiden's hair might be represented as nearly white; the golden tresses lost all distinction; and the pink rose pinned on the front of her dress was nearly black. The bright gorse blossom on the hillside came out darker than its foliage, and the thousand varying shades of the trees were lost in meaningless dull tints.

The cause of this difficulty has been already discussed in standard works on the chemistry of light, and we need therefore only refer to it very briefly here. The diagram shows the rays of the spectrum bands in their order divided at proper intervals by the Fraunhofer lines. The black line describes roughly the relative luminosity or brilliancy of the various rays as they appear to the human eye; the dotted line, on the contrary, shows the proportion of these rays acting on the particles of silver halides, or in other words, the relative chemical intensity of the spectrum upon the sensitive dry plate. Thus it will be seen that that part of the spectrum which appeals most strongly to the human eye—the orange and yellow—is just the part that exerts no perceptible chemical influence on the silver salts. On the contrary towards the end of the blue, shading off into violet and ultra violet, the chemical action becomes vigorous—just the part of the spectrum which attracts little notice or is even invisible to the human eye. As a rule, therefore, the perception by the eye with regard to the luminosity of the rays reflected from coloured objects is almost diametrically opposite to the record of luminosity shown on the ordinary dry plate. The fact is demonstrated in a most striking way if we place side by side



a yellow viola and one of the very dark-blue variety. We have no doubt which of the two reflects the brightest and most luminous rays, judged by the test of our own eyesight. If an artist were called upon to sketch them in pencil or any other monochrome method he would convey the impression by shading the yellow viola as nearly white and the blue one as nearly black. But if we photograph them on an ordinary plate, in which no attempt at colour compensation has been made, a reverse result will be attained in the print. The dark-blue flower will be white, the bright yellow one black.

The science of orthochromatics has properly, then, nothing to do with colour *per se.* It attempts merely to render in more truthful gradations the illumination of objects to be photographed. We can only reconcile the optical nerves with the haloid salts by reducing the action of the short length waves of light upon the plate, the blue, violet, and ultra violet; and on the other hand increasing the sensitiveness of the silver salts to the rays at the yellow and red end of the spectrum.

Professor J. W. Draper, of New York, who, it will be remembered, in 1840 photographed the moon for the first time on a Daguerrotype plate, is frequently claimed as the father of orthochromatic photography. He discovered that the chemical action produced by rays of light depended upon their absorption by sensitive bodies. But it was not until 1873 that Dr. H. W. Vogel, of Berlin, applied this, practically by staining collodio-bromide plates with a yellow dye. He was able in this same year to prove that silver bromide stained with proper yellow or red dyes had its sensitivity to the yellow and green rays considerably increased. Colonel Waterhouse shortly afterwards suggested the application of the coal dyes, and especially eosin for the purpose; and in 1879 Mr. F. E. Ives obtained some valuable results with an alcoholic solution of chlorophyll, the green colouring matter of leaves. Later on M. Tailfer, a French chemist, applied orthochromatism to the dry plates, by staining the previously prepared plates with eosin or erythrosin in conjunction with ammonia. The dyes still most in favour are erythrosin, pinachrome, pinacyanol, and cyanine, the two latter being chiefly used when considerable sensitiveness to red rays is demanded.

The Yellow Filter.—But although by the use of suitable dyes the silver salts are rendered much more sensitive to green, yellow, and red rays, there are still a vast number of rays impinging on the plate and being absorbed by it at the opposite end of the spectrum. Dr. Kenneth Mees and Dr. Sheppard are agreed that, if no glass is used, practically two-thirds of the whole effect on the ordinary plate is due to the ultra-violet rays, and if a sheet of glass is used, about one-third. Messrs. Newton and Bull have shown that the ultra violet rays are even more effective with enclosed arc rays and wet collodion. Such rays are most disastrous for colour rendering. This light is quite invisible to the eye; its effect on colour cannot be gauged, and it entirely falsifies the tones. In a recent lecture before the Royal Photographic Society, Mr. R. W. Wood exhibited a number of photographs taken by these invisible rays, when Chinese white appeared as black. Incidentally they have their value in detecting certain chemical and other phenomena unseen by the eye, but in pictorial photography we would rather be without them. Hence the yellow filter, which may be introduced either as a lens cap in front or behind the lens, or in the diaphragm slot.

The Yellow Screen for Landscape.—Even with an ordinary plate the yellow screen will give better renderings of landscape effects, such as clouds floating on a blue sky, autumn tints, sheaves of corn, etc., etc. Some years ago we used a simple form of this light-filter, recommended by Mr. G. T. Harris in his little work on landscape photography, and it is a very serviceable one. It was made by dissolving 15 gr. of gelatine in 2 oz. of cold saturated solution of ammonium picrate; this was coated on two circles of flat cover-glass. When dry the two circles were cemented together with Canada balsam. If the slab on which the glasses are coated is inclined slightly, much of the liquid gelatine will flow towards one end. We can thus produce an extra filter for use when photographing landscapes in which the sky effects are worth preserving. This picrate-yellow filter does not interfere with colour values, except by subduing the violet; the exposure is about doubled.

Deep filters must be employed with caution in landscape work. They are very serviceable for dispersing mist on wet days and for afternoon work in cities. But the exposures are necessarily long, and there is the danger of over-correction of colour-values. A field of yellow corn may appear in the print as white as a snowdrift.

Many of the firms dealing in photographic apparatus supply sheets of gelatine stained for the purpose of making yellow filters. A single layer will double exposure, two layers require about four exposures, and so on. The best light-filters are made by staining gelatine with rapid filter yellow K. The making of such filters is now understood much better by manufacturers than in former years, and satisfactory patterns may be obtained at nominal prices. Such filters should, however, be tested, not only as to the extent they influence exposure, but as to whether they are made on optically correct glass or affect the focus. According to Sacco, the angle between the two glass surfaces must not be greater than one minute.

It must not be supposed, however, that any kind of yellow filter is suitable for use with all kinds of orthochromatic plates. Each needs its own particular filter to produce the best possible results, just as in the newer processes of actual colour photography. For this reason some makers are supplying plates which do not require any screen, a layer of easily soluble dye upon the surface of the film (which will disappear during development) acting as the light-filter. Dr. E. Koenig advises the bathing of ordinary dry plates in the preparation known as Erythrosine-filter-yellow. One gramme erythrosine-filter-yellow is dissolved in 120 c.cm. distilled water, and 60 c.cm. alcohol or methylated spirit is added. The solution keeps indefinitely in the dark.[1] The plates to be sensitised are carefully dusted and bathed in the dark for about three minutes in the dye solution, then drained and placed in a perpendicular position to dry. The drying must take place in a perfectly dark room without ventilator. As many as twenty-four quarter plates may be bathed in this solution, and the bathed plates generally keep better than unbathed plates of the same brand. The general sensitivity is reduced by about one-half. Plates made by the boiling method are not, however, very suitable for this treatment.

The above plates give a fair rendering of pale greens, orange, and yellow. For reds it is necessary to substitute one of the two new pinorthol dyes, No. 1 of which contains pinachrome,

[1] Or, separating the dyes, the same results may be attained with filter-yellow 7·7 gr., erythrosine 1·5 gr., water 21 oz., spirit 10½ oz.

and No. 2 pinacyanol in combination with yellow. With all these plates it is quite unnecessary to use a yellow filter on the lens. But there is some dispute among practical workers as to whether these dyed plates give satisfactory effects, as compared with orthochromatic plates and the screen.

It is not necessary to give very elaborate instructions as to when an orthochromatic plate is proper or the reverse. For landscapes of all kinds it is a decided improvement; but when the atmosphere is misty the worker must decide whether he wants mist or absence of mist in his picture, because the screened ortho-plate will ignore it more or less. At eventide, when the light is of yellow tinge, the filter is not needed, but on dull days the greens of the woodland are obviously improved by its use.

The advantages of ortho-plates over ordinary plates for marine pictures and seaside effects are very great, and the yellow screen must be employed to compensate for the intense illumination and the omnipresent blue rays. For the delicate colouring of flowers and fruit, as well as for fabrics and in copying paintings, the ortho-plate follows as a matter of course, the yellow screen being less necessary if the source of the illumination be gas or oil. For instantaneous work, even, it will frequently commend itself, and for interiors when there is much colour and time can be spared for a very long exposure. The chief point to be noted is that an ortho-plate is more useless than any other if under-exposed, but it will bear a tremendous amount of over-exposure.

Compensating Screens.—For some special departments of work it is sometimes found advisable to employ colour-compensation screens of various tints, in order to secure the maximum amount of contrast. The rule, which will, however, admit of exceptions, is to photograph a coloured object through light of approximately the same colour, if contrast within its own structure is desired. But if the main purpose is to obtain contrast with adjacent objects of other colours, then it should be photographed through light of complementary colour.

Development.—In the development of orthochromatic plates no unusual difficulty is likely to occur. Nearly every developer is suitable, provided that the worker is sufficiently experienced in it to keep matters under control. Density comes more quickly than with ordinary plates, and the object of colour-gradation might be lost if the negative is allowed to get too hard. The light of the dark room must, however, receive attention. Deep ruby might serve with care, but the ruby light is most unpleasant to the eyesight and very difficult to discern objects by. Dr. Koenig advises a combination of red and green in two separate sheets of glass, the gelatine sides facing each other. Such light is not only safe, but is most agreeable to the eyes. The proper dyes may be obtained, and are mixed for use as follows :

Red.—500 c.cm. 6 per cent. gelatine, 4·5 grammes dark-room red dissolved in 100 c.cm. water.

Green.—500 c.cm. 6 per cent. gelatine, 4 grammes dark-room green in 100 c.cm. water.

Dark Red.—The same proportions as for red.

7 c.cm. dyed gelatine will coat 100 square centimetres of glass.

Messrs. Newton and Bull advise the following screens :

1.	Tartrazine . . .	1 mgram.	per sq. centimetre of glass.
	Rose Bengal . .	$\frac{1}{2}$,,	
2.	Methyl Violet . .	$\frac{1}{2}$,,	,, ,, ,,

The proportion practically comes to $\frac{1}{10}$ and $\frac{1}{20}$ gr. respectively to the square inch of glass. The red screen transmits light from the end of the visible red to λ 5,900 in the yellow. The methyl violet absorbs from λ 6,400 to λ 5,000, leaving only the extreme red, to which the best panchromatic plates can only be very feebly sensitive.

For further particulars on this subject we must refer the reader to Dr. Koenig's *Natural Colour Photography*, translated into English by E. J. Wall ; *The Photography of Coloured Objects*, by Dr. Kenneth Mees, D.Sc. ; or *Colour Correct Photography*, by T. T. Baker.

CHAPTER XV

INDOOR PHOTOGRAPHY

Interiors.—We may sum up the difficulties of this subject under two heads, viz. those of perspective and those of lighting. Only the case of the small interior is dealt with here. Churches and other large buildings are treated in the chapters on Architecture.

The great problem in interiors of this kind is that the average room is of no great length in comparison with its breadth, generally the proportion is not more than 3 to 2. How are we to get on our plate sufficient of the area to convey any idea of its size and arrangements? A short-focus lens is a necessity; but then, especially if the view be taken cornerwise, the edges may show distortion or at least exaggerations. In the end, the print will have to be trimmed down to cut off these exaggerations, and we shall be little better off than if we employed the long-focus lens. We can reduce this source of trouble most effectually by focussing for the foreground, by stopping down the lens sufficiently, and by accuracy in levelling the camera. The focussing screen must be absolutely vertical.

To arrange a domestic interior in order to produce a successful picture generally requires the exercise of an inflexible will and an indifference to giving trouble. Tables have to be moved out of the way, curtains and hangings adjusted; every picture must not only hang exactly straight, but the glass surface must be *dusted*, for the camera will betray all these little deficiencies.

Lighting will present fewer difficulties, if only the source of light is behind the camera. But this in drawing-rooms and studies can very seldom be arranged. It is not merely the dangers of halation from windows; these can at least be mitigated by the use of backed plates or film negatives. The great trouble is that the contrasts of light and shade are so excessive when the windows either face the operator or are on one side of him. Sunny days are unsuitable for taking such interiors, and very often it is well to shade the window with curtains or blinds, and rely upon the flashlight for the actual exposure.

The smoke of magnesia is not altogether desirable in private apartments, but it is difficult to suggest any flashlight mixture that is not attended by disagreeable fumes. A favourite mixture is composed of

Picric Acid	35 gr.
Chlorate of Potash	50 ,,
Powdered Magnesium	12½ ,,

Owing to the explosive nature of picric acid it needs great care in mixing. The materials should be gently shaken together on a sheet of paper, put up into pill-boxes, and lighted with a long taper on a metal plate. A safer mixture to handle is

Powdered Magnesium	10 gr.
Sodium Nitrate (powdered)	50 ,,

This gives a good colour rendering. On the whole, flashlight candles are the best and safest to use, especially indoors. Flashlight powders are always more or less explosive, and must be fired on an open metal surface. The reservoir flash lamps are only suitable for magnesium powder.

In photographing crypts, caves, and suchlike dark places with flashlight, Orostini's table shows the quantity of magnesium to increase approximately, in proportion to the square of the distance in yards. Thus, supposing an object at 1 yard distance requires 1½ gr. magnesium, 2 yards will demand 4 times as much, 3 yards 9 times, 4 yards 16 times, and so on. The amount must also be doubled for each stop in the diaphragm beyond *f*/8. The focussing in these dark caverns must be estimated by scale. M. Martel, the explorer of the caverns in Southern France, used for distances under 15 metres three or four strips of magnesium ribbon each about half a metre (say 20 inches) long wound into a spiral torch, which gave an exposure of from 1½ to 3 minutes. Three of these were enough up to 15 metres, one spiral serving well up to 10 metres. In all cases the charge must be fired behind the lens of the camera.

Copying.—Engravings, black and white, and all line work should be fastened to a vertical easel, and lighted as evenly as possible. If the light is on one side only, a white sheet may be hung on the opposite side as a reflector. The lens should be hooded. A glass-covered studio with windows all round is preferable, or still better, the open air. A long-focus lens which will just cover the plate to its edges is the best for the purpose; if the focus is too short, the shadow of the camera will probably show in the negative. Some kind of frame to keep the pages straight and level must be contrived when copying out of books; and if there is printing on the other side of the page this should be backed with some black material such as black paper, or there will be danger of its partial appearance in the negative. Photo-mechanical plates are usually employed with a small stop, e.g. *f*/22 will be scarcely fine enough; and the exposure is therefore a long one, probably more than one minute near the window. For developer, hydroquinone, adurol, or glycin will give the best results. The lines of print must stand well defined on the negative as clear glass on a black ground.

Engravings, etc., may also be copied by artificial light, and have the advantage of a constant time of exposure whatever the season of the year. Two Welsbach C burners near front of camera will under ordinary circumstances give exposure of under five minutes, and two duplex burners four times as long. The burners may be backed with two pieces of white cardboard or tin bent into concave shape in order to shade them from the camera lens, and concentrate their light upon the object to be copied. Or a measured length of magnesium wire is often burnt, first on one side, and then a similar quantity upon the other side. The light must be as near lens as is possible without the danger of stray rays impinging on the surface of the front combination.

In photographing books in libraries, Herr Fassbinder adopts an ingenious device, which will save a great deal of trouble. The camera is fitted with the reversing mirror, generally adopted in the photo-engraving processes, which allows of the open book being simply laid on a convenient shelf below it, and the page kept flat by weighted lengths of silk. The originator uses bromide paper, which gives white lines on a black ground. For ordinary copying purposes the plate would have to be inserted in the dark slide, glass side outwards.

Photographs are usually copied under the same conditions as engravings, except that ordinary plates, or those of medium rapidity, are employed, and are developed carefully in order to retain as much soft detail as possible. Bromides and platinotypes seem to give the best results with photo-mechanical or slow lantern plates. Many operators prefer to copy a bromide print while still wet—that is to say, squeegeed on to a glass plate and surface-dried with blotting paper.

Pictures.—Framed pictures sometimes have to be copied *in situ*, hanging on the walls of the gallery. The camera must be slanted to as nearly as possible the same angle from the perpendicular, and exposure assisted with flashlight. But the results are not likely to be satisfactory. Oil paintings are best copied in sunlight, and the exposure, even under these conditions, is often a very long one. Isochromatic plates must be used, and, by daylight, the yellow screen for both oil and water-colour pictures. With an oil painting the varnish, brushmarks, cracks and other inequalities of the surface create most injurious reflections, and in some particular directions these irregularities are very strongly marked, and especially in diffused light. For this reason, unless direct

Will Cadby.

CHILD STUDY.

p. 144]

sunlight can be secured, gas, oil, or arc lamps focussed directly upon the surface of the picture should be chosen. The lens can be worked at a comparatively large aperture.

Stained-glass Windows.—These, we find, give the best results when the light is not too strong. A yellow screen is often not necessary, but an isochromatic plate must be used.

Faded Documents.—The documents must be photographed by as powerful a light as possible, direct sunlight, or the light of an arc lamp. A faded inscription usually takes the form of faint yellowish markings: these, Dr. R. A. Reiss recommends, should be brought out by a blue filter of ammoniacal sulphate of copper solution in a glass cell. A gaslight paper will allow of these marks being further intensified. Repeated reduction and intensification of the negative is another valuable method. Each stage will mark a further degree of contrast.

Finger Prints.—The following methods were recommended by Mr. H. Nolan in a recent article in the *British Journal of Photography.*

1. Finger-prints in dust: (*a*) On colourless glass; illuminate by transparence with oblique light; dark background: (*b*) On dark surfaces (a very easy subject); illuminate by direct light.

2. Finger-prints in grease (ordinary finger-prints). (*a*) On light surfaces such as china plates; dust on (dry) very fine graphite powder; blow off with bellows, etc., *not with breath.* The "dusting on" is best effected by charging a heavy flat-ended camel-hair brush with the powder, holding it near the surface, and jerking it by a blow on the hand which is holding it. (*b*) On dark surfaces, such as the black or green paint of a safe, mahogany furniture, etc.; treat similarly, using fine, dry whitelead powder. (*c*) "Invisible" finger-prints on paper. Develop with aqueous solution of silver nitrate (5 to 8 per cent.).

3. Finger-print in blood on dark surfaces (e.g. black bottles). In dark room illuminate by direct rays of arc or magnesium light, preferably concentrated. One may get reflections, but the pattern of the papillary ridges will stand out clearly.

Works of Art, Coins, etc.—Several methods have been suggested for reproducing medals and coins. The easiest way in the end, perhaps, is to photograph a plaster-cast, stained to a shade that will correspond with the metal of which the original was made. Another way is to spray the medal with grey colour from an airbrush, or to smoke it over burning magnesium ribbon. Some have tried with success a single swinging lamp as the source of light, thus destroying reflections. At the L.C.C. School a special method has been devised by Mr. W. I. Smith for fastening the medal on the easel. An aperture is cut out of millboard corresponding roughly to the shape of the medal but a little smaller. It is then cut in half, the medal is laid down on the copying board and one half of the millboard placed on each side of it. These can be wedged up closely and pinned down with drawing pins, so that they hold the medal safely.

Dr. E. Demole has illustrated the catalogue of the Numismatic Society of Geneva by a very ingenious process. The coins or medals are placed between two sheets of thin white glazed card, and damped. The whole is put between two pieces of thick felt and submitted to strong pressure in a copying press. The impressions are then lighted from one side, and photographed on to smooth glazed bromide paper. As the cardboard impression reversed the lettering, the result is a true positive, and owing to the shadows cast by the side lighting, a good representation of the essential features of the coin.

Highly polished metallic surfaces, especially silver, must either be dulled by immersion in ice-cold water, or dabbed over with fine white powder. Brasses or other engraved metals are generally smeared over with putty. The lighting may sometimes be contrived from one side, so as to diminish the reflections from the polished surface. Glass vessels are filled with some yellow or faintly pink liquid, and the interstices of the engraved pattern filled in with French chalk, and afterwards dusted to remove the chalk from the rest of the surface.

Duplicate Negatives.—The best method is to make a transparency by direct contact in the printing frame, either on a photo-mechanical plate or the slow lantern plates which may now be obtained in all sizes for the purpose. From this any number of new negatives may be made, using the same kind of plates as were employed for the transparency.

Reversed Negatives.—A reversed negative is a great saving of time in the carbon process and is useful for many photo-mechanical operations. Such negatives are made (1) from transparencies in the enlarging lantern, (2) by photography with the reversing mirror, or by putting the plate in the dark slide with the glass side uppermost, (3) by contact. Soak a dry plate for five minutes in a 10 per cent. solution of potassium bichromate to which an equal quantity of methylated spirit has been added. Blot off and dry in a dark place. When dry expose in the printing-frame in contact with the negative to be copied until the image can be faintly seen through the glass at the back. Then develop in any alkaline developer, and fix as usual.

Another way sometimes recommended for securing a reversed negative is less reliable, but most interesting as an experiment in the reversal of the latent image. Expose an ordinary dry plate (in the printing frame in contact with the negative) to diffused daylight for about 30 secs. being over 100 times the normal exposure. If development is carried on with ferrous oxalate or hydroquinone, a reversed replica of the negative will present itself. The reason probably is that prolonged action of light brings about a chemical change in the upper layer of silver salts which enables it to protect from further action the layers beneath it.

Theatrical Scenes.—Mr. Arthur Payne adopts an ordinary dry plate of medium sensitiveness bathed for three minutes in the following bath:

Distilled water	400 parts.
Ammonia (·880)	6 parts.
Orthochrome T stock solution (1 : 1000) . .	8 parts.

The bath is filtered before use, and the temperature about 65° Fahr. After bathing the plates are washed for three minutes and dried in the dark, preferably in a drying cupboard. They should be used within a week or ten days of bathing. The sensitiveness to yellow light is increased wonderfully by this treatment, frequently up to 500 H & D.

Mr. Payne has secured some remarkable successes with these prepared plates, which enable scenes in a theatre to be photographed during the performance itself, without any alteration of the stage lighting. Some of these required only $\frac{1}{8}$ of a second at *f*/4. A longer exposure than this is of course desirable, and two seconds at *f*/8 would be a more general rule. The nearer the camera to the object, the shorter may the exposure be. For scenes of the whole stage, the worker may occupy a position in the dress circle; for single figures at the side of the stalls.

Flowers and Fruit.—Studies of this kind are often to be accomplished by artificial light. Sprays of cluster roses look well on a background of black velvet. Dull-surfaced vases, etc., may be used for bunches of flowers or piles of fruit, and no sprays should be allowed to project too far forward, as the focus is necessarily short and the field of sharp definition a narrow one. Cardboard reflectors, bent into a concave semi-cylindrical shape, will mask the lamps and concentrate illumination upon the object.

Frederick H. Evans.

"LESBIA HATH A BEAMING EYE."

[p. 149

CHAPTER XVI

PORTRAITURE: MATERIALS

AN idea is current among many people that an extensive outfit is necessary for the production of really good portraits and also that the most perfect and most expensive apparatus should be used for that purpose. It is a fact, however, that there is scarcely any art wherein the result depends less upon the actual tools employed, and more upon the intelligence and proper use of them, than in photography.

Costly appliances alone can never guarantee good results. In no work does the condition of success lie with the operator in a greater measure than in photography. A strong individuality coupled with a sense of the beautiful is very nearly if not quite as great a factor in photography as in painting or any other of the graphic arts. In addition, the photographer, certainly the portrait photographer, must have a quick decision and a thorough technical knowledge, and he will then obtain good pictures with the simplest materials.

The Camera.—For a beginner desirous of making a start the half-plate size is to be recommended. The picture which it enables one to secure is large enough to produce a satisfactory effect when suitably mounted. It is also a very convenient size for travelling, and negatives of that size can, if necessary, be enlarged. The camera should have at least a double extension, to allow of the use of long-focus lenses. The front of the camera carrying the lens should be quite rigid, because the longer the focus of the lens, provided the aperture remains the same, the heavier the lens becomes.

The front should also have a rise and fall and, if possible, a side movement; and either the focussing screen or the lens front should have a swing movement.

The Lens.—The point which most beginners probably consider to be the most important is that of the lens. Undoubtedly it is an important factor, but not nearly as important as is commonly believed. Modern rapid lenses of the anastigmatic type may be described as quite universal instruments, their main characteristic being the power they possess to draw with extraordinary accuracy. Strange as it may appear to the beginner, it is a fact that this remarkable power of definition may detract greatly from the artistic value of the portrait. It follows therefore that a lens possessing great depth of definition at full aperture should be avoided when we are bent on *pictorial* portraiture, since it is impossible to separate that portion of the picture which is to concentrate the interest from the background—this latter being merely an accessory to the main idea—the portrait, or the figure. Another reason against their use is, of course, that the background would be rendered almost as sharp as the portrait itself, whereas it should be kept subdued and without obtrusive details.

We must have the power to distribute the definition or the accent at will, and this is only possible with lenses which have not a great depth at full aperture. To this class belong the Goerz double anastigmat B., Voigtlander Heliar, Zeiss Unar, and some other well-known makes. They are of a slightly different type from the modern anastigmat before mentioned, and work at an aperture of about $f/4{\cdot}5$. Under good lighting conditions, and provided the sitter can remain still for the longer exposure necessitated, the use of less rapid and far less expensive lenses may be recommended.

Many workers use, with success, the simple uncorrected lens. The soft definition given by its combination is so pleasing in effect as largely to counterbalance the defect of slowness. A cheap portrait lens can be made by taking a R. R. lens and using the front half only, thus obtaining a so-called "landscape" lens, giving soft drawing with a moderate depth of focus. Of course, when dealing with nervous persons or children, or if the light is poor, it is essential to employ the rapid lens. According to the conditions present there will always be a difference of opinion as to the relative merits of the single lens and the more powerful corrected lenses of modern type. But a really good double cemented lens, combining great rapidity with moderate depth and soft drawing, does not, as yet, exist, although with at least one well-known type it is possible to partially unscrew, and by thus separating the condition of the back combination obtain a soft and much more artistic result.

Focal Length.—An important and much disputed point is the focal length of the lenses. Roughly speaking the focal length should not be shorter than the diagonal of the plate to be used, and even then, with such a short focal length as this represents, it will be necessary, should it be desired to take a large-scale portrait, to bring the camera so near to the sitter that the peculiarities of faulty perspective will appear in the picture. We need not in this place discuss what those peculiarities are, or explain the reason for their existence. Suffice it to try an example to prove that, though the position may have appeared quite natural to the photographer, the drawing will be so ridiculously exaggerated as to destroy any chance of a satisfactory rendering. At the same time it should be pointed out that the peculiar perspective is only due to the wrong use of the lens, and not to any faulty quality inherent in it. It is produced simply by the lack of distance between the camera and the sitter, in relation to the scale of the portrait. Of course, if the idea is to enlarge the subsequent result, it is quite possible to use a lens of quite a short focus, but where, as will be mostly the case, the resulting negative is intended to be used direct, a lens of not less than double the diagonal of the plate should be used and this will be the length for head and shoulders and half-length portraits ;

for large heads the focal length of the lens should be even longer than this.

This faulty drawing caused by the use of short-focus lenses is the reason why so many amateurs' portraits are unsuccessful. From what has been said it will be seen that it is desirable to have at least two lenses of different focal lengths.

The Plate.—The plate used for portraiture must naturally be of a high speed and should be capable of giving a soft or strong negative in response to its treatment. It is particularly necessary that the plate shall be able to render the subtle tones of fine modelling in the human face which can give to the photographic portrait its peculiar charm, and which places in the hands of the pictorial portraitist such tremendous advantages over the painter artist.

Delicate drawing and expression of tones are injuriously affected by the defect known as halation, and this may be shortly described as the double image caused by reflection of the rays from the glass side of the plate. This defect is especially strong if the lens be directed against the light. It frequently happens that it is necessary to use an arrangement of this character and indeed many charming effects can be so obtained. When it is desired to work at any considerable degree against the light, we must employ "backed" plates in order to absorb the reflected light, and thus preserve the delicate gradation of tones.

Orthochromatic Plates.—The use of the orthochromatic plate for portraiture is to be highly recommended, but at present the longer exposure necessitated by the yellow screen discounts the value of this class of plate to some extent. In theory, of course, the plates are almost indispensable; the rendering of the tones and colour values is more correct, and it is one of the chief charms of a picture when these values are correctly rendered. The hair, for instance, has in each case not only a definite colour and tone value according to the personality of the sitter, but its own tone value is different from the flesh tones.

Only if we are able to correctly translate the relation of the tones, after allowing for the absence of colour, do we get a lifelike effect; and only thus does the flesh appear as real flesh, and the hair as real hair. The correct representation of tone values is the basis upon which all the claims on behalf of photography have been made by artist photographers. No graphic art can hope to rival photography in this rspect, and it is important therefore to develop the capacity to its highest exprcssion, and to this end the plate must be capable of giving a long range of gradation. This is not the place to discuss the authentic difference between the ordinary and the orthochromatic plate. It will be sufficient for the purpose to mention that the former is vastly more sensitive to blue and violet than to the warm green, yellow, and red rays, and, as is well known, white light is composed of certain proportions of all the rays. It results therefore that a plate which is only sensitive to a portion of the rays cannot give an entirely true rendering, and the effect would be still more inaccurate were it not that coloured objects reflect not only their own colour but a proportion of white light as well.

The plate manufacturer has great difficulties to overcome before a highly sensitive and harmoniously working orthochromatic plate of good keeping quality can be placed upon the market. But the time cannot be far distant when the demand for such will produce the supply, and the difficulties presented by the combination of high *general* sensitiveness with harmoniously working *colour* sensitiveness will be satisfactorily realised.

There are a few well-known and old-established makers, such as Messrs. Wratten and Wainwright, who even now produce exceedingly valuable material in this direction.

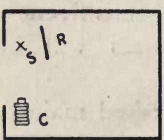
CHAPTER XVII

LIGHTING AND POSING

THE ordinary results obtained by the average professional worker might lead one to suppose that the possibilities both of lighting and posing were limited to a few stereotyped forms. As a matter of fact, the variety of lighting effects is almost endless, and in this respect can only be compared with the infinite variety available with posing the sitter when we come to deal with that point. It is here proposed to deal only with a few of the most instructive forms, which will serve as an impetus leading the student to consider the subject and, if he be possessed of sufficient enthusiasm, to make a series of experiments on the lines suggested.

Let us take an ordinary room with one window. The illustrations Nos. I. to VII. give an idea of the possibilities. No. I. shows the model sitting near the window; the light comes straight from the side as shown in diagram A. The side of the face turned towards the light is fairly well modelled; but the shadow portion almost disappears in darkness, and the result is inharmonious in effect. In cases such as these it is necessary to have recourse to a reflector, and we see in the following examples, Nos. II., III., how a decided effect can be obtained by its use. At the same time we must be careful not to produce the unnatural or exaggerated effect caused by too much reflected light, and thus suggest a double lighting.

A



The simplest form of reflector is a white sheet hung over

I.

II.

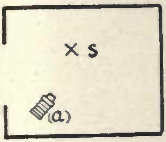
III.

IV.

a screen or clothes horse, or even a sheet of newspaper hung over the back of a chair.

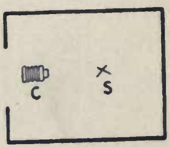
A strong reflected light can be produced by using a mirror. This was done in No. II., the position of the sitter being the same as in No. I. The mirror was held by another person at about knee-height in standing position. The difference is extraordinary. The whole of the shadow side, cheek and forehead, which had in illustration No. I. been almost completely immersed in the background, are clearly brought out, but the reflection is so strong that the face appears to be lit from two sources of light. The unnatural effect will be noticed in the left eye where the light spot surpasses in brilliancy the high-light in the right eye. This illustration demonstrates the fatal effect produced by the use of too strong a reflected light. The double lighting robs the face of its fine modelling and destroys possibly an artistic result.

B



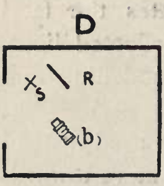
In No. III. a sheet of white bristol board was used instead of a mirror. In No. IV. the sitter was placed more towards the back of the room, as per diagram B, the camera being at (*a*). No reflector was used in this case. The result is that the head is sufficiently lit and the modelling satisfactory. If we bring the sitter to the middle of the room and opposite the window (No. V., diagram C) we obtain the so-called front lighting, a form of lighting which is usually interdicted in the handbooks. In this form of lighting practically all the shadow has disappeared and the form is marked by very slight contours. Nearly all professional workers refuse to admit this form of lighting, on the ground that the face is expressionless, owing to the absence of shadow. It seems, however, that it occasionally should be employed with the deliberate intention of giving effect either to an idea or to characteristics of the sitter, or

C



in such a case as a child's study where a delicate rendering is necessary. No one who has seen Cadby's child studies, nearly all taken with this form of lighting, will fail to appreciate at its full value the fascination of correct drawing, (see illustration, p. 144). One of the strongest points in favour of the photographic art can be demonstrated by this form of lighting more clearly than by any other, and it should not be condemned merely because it is rather more difficult to handle successfully. We must use such a lighting, of course, with discrimination. The effect, for instance, of using it in the case of a face naturally weak and unintelligent, would probably be to produce a senseless and idiotic expression.

Now place the sitter once more near the window, (diagram D), the camera being at (*b*), the effect will be as in figure VI. In order to soften the strong direct light it is well to pin a piece of butter muslin across the opening of the window; the effect of doing this will probably be much more noticeable in the resulting negative than it will be apparent to the eye, at any rate to the untrained eye.



In these few examples, some idea can be got of various lighting effects possible under the most simple conditions. How often has one seen it said that the student should make a series of similar experiments for himself, and it would be interesting to know how often this advice has been followed. It remains, nevertheless, the fact that by no other means can so rapid improvement be made, provided the experiments are conducted with ordinary common sense. Going through the few examples which we have made, we find that the characteristics of a person can be accentuated according to his position relatively to the light and to the camera. There is no secret in successful photography. It is a matter of common sense and principles, applied with judgment.

For instance, in the case of old people with well accentu-

V.

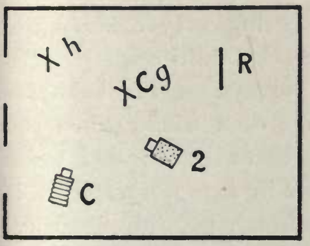
VI.

VII.

VIII.

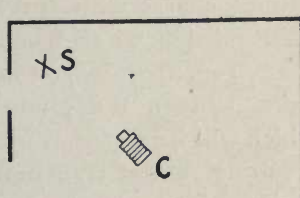
ated features, a soft light would be employed in order to avoid too great hardness and heaviness. But in the case of young people, where the face is full of "unwritten promise," a stronger and more accentuated light would be used in order to avoid weakness. Now, suppose that we have two windows; if we place the sitter at *g* (diagram E) the light will be received not only from the side window nearest to him but also in a more diffused form from the distant window, and thus will fall on the shadow side of the face and result in a soft harmonious light. Portrait No. VII. was taken under these conditions. The position of the camera and sitter was the same as in diagram B (illustration No. IV.) and a comparison in order to see the difference made by the second window is instructive.

E.



More interesting effects can be obtained by photographing the sitter against the light. If the sitter were placed in a direct line between the camera and the window, the face and figure would appear almost as a silhouette, and much too dark and hard, against the light behind it. A more pleasing effect will be obtained by placing the sitter a little away from the two windows. The figure is now lit from behind at an angle, and the profile stands out in fine relief against the dark wall. The effect is clearly shown in No. VIII. and diagram F. The sitter is placed between the camera and the corner of the room and the lens is pointed towards the light. To diffuse an otherwise too hard light the muslin curtains were drawn.

F.



Effects like the above may be resorted to in special cases, but they should be an exception rather than a rule. The treatment requires judgment and, what is intended as a subtle variation only, may easily become a bore and lead to a mannerism. It should be our endeavour to develop in all directions and never to allow ourselves to be limited to any special form or effect. It must be remembered also that such a pronounced form of lighting may destroy the likeness owing to the somewhat unusual conditions.

Under ordinary circumstances the eye of the beholder will not rest comfortably on the face of a friend when the latter is placed in front of the source of light; and when the result of such a lighting is seen in a photograph, it is at once considered extraordinary, although possibly beautiful in effect. (See illustration "Maud Allan—a study in tones.")

Posing and Expression.—After lighting, these two factors are most important, the one depending on the other. It is the duty of the portraitist to make a true and sincere picture of his sitter, and to do this he must avoid any attempt at "posing" as it is ordinarily understood. The subject must be arranged with taste, and the most perfect result will be obtained by the man who understands how to combine natural charm with truth. We would submit that success does not depend so much on the following of certain fixed laws of composition, as in the innate sympathy which must exist between the photographer and the sitter, sympathy which will be apparent by an increasing ease and naturalness, resulting in the true individuality of the sitter being duly expressed. Even the most experienced photographer cannot do much, if all he has is mere knowledge of the rules of composition. Nature must come to his assistance. Composition alone and study of effect on preconceived lines can do nothing. One may succeed in getting harmonious effects, but will at the same time lose the "soul" of the sitter, the one thing necessary in a portrait. It is of great help to study the work of others in this respect and to endeavour to see what it is that gives to a picture the attributes of

E. O. Hoppé, F.R.P.S.

MAUD ALLAN—A STUDY IN TONES.

p. 162]

success; and then to compare it with one of our own productions, and endeavour to find out in what respects the latter is lacking. Such an exercise is of great assistance for the purpose of strengthening the artistic perception, but, of course, if we are slavishly copying, we are not only untrue to nature, but we are stealing another man's ideas, and worst of all, putting a limitation on ourselves.

We have to observe our sitters keenly, but without obtrusiveness. They must be entertained in animated conversation, all apparently without special purpose. With little art they may be led to that part of the room where one effect or another can be obtained. In this connection, there is a great advantage in photographing the sitter in his or her own home. It is surprising how different one and the same person will appear under conditions which are quite familiar to himself as compared with his demeanour in the studio. We can safely occupy him with something or other, either writing or reading, in as easy a position as possible and leaving him the greatest possible freedom in his choice of position. Move the camera rather than the sitter, but watch him of course, with regard to the arrangement of lines and light. It is obviously wrong to choose the position of the camera and make the sitter shift himself to suit the convenience of the instrument. Thus in sitting down there is no possible chance of obtaining the sameness of effect, since every one sits in a different manner, and no two people will ever automatically take up an identical position. One cannot, of course, do entirely without alterations or suggestions; one must take precautions to prevent foreshortening or wrong perspective. But instructions to the sitter should be given as hints and suggestions rather than as definite requests. Let the alterations be made by him and never by the operator. Apart from the fact that the result will be forced, it should be considered "bad form" to touch your sitter.

An eye for harmony is more a matter of sympathy, strengthened by constant study of nature than a product of fixed rules of composition. Strive to obtain natural and sincere portraits and, in proportion to your efforts, so will come the success of your portraiture. Do away with posed attitudes, try to observe the varied expressions of life instead, and remember in this connection, that a result is not necessarily artistic because it is natural and according to nature. It is *selection* which makes nature artistic.

E. O. Hoppé, F.R.P.S.

WARD MUIR.

CHAPTER XVIII

PORTRAITURE: GENERAL REMARKS

The Hands.—Of the utmost importance is the treatment of the hands. The writer considers that they are almost of as great importance as the face itself; they are absolutely significant of the sitter, and they must be so treated as not to disturb but assist the general impression. This is not easy by any means. The weak feature in many an otherwise successful portrait is frequently the hands. Fortunately there is a way in which every beginner may overcome this difficulty, if he will use judgment and common-sense—by studying the Great Masters.

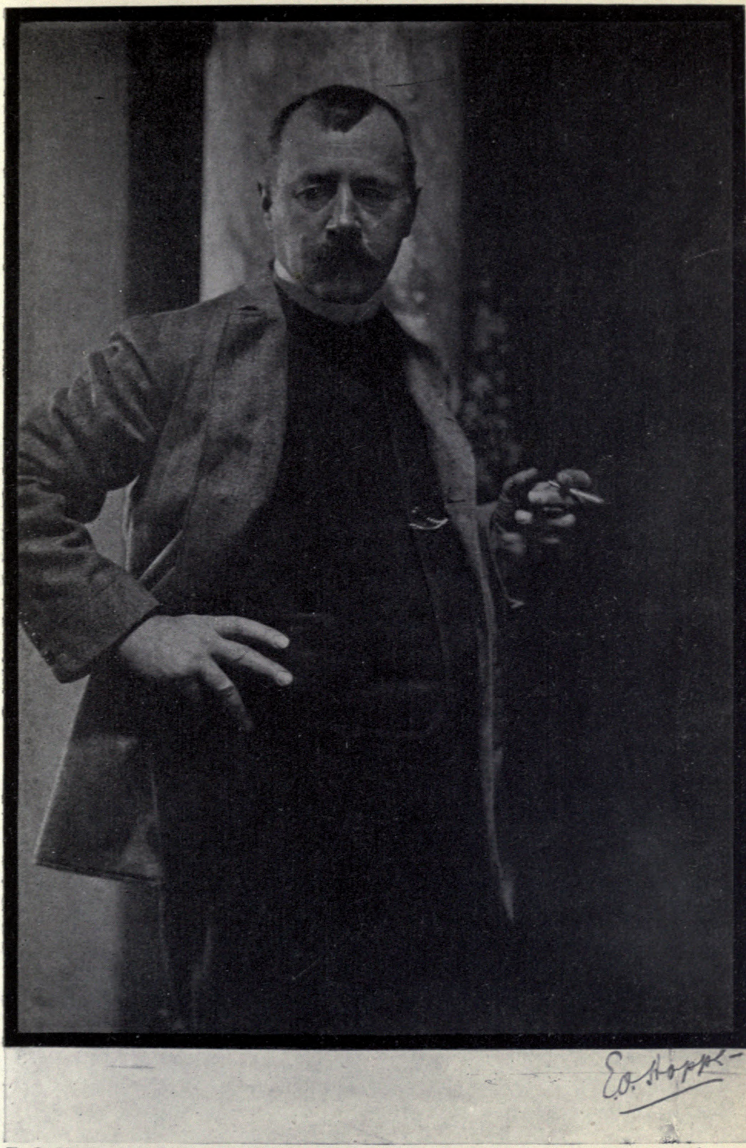
If there is any secret at all in the way to acquire success, it lies in the manner of the photographer; he must know or learn how to interest his sitter. A hint, which may be of some little use, is to take the sitter into confidence as to one's manner of working, and the idea which the photographer has for the treatment of the portrait in hand. The subject is bound to be an interesting one, but, of course, the photographer will never use any "arty" phrases, or such expressions as to "look pleasant."

The Exposure.—The height of the camera has its influence in the result. For standing figures it is advisable to have the camera slightly under the height of the eyes; for sitting subjects, slightly tilted towards the figure. According as the camera is above or below the head level, so are the proportions of the head modified.

Stops should not be used unless absolutely necessary, and for a particular purpose. It is important that the exposure should take as short a space of time as possible, and it is certainly better to use the lens at full aperture for the purpose of throwing the background out of focus, and making it subservient to the matter of chief interest.

Backgrounds.—The background and the surroundings should have a decided bearing on the sitter. As we can only deal with colour in a very limited sense, the enlivenment of the background by well-graduated and unobtrusive shades of light is of great importance. Here again a careful study of good painting will prove most helpful. Great painters never choose dull and lifeless backgrounds for their models, and the camera worker should strive to impart life to his work by a proper choice of surroundings. In connection with this great attention should also be paid to the method of treatment of a particular portrait, the "key" as it is usually called, according to the peculiarities of each individual sitter. One must not find salvation merely in dark sombre notes (a "low key"), or in high scales of a few delicates tones (a "high key"); but our aim should be many-sided forms of expression. It will be hardly necessary to point out here that it is a very great mistake if the sitter puts on a "special" dress for the purpose of having his portrait taken. The more taste a sitter possesses, the less necessary will he find it to dress or adorn himself otherwise for a portrait than for any other ordinary event in his life. It is only where special garments and special ornaments are of peculiar importance and signification that there is any peculiar object in assuming them—they serve as theatrical accessories. One would, however, like to see these kept in their proper place, as pictures of a *genre* nature. Frequently such pictures are theatrical, in so far as the subjects are shown in more or less artificial attitudes and surroundings, which only too often have no relation whatever to their ordinary everyday life.

The Eyes.—Modern portrait photography will still have to overcome a serious prejudice on the part of sitters—viz. that the eyes, when not fixed directly on the spectator, must be wide open and fixed on a certain point not far from the



E. O. Hoppé, F.R.P.S.

PROFESSOR HANS VON BARTELS.

[p. 167

camera right or left. The eye is the mirror of the soul. But how is this soul to be expressed if the photographic reproduction insists on the exact direction in which this eye is to look, by means of which eyelashes and eyelids are cramped in their play? Once in the family circle of the Maeterlinck, Yvette Guilbert posed absolutely still, without moving a muscle of face or body except the eyes, and through these she expressed hatred, love, contempt, pain, indifference, despair, and madness. How could that be possible if the pupil, lashes, and lids do not change their position with regard to each other, and alter the appearance of the eye? Without this constant living change, the eye would be deprived of its best power of expression. If the photographer works in such a way that he prescribes a special direction for the eye he only has regard to the aspect which appears most favourably to him and not to characteristic expression. It is a cause of thankfulness that lately some photographers have learnt to pay attention to the expression of the eye and permit greater freedom in the choice of the direction of the glance. Even the completely shadowed or apparently almost closed eye, when the head is bent, serves as a useful means at times for giving expression.

A good portrait must be not only a good likeness; it must reveal something of the character and temperament of the sitter, his surroundings, the depth of his mind and feeling, the manner in which his intelligence works, his social customs, and his way of regarding and passing through life.

Of course, it is true that many people do not want what occupies and influences them in their lives to appear and be fixed in their portraits—on the contrary, they wish to hide all that moves them under a mask of indifference or a dissembling smile. They prefer to be *conventional*, and are better satisfied when the photographer produces as flattering a portrait as possible, and effaces by retouching everything from the face which may express a distinctive passing feeling. But they overlook the fact that these momentary glimpses of feeling give the intellectual expression, and that when they are smoothed over and made to disappear the result leaves only a soulless mask.

When we next pass a shop that has a display of photographs of actresses or self-advertising beauties in the windows, it will be worth while to make this very simple experiment: Let us gaze at the collection for one minute, and we shall find a main impression that is left on our mind is one of "parted lips and even teeth."

No! we must "show Virtue her own feature, Scorn her own image, and the very age and body of Time his form and pressure."

Retouching.—Excessive retouching has been the greatest enemy of the proper original presentation of the portrait. It is the source of the smoothness and insipidity of the pictures which we find on postcards, etc., and which are so displeasing to cultured persons. This artificial beauty is very far removed from being equal to the beauty of a true portrait. Beginners frequently say that they can only take as their models handsome women, pretty children, and other pleasing subjects to do credit to their skill. But a picture may be made from any subject if it be properly and *naturally* treated, so that its very honest simplicity will cause a pleasing and a pleading impression of artistic truth.

Retouching should not be employed at all *except to remedy defects in the negative itself.* The so-called improvements made in the lines of the portrait destroy the likeness and lessen the artistic value of the whole. A portrait must be more than a likeness. "Not the exactness of the exterior," said Bonaparte to David, who was about to paint his portrait; "*a pimple on the nose makes the likeness.*" One might add to this: An orchid and an eyeglass are to some a portrait of a great statesman (now, alas! in ill health); and can I mention a big, a very big, collar without your at once thinking of "The Grand Old Man." The character and expression of the countenance must be depicted, permitting a glimpse of the working of the soul within.

It is absurd to *remove* wrinkles. Just let us think for a

Rudolph Dührkoop, F.R.P.S.

PORTRAIT STUDY.

[p. 169

moment. Let us bring back to our memory the grand old heads of Carlyle, Tennyson, Longfellow, Charles Kingsley, and that old pulpit warrior General Booth. The wrinkles on their faces are so many medals of honour—so many scars inflicted in their intellectual struggle and conquest—and each separate trace of time should be a mark of man's nobility. Each one of you will probably have some dear friend whose likeness you would wish to have near you when she herself has passed away. Do you want then to regard her as she was or as she was not? Do you want to have removed from her dear visage that delicate tracery round the temples that reminds you of her kindly humour, or those marks of patient resignation round the sweet old lips? I am sure you do not.

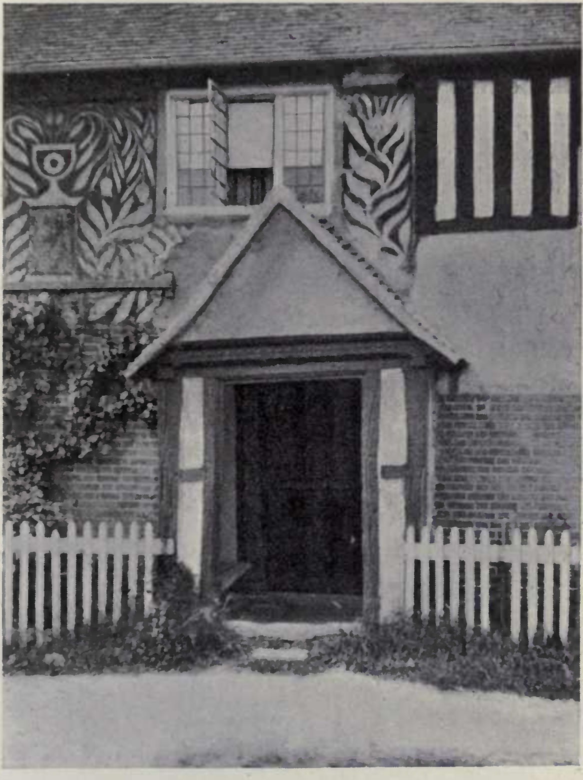
> If to her share some female errors fall,
> Look on her face and you'll forget them all.

CHAPTER XIX

ARCHITECTURAL PHOTOGRAPHY

IF any apology were necessary for the introduction of this chapter we might find it in the words of Ruskin. He says: "The greatest service which can at present be rendered to architecture is the careful delineation of its details from the beginning of the twelfth to the close of the fourteenth century, by means of photography. I would particularly desire to direct the attention of amateur photographers to this task; earnestly requesting them to bear in mind that while a photograph of landscape is merely an amusing toy, one of early architecture is a precious historical document; and that this architecture should be taken, not merely when it presents itself under picturesque general forms, but stone by stone and sculpture by sculpture." On the other hand, the modern student might dissent from the insinuation that architecture ceased to be worthy of record at the end of the fourteenth century.

The Study of Architecture.—There is, unfortunately, a widespread notion, among people who have never studied the subject of architecture, that it is dry and uninteresting; and the fact that it cannot be understood and enjoyed without a certain amount of preliminary study is probably the reason why the number of architectural photographers is small, compared with the many who devote their attentions to some more popular branch, such as landscape work. Instances of this lack of appreciation are sometimes met with in postal photographic portfolios, the remark, "uninteresting subject," on an architectural print being by no means uncommon; and we remember hearing, in reference to a successful photograph of one of the finest Norman churches in France, the following offhand expression of opinion: "Oh, that's quite ordinary, isn't it?"



COTTAGE WITH PARGEWORK, NEWNHAM, KENT.

Some knowledge of the history of architecture, the sequence of its various periods, and its artistic and scientific evolution, is most desirable, if not essential, for any one wishing to deal intelligently with this particular branch of photography. Good books by well-known authorities on the subject should be read, which, besides affording insight into the development of the art, will help one to distinguish good architecture from bad, and to decide what is worth photographing and what is not. There are two kinds of architectural photograph—"the picture," and "the record"—the former naturally being favoured by the photographer with a good eye for composition, and the latter by the worker of an archæological turn of mind; but the photographic apparatus necessary for either style of work does not materially differ.

Photographic Apparatus.—A stand camera is undoubtedly the most suitable type, as, although good work can often be done with hand cameras, they are usually more limited in movements, and less adapted for use with lenses of various foci. In deciding the question as to what size of camera and plate is best for this class of work, many points have to be considered. The chief advantage of the big camera is, of course, that a large negative enables one to make prints of an effective size direct in any process; perhaps also the composition of pictures on the focussing-screen is easier, and defects such as halation, pinholes, and other flaws are less noticeable in contact-prints than in enlargements. On the other hand, if the worker is content with a small negative, and does not mind the trouble of making enlargements, we think the small camera is far preferable. Points in its favour are, less initial expense on outfit, less expenditure on plates, and greater portability, also the greater depth of field given by the shorter-focus lenses permits of their being used at comparatively large apertures—a great advantage when poorly lighted interiors are to be photographed.

It is essential that the camera be provided with ample rise and axial swing of front, or a swing back. The front movement is much to be preferred, as it does not necessitate an alteration in the position of the tripod after it has once been placed at the correct level, and final adjustments can easily be made with the head under the focussing-cloth.

When the lens is of sufficient covering power, it is better to simply raise the front rather than swing it, and with a first-class lens this can be done to a considerable extent without showing appreciable falling off in equality of illumination. A larger stop, too, can be used than that necessary if the front of the camera be swung, and the lens stopped down to correct the effect of the axis of the lens not being at right angles to the plate. The swing-front, however, is useful when the lens is of small covering power, and a long exposure is not inconvenient.

Lenses.—It is always advisable to carry two or three lenses of different foci, so as to have a choice in the matter of what to include on the plate from a chosen view-point. Although the rule of "use the longest focus lens you can" holds good in architectural photography, it will be found that generally for interiors a lens of what some pictorial workers would consider short focus is the most useful, for example, 4 to 5 in. for a quarter plate. For this size of plate a battery of lenses of 4, 5, and 6 in. equivalent focus would meet most requirements, and for larger plates lenses of proportionately longer foci. Many lenses are convertibles, and the separate components may be useful for detail work, or when a narrow-angle lens is required; but this is seldom, except with distant general views. For this branch of photography anastigmat lenses are to be strongly recommended on account of their covering power and large field of critical definition.

Levels and Tripods.—For general use a good circular spirit-level, accurately screwed on the top of the "body" of the camera, that is, the frame which carries the reversing back, is all that is required in this direction. But in cases where the back is likely to be used tilted (as when we come to deal with telephoto work) a T or double-tube level will be preferable. Occasionally a level suitably mounted for placing against the focussing screen and back of camera may be of assistance.

Some workers make a point of recommending a large and heavy tripod; but, used with care, the ordinary tripods supplied with camera sets are, as a rule, sufficiently rigid.

Exteriors.—To the careful worker the photography of exteriors will present few difficulties. It is often better to be content with taking portions of a building than to crowd the whole of it on to the plate by means of a very wide-angle lens, most architectural subjects requiring plenty of foreground. The camera should not be placed directly opposite to the subject (unless "elevation" records are wanted), but rather to one side. Care should be taken that the back of the camera is perfectly vertical, and the exposure in court-yards, or when porches, arcading, etc., are included, and in detail work at close quarters should be liberal.

Figures.—There are two methods of exposure with the stand camera, in localities where people are passing frequently. One is to arrange the subject on the screen, get the plate in position, watch until the figures passing are in suitable positions, and then make an instantaneous exposure by means of a shutter. This is often the better way, as well-placed figures usually help the picture, and give it life; but care must be taken that the front is not raised very high when using the lens at a large aperture, or inequality of illumination will become noticeable. The other way is to stop the lens right down, and give a long exposure, with the result that the moving people generally do not show at all. If any one should stop, or loiter in the view, the cap may be replaced, and the exposure completed in sections. For these exteriors with figures, which sometimes will almost come under the heading of street scenes, if the subject is not a difficult one, a reflex camera, provided with a good lens and rising front, is the most convenient instrument to use.

Occasionally, also, figures may add value to records of buildings, by giving a scale, but as a rule they are better omitted. They are apt to claim more attention than the actual subjects of the photographs. Yet, however much one may be inclined to dispense with figures, it frequently happens that when the stand camera has been erected in the street, small boys and girls take up positions in front of the building it is desired to photograph, and stand eagerly waiting to be "took." When this occurs, the best plan is to get everything ready, make a feint of exposing, and then look about, ostensibly for fresh subjects. The youngsters will most likely move away, or else come alongside to admire the camera, when, provided they are outside the angle of view, the exposure may be made. Even should this ruse not answer, the lighting up of pipes, or cigarettes, coupled with an apparent loss of interest in the subject, will very soon have the desired effect; indeed, it is surprising how quickly the youthful patience is exhausted. When engaged in the telephotography of elevated details, it is sometimes very amusing to see a number of these little ones carefully posing themselves for their portraits, blissfully unaware that there is not the faintest possibility of their appearing in the resultant photograph.

Telephotography of Details.—There is a great deal of beautiful sculpture, both of figures and foliage, in the doorways (especially in the tympana and archivolts) of many cathedrals and churches, and this can undoubtedly be best recorded by means of telephotography. Accordingly, if much detail work be contemplated, a telephoto lens will form a very useful addition to the kit. The simplest and best way is to get a telephoto attachment (or negative lens with rack and pinion) fitted to the lens (positive) that is commonly used with the camera. For architectural work, a negative lens of about half the focus of the positive lens should be employed, and the two combined will form a telephoto lens of medium power. The chief point to remember in detail work with the telephoto lens, when the subject is above the level of the camera (which is nearly always the case), is that, when tilting the camera the back should not be kept vertical, as when using ordinary lenses. At all times, when only slight tilting of the camera is necessary, we strongly recommend that the back of the camera be allowed to tilt with the rest of the instrument. It will be found that this method gives good definition all over the plate at a fairly large aperture, and convergent distortion is negligible. Even when the tilt is considerable this may be the better way, in order to ensure good definition at top and bottom of the plate, and the distortion can be subsequently corrected when printing. If the back be kept upright when tilting the camera, the vertical lines of the subject will show divergent distortion in the photograph, the cause of which has been explained by Mr. A. Thomas as follows: "The reason of this is the alteration of the angle of the cone of light in the camera, through the magnification of the image, without a corresponding increase in the extension of the camera."

In practice we have found the following rule give results showing no appreciable distortion. Let the back tilt with the camera and, when the subject has been focussed, measure the camera tilt with a plumb line and protractor. Find out the proportion of the complete focus of the combination which lies in front of the negative lens, and set the back at an angle of the same proportion of the full tilt from the vertical. For example, suppose a 6 in. positive combined with a 3 in. negative attachment is being used at 3 magnifications, and the tilt of the camera from the vertical is 25°. The focus of the combination is 18 in., and the camera extension, from back lens, is 6 in.; thus the proportion of focus in front of the back lens is $\frac{2}{3}$. The tilt of the back from the vertical should then be $\frac{2}{3}$ of 25°—namely 16° 40′.

A tilting table, although convenient, is by no means necessary in most telephoto work, as the required tilting can be done with the tripod, provided one of the legs be set in the centre at the rear, instead of in the more usual position in the front.

Focussing.—When the subjects being photographed are not well lighted, focussing is sometimes difficult, as, even at fairly low magnifications, the tele-lens admits comparatively little light. In such cases a good focussing magnifier, used on a part of the screen, which has been rendered clear by

E. A and G. R. Reeve.

cementing a piece of very thin glass to the ground side of it with Canada balsam, will be a great help ; but the magnifier must be accurately adjusted.

When photographing details at the back of deeply recessed porches, what lighting there is is necessarily direct. This tends to flatness and lack of relief. The defect can be remedied to some extent by strengthening contrast, either by intensification of the negative, or by using a strong printing medium, such as gaslight paper.

CHAPTER XX

ARCHITECTURAL INTERIORS

Composition of View.—Only the briefest suggestions can be given as to the general arrangement of interior views on the focussing-screen, as so much will depend upon the subject; but there are a few rules which apply to most cases. The camera should not be placed in the middle of a nave, aisle, or passage, but nearer to one side, so as to avoid a too symmetrical arrangement of lines. If arches form a prominent feature, some support should always be shown (a column, or portion of one) at the side of the photograph. The effect of an arch springing out of the picture, either at the side or top, is almost invariably bad. The greater the amount of unsupported arch shown, the more unpleasing will be the result. If the apex of an arch cannot be included, it is usually more satisfactory to cut off the arch just above the capitals. Bases of piers and columns should always be included. Sacrifice the top of the picture rather than foreground when it is found impossible to take all that is desired on one plate, except in record work, where pictorial effect is not a consideration. A rather low view-point, such as the level of the eyes of a person sitting down, or kneeling, will often give a pleasanter result than a high one, as the latter tends to make the foreground appear "steep." When difficulty is experienced in including the top of the subject and sufficient foreground, it can frequently be overcome by lowering the camera, and further raising the front.

The photographer of interiors is often hampered by chairs

E. A. and G. R. Reeve

CHOIR OF ST. PIERRE, CHARTRES.

[p. 179

and benches, and, when possible, these should be moved out of the way. When they are too numerous for this to be done, or are fixtures, advantage should be taken of any opening, or passage, to break up the foreground, and help the eye into the picture.

There are various dodges for preventing the ends of tripod legs from slipping on a smooth floor. Pieces of rubber or cork may be fitted to the points, or a string tied round the legs. Some use a device of three thin slats of wood fastened together at one end, and radiated and having indentations in which to place the points of the tripod legs. A mat may sometimes be handy, and will serve the same purpose. But with most floors, in cathedrals and churches, there is usually no need of these devices, if the tripod legs are not spread very wide.

Focussing.—The usual method of focussing, that is, focus the principal object, and stop down till the rest of the picture is sufficiently sharp, applies to interior as to exterior work. The amount of stopping down necessary to secure the requisite depth of field will of course vary with the length of focus of the lens. With a lens of five inches equivalent focus, provided the covering power and definition are good, there is often no necessity to use a smaller stop than *f*/8 or *f*/11, and with many subjects even *f*/6 gives satisfactory results. The photograph of the choir of St. Pierre, Chartres, reproduced on the opposite page, was taken on a quarter-plate (Lumière anti-halo) with a five-inch lens at *f*/8. Some photographers, in taking general views, focus an object roughly a quarter of the distance from the foreground to the furthest point, and then stop down till the latter is sharp. In very dark interiors a focussing magnifier, used as recommended for telephotography, is of great assistance. When, owing to insufficient light, difficulty is experienced in seeing how much foreground is included on the screen, or how much at either side of the picture, a piece of white paper or a handkerchief placed on the floor will often prove helpful, or, if the photographer is fortunate enough to be working with a friend, a lighted match, held in the required position, will enable him to find the nearest point of foreground, and also to judge the focus. The same methods are useful in focussing any dark object in a bad light.

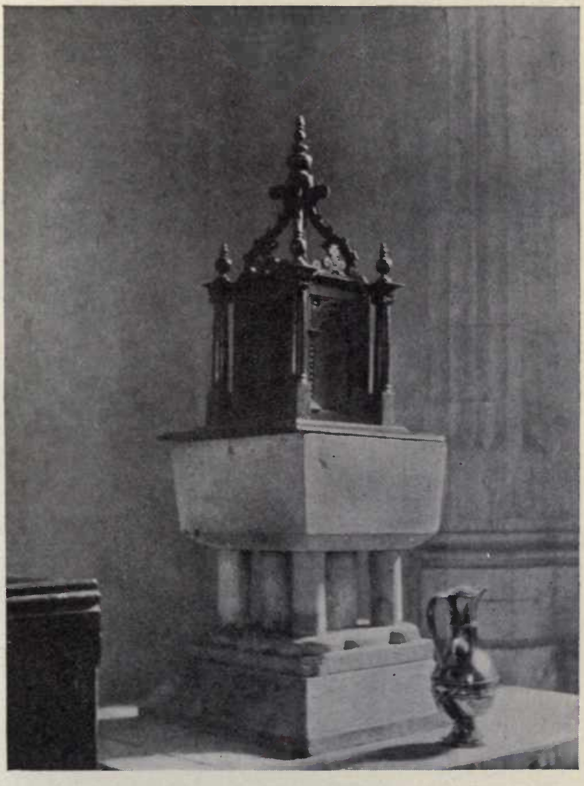
Flashlight is sometimes employed to lighten dark shadows in interiors, but it will seldom be found necessary. When used in this manner as an auxiliary to daylight, care must be taken in selecting the position of the flash so as not to produce a false lighting, which could not possibly have come from a window or doorway.

Exposure.—There is considerable diversity of opinion among architectural workers as to the utility, or otherwise, of exposure meters for interior work. Some experts hold that meters are practically valueless, while others strongly advocate the use of them on every possible occasion. Personally we have found that the paper supplied in meters is not sufficiently sensitive to interior lighting, and we have known the correct time of exposure elapse without the paper showing any perceptible sign of change, let alone darkening to the "quarter tint." When the light is coloured by stained glass the relative sensitiveness of meter and plate may vary widely.

A simple rule, which many workers find helpful, is to stop down until detail is only just visible on the focussing screen in the darkest parts of the subject, and then expose for ten minutes, using an extra rapid plate. Such a method no doubt forms a useful guide in determining exposure, but there are varying factors which must be taken into account, such as the actinic value of the light in different interiors, and also the visual ability to discern details on a dark focussing screen, a faculty which all photographers do not possess in equal measure.

A little experience, however, will soon enable a careful worker to judge with a fair amount of certainty what exposure should be given, particularly when notes of previous work have been kept, and are, as they should be, available for reference.

Woodwork.—The photography of the carved wooden chancel, rood, choir, or parclose screens, often met with in the churches of East Anglia and the West of England, seldom presents any special difficulty, the chief point to remember being to make sure of giving ample exposure.



FONT COVER, ALDINGTON.

Nothing looks worse than the effect of under-exposure in records of carving, a by no means uncommon fault, when, as is often the case, the wood has become dark with age, and in deeply cut work strong contrasts of light and shade are present. The same remarks apply when dealing with choir stalls, font covers, bench ends, "poppy-heads," etc., indeed, all the wood carving to be found in interiors.

The most difficult subjects of this class to photograph are the misereres, or projecting brackets on the under side of the seats in some church choir stalls. They are generally badly lighted, and very dark in colour. Their position being too near the floor for the tripod to be of any use, either books or hassocks must be requisitioned to support the camera. If much work in this direction is contemplated, it is more satisfactory to construct a small stand, designed for the purpose, and adapted for use in the confined spaces in which this branch of work has to be done.

Roofs, etc.—It may occasionally be desired to photograph portions of the interior roof of a church, in order to show the method of vaulting in stone, or, for instance, the ornamental bosses at the intersections of the vaulting ribs, or the form of construction in the case of a wooden roof. When using a stand camera a tilting table is most convenient for fixing the camera in the required position, but if a hand camera, of either the magazine or reflex type, be used, it can be placed, lens upwards, on a tripod head, a chair, or even on the floor, if necessary, the correct position being ascertained by means of the finder; thus for this particular work the hand camera has a certain advantage, in point of simplicity, over the stand camera. Another method is to fit a surface-silvered mirror attachment to the lens, and photograph the reflection of the roof. By twisting this attachment round on the lens it will also serve for photographing brasses and inscribed stone slabs in church floors, or, if a direct view be required, a stand camera attached to a tilting-table can be employed; but when dealing with large subjects of this class a specially constructed frame-work to carry the camera is to be preferred.

Fonts.—The photography of fonts often requires considerable care, owing to their position in the churches. Frequently they are very poorly lighted, and sometimes the camera has to be placed in a strongly-lit position, while the font is in comparative darkness. In such cases, if the light shines on the front of the camera, the lens should be shaded, otherwise there will be a likelihood of flare occurring.

MODERATE HALATION.

The halation in the chancel almost gives a pleasing effect, but, by spreading to the screen, has become a bad fault.

Plates.—The choice of the particular brand of plate to be used is largely a matter of taste, every photographer having personal preferences in the selection of his materials. Where record work, requiring the reproduction of fine detail, which may be subsequently enlarged, is the main object, a plate possessing a fine grain is desirable, and in this respect a moderately rapid plate will generally be found more satisfactory than one of the ultra-rapid variety, both for exterior and interior work.

Halation.—When dealing with interiors, the best method of preventing halation must be considered, more especially if brightly lit windows be included in the view. The use of backing on plates has been widely advocated as a preventive of halation, and no doubt it serves the purpose very well up to a certain point; but there are plates on the market, such, for instance, as Messrs. Lumière's anti-halo plate, and the Agfa Isolar anti-halation plate, which are decidedly preferable to any backed plate, if we wish to prevent halation or reduce it to a minimum. These plates are prepared with a substratum of gelatine, coloured a deep red, between the film and the glass, which effectually prevents any light, sufficiently actinic to affect the sensitive emulsion, from reaching the glass, and being reflected back again on to the film. The red colouring is removed from the negative, either during development, fixing, and washing, or in a subsequent clearing bath. Nothing is gained by backing these anti-halation plates, a fact which clearly proves the efficiency of the red substratum. In practice, as well as in principle, they are undoubtedly superior to backed plates, and, although rather more expensive than the latter, the better results obtainable with them make them well worth the slightly higher price.

Attempts have been made from time to time to justify halation, and to claim that, so far from being a fault, it is often beneficial in pictorial work. It is said to give "mystery" to such subjects as church interiors. But while the effect thus gained may possibly be helpful in rare instances, there can be no doubt that in the great majority of "pictures," as well as in all records, halation does far more harm than good, obscuring detail and destroying all fine gradation of light and shade.

For most exterior photography backed plates are sufficiently halation-proof, although, of course, there is no objection, except the extra cost, to using the substratum plate for outdoor subjects also. Orthochromatic rather than ordinary plates should be chosen, their greater colour sensitiveness being useful for interiors where there is much stained glass, and for exteriors where the stone-work is more or less yellow or at all warm in tone.

With regard to orthochromatic screens, these will very seldom be found necessary or desirable, except when, for instance, a photograph of a stained-glass window showing correct colour-values is required, or occasionally out-of-doors, when the sky may form a considerable part of the picture.

Developers.—In the matter of developers, no less than in that of plates, each photographer has his personal fancy; and, while there is probably not much to choose between the various re-agents when outdoor work alone is concerned, the question as to which is the most suitable developer for interiors is worthy of a certain amount of consideration. In many interiors there are strong contrasts of light and shade, and in such cases, in order to obtain a negative with a full and pleasing scale of gradation, more care must be exercised in the developing of the plate than is usually necessary with exterior subjects.

Developers may be roughly divided into two classes—those which bring up the whole of the detail quickly and then gradually add density, such as rodinal, amidol, and metol, and those which give considerable density in the high lights, before filling in detail in the dark parts of the subject, such as pyro (used with various forms of alkali) and hydroquinone. Pyro-soda is an old favourite, and is still very popular among architectural workers, but for interior work it has a tendency to clog the high lights before the shadows have reached sufficient strength; and the contrast may be further augmented by the slight yellowish stain sometimes present in the pyro-developed negative. But if rodinal be employed, there is no fear of the high lights clogging before the shadow detail is through; and, such developers being non-staining and the deposit given a pure black, the printing quality of the negative is more uniformly reliable than is often the case with pyro development.[1]

Permits.—With regard to the necessary permission to photograph interiors of cathedrals and churches in England, this can, as a rule, be obtained from the local dean or rector, full particulars being given in the Photographic Red Book. In France the cathedrals are State-controlled, and application should be made to M. le Ministre des Cultes at Paris. We may mention that the French authorisation has sometimes to be countersigned by the diocesan architect, and does not always apply to crypt photography, for which a separate permit may be necessary. Similar rules are in force in most other countries.

In conclusion we would point out that to get an idea of the charm of architectural work one has only to give it a trial. The more closely we study our subjects, the more will their intensely human interest and associations appeal to us, and the more shall we be in sympathy with the artistic ideals of the mediæval craftsmen. The mere setting about to record a building carefully is bound to lead to a more thorough appreciation of it. One is inclined to think sometimes, say, on arrival at an unfamiliar town, "There is not much worth taking here"; but a closer inspection, with a view to doing a single church or castle something like justice with the camera, will most likely bring about a change of opinion. In our own experience a slight feeling of disappointment has often been changed to one of appreciation and enjoyment, by allowing ourselves time to examine a place from a photographer's view-point, and waiting, perhaps till next day or longer, for a particular lighting, when the average tourist would have been content to "do" the town in a few hours. Especially is this the case with a church interior. The effect of the building "grows" on one, new aspects present themselves, and what might have been but a superficial and easily effaced impression becomes a lasting memory.

[1] The Pyro-Caustic Soda developer would be worth a trial for this class of work.—Ed.

CHAPTER XXI

DEFECTS IN THE NEGATIVE AND THEIR REMEDY

Pinholes.—The annoying small transparent spots and microscopic holes, often found in the negative, are generally to be ascribed to dust on the plate at the time of exposure. Plates should never be kept for more than a day or two in the dark slide; somehow or other they will always accumulate dust there, and may possible absorb moisture from the air. The practice of wetting the plate with water before developing is another cause of these holes. Sometimes, but very rarely, they are due to defects in the gelatine. If the pinholes are very minute we must make up our minds philosophically to ignore them. Larger holes may be filled up with a mixture of India ink and gum water, with two drops of formaline. A very finely pointed brush must be used and the colour, almost dry, toned down to match the surroundings. The operation requires skill and exactness, and the colour tone must not be too dark or it will appear as white spots on the print.

Patches.—Irregular rounded patches of lighter tint, frequently bounded by a fine dark line, are caused by the fact that the developer did not flow over the whole plate at once, and action commenced much later on these portions. Strangely enough, however long development may be protracted, these portions never "catch up" to the rest. Patches of varying density are due, as a rule, to parts of the negative drying before the rest, and at a different temperature. For instance, when half the film was dry, the plate may have been held near a fire to finish it off quickly.

Fog.—If the whole plate is masked by a grey fog and the margin covered by the rebate of a dark slide remains clear, we know that the fault is due to a leaky camera. A round halo in the very middle shows that the automatic shutter is slightly out of gear and lets in light while the camera closes. If the fog covers the plate, rebate edges included, either the developer contained an excess of alkali, or the dark-room light is defective. Streaks of light from the angles towards the middle indicate that the joints of the dark slide are becoming loose, or that the slide does not fit close enough in the camera. Green fog is nowadays a rarity except with very stale plates, and will generally disappear in the clearing bath. Black spots of various sizes, some of them with curved tails, are caused by particles of developer insufficiently dissolved.

Powdery substance on the face of the film is due to impure chemicals giving a precipitate insoluble in water. Often this consists of a salt of lime from hard water used in washing the plate.

Intensification.—Very frequently our negative, although otherwise satisfactory, is lacking in density or contrast, and is so thin and weak that we cannot get good prints from it. It is possible in that case to deposit on the existing image a new one of chromium, copper, or silver. Before treatment the negative must be quite free from all traces of hypo (unless the chromium method is adopted) and if there is any surface fog it must first be removed by reduction (q.v.).

The old-fashioned and still widely practised mode of intensification by mercury is not one which is desirable. Apart from the deadly poisonous nature of mercury bichloride, the action of this substance on gelatine, the tendency of the negative to fade, and numerous other incidental uncertainties, all cry out against its adoption, now that safe and more efficient substitutes are available. In the mercury process the negative is first bleached white in a solution consisting of

Mercury Bichloride	¼ oz.
Hydrochloric Acid	10 minims.
Water	10 oz.

the bleaching generally being fully accomplished within ten minutes. The plate is then washed in three or four changes of water and either redeveloped in any clean-working developer, such as hydroquinone or rodinal; or simply blackened by immersion in a bath of water 4 oz., ammonia 1 dram.

Mercury and Silver Intensifier.—

A.	Potassium Bromide	20 gr.
	Bichloride of Mercury	20 „
	Water	2 oz.
B.	Cyanide of Potassium (sticks) . . .	20 gr.
	Nitrate of Silver	20 „
	Water.	2 oz.

The silver and cyanide must be dissolved separately, each in an ounce of water, and then the cyanide poured in until the precipitate is not quite redissolved. Bleach the plate in solution A, and then, after washing, transfer to B. The solutions may be used over and over again, and, if intensification has been carried too far, on immersion in the hypo bath the plate will revert to its original state.

Bromide of Copper.—This intensifier is nearly as effective as chloride of mercury, and is attended by fewer inconveniences.

Dissolve separately, each in 2 ounces of hot water,

Potassium Bromide	¼ oz.
Copper Sulphate	½ „

and then mix and if necessary filter, to get rid of the white precipitate. The resulting solution may be used to bleach the negative, which may then either be blackened with nitrate of silver or redeveloped. Only very careful rinsing is correct with a negative bleached with copper bromide, on account of the white deposit being not quite impregnable.

Chromium Intensifier.—This is the simplest, and at the same time the most reliable of intensifiers, and we have used it exclusively since the introduction of Mr. C. Welborne

Piper's formula, five or six years ago. The presence of hypo in the film need cause no anxiety; just a rinse after fixing is enough; and the operation may be repeated several times if the first application does not give enough density. Three grades may be used according to circumstances: A gives moderate density, B considerable, and C great intensification.

	A.	B.	C.
Potassium Bichromate	5 gr.	10 gr.	10 gr.
Hydrochloric Acid (sp. 1·160) .	1 min.	5 min.	20 min.
Water	1 oz.	1 oz.	1 oz.

Bleach in one or other of these three solutions, wash until the yellow stain has fully disappeared, and then redevelop with any clean developer. Mr. Piper recommends amidol.

Reduction of Negative.—Many negatives, owing to over-exposure, over-development, or surface fog, have become so dense that whole days in the printing frame, even in sunlight, would be required to get prints from them. It is then advisable to reduce the thickness of the image, and Farmer's reducer is prescribed. It consists of hypo (fresh) 2 oz., water 10 oz., to which, just before using, a few drops of ferricyanide of potassium ½ oz., water 10 oz., are added. The mixture will not keep for more than half an hour: the more ferricyanide is added, the more rapid the reduction. With a solution strong in ferricyanide the shadows are attacked very greedily, and it is better to proceed carefully with a weak solution, unless the shadows are very much clogged. When reduction has been carried to the extent desired, the negative may be well washed.

Another very good method of reduction, but one requiring considerable judgment and skill, is to bleach the negative in the copper bromide solution given for intensification, and then dip for a moment or two into the ordinary fixing bath. The solution should be diluted to half its strength, and the plate should only be allowed to acquire a greyish-blue colour, not the pure white necessary for intensification purposes.

Where only part of a negative requires reduction, our usual plan is to mix up a quantity of Farmer's reducer, or bromide of copper with a little glycerine, and apply to those parts with a brush.

Persulphate Reduction.—Some negatives, while printing perfectly well in the shadows, have high lights so dense that they appear on the print as masses of plain white, without the slightest relief. If an ordinary reducer, such as Farmer's were applied, the heavy thickness of silver would remain comparatively unaffected, while the shadow detail consumed away into clear glass. In old days we used what was known as Baskett's reducer, consisting of terebene 2 oz., salad oil 2 oz., and a tin of Globe Metal Polish. A few drops on a wad of cotton wool were rubbed gently and evenly over the surface of the film, and the obnoxious thick deposits gradually worn down to the required degree. Green fog was often polished away in this manner. However, within recent years, it has been discovered that ammonium persulphate has the peculiar property of attacking the high lights while leaving the delicate detail in the shadows undisturbed. The nature of the action is not fully understood, but is believed to be due to the oxydisation of the gelatine in those portions of the film where the silver has been most thickly deposited.

The plate intended for persulphate reduction must be fully fixed, and hypo well washed out. Use a 2½ per cent. solution. When first made up the solution works very slowly, increasing in power for some days; it is not well to keep the solution for more than a fortnight, nor to use the same solution for more than two plates in succession. A 5 per cent. solution of sodium sulphite must be ready to stop the action when it has been carried nearly to the required point.

Permanganate of potassium has also been suggested by Prof. Namias for reducing high lights in an under-exposed negative in the proportions 1 part permanganate, 2 parts sulphuric acid, 660 parts water; but in action it is far less reliable than the persulphate. Red stains must be removed with a weak solution of oxalic acid.

Rehalogenation.—This name has been given to a method invented by Dr. Eder for improving the gradations, and softening an under-exposed but over-developed negative. The image is converted back into a bromide or chloride of silver by bleaching, and then redeveloped. A good bleaching solution is

Potassium Bichromate	30 gr.
Potassium Bromide	60 ,,
Water	10 oz.

After bleaching wash in several changes of water, redevelop with rodinal, or other clean-working developer, and plunge in the fixing bath. If the latter were omitted, the effect would be merely intensification; as it is, the result may rather be described as correction of the relative densities of shadows and high lights.

Stains.—Developer stains which have resisted the fixing bath may be removed with

Thiocarbamide	45 gr.
Citric Acid	45 ,,
Water	10 oz.

or by a 2 per cent. solution of ammonium persulphate with a few drops of ammonia added to prevent reduction of the image. Silver stains, especially those caused by setting off in damp weather from silver printing papers, can only be removed with cyanide of potassium in solution 10 gr. to the ounce.

Cracked Negatives.—If it is desired to save a negative the glass support of which is broken, the film remaining intact, this latter must be transferred to a new glass plate. There are several methods, one of which is to begin by coating the dry film with a layer of enamel collodion, and then place the negative carefully supported on a flat surface, in a 5 per cent. solution of hydrofluoric acid. The dishes used must be of vulcanite or papier maché, glass and

E. O. Hoppé, F.R.P.S.

PORTRAIT STUDY.

p. 192]

porcelain being attacked virulently by this agent. In a few moments the film will commence to detach itself from the glass. Have ready a new glass thinly coated with gelatine. Pour off the solution and replace with cold water; gently work the new glass under the film and draw the two together into position. The film on its new support may now be set to dry after adjustment of any wrinkles or frilling with a soft camel-hair brush.

Another method is to prepare a temporary support by soaking a piece of thin paper in hot melted paraffin wax. After the negative has been soaked in the hydrofluoric acid solution the temporary support is pressed on to the film and the two are removed together in contact, and immersed for a moment or two in

Methylated Spirit	5 oz.
Water	1 „
Glycerine	1 „

when the new plate is introduced, the whole is squeegeed once more, and the temporary support may be drawn away.

Enlarging the Film.—Those who desire a larger negative than the original may try the following solution in order to remove the film:

Hydrofluoric Acid	¼ oz.
Citric Acid	1 „
Glycerine	¼ „
Water	8 „

No temporary support must be used nor the enamel collodion, these serving the purpose of preventing enlargement. As soon as the film is loose slip the larger glass support under it, guide into contact and transfer to clean water.

Varnishing.—The hot method of varnishing negatives is the best, but the requisite dexterity in distributing the liquid evenly over the plate is not often attained in these days, when the wet-plate process no longer gives one a chance to practise. See that the film is clear of dust, then warm the back of the plate at the fire or a gas-burner until it is nearly as hot as the hands can bear; then, holding it by a corner, pour the varnish on the centre of the plate. By inclining the plate gently coax the flood up one side, down the next till, at the last corner, the surplus may be poured into an extra bottle for refiltration. Heat may be again applied as soon as any streaks across margin and back have been wiped away.

The best hot varnish for gelatine negatives is made by dissolving 2 oz. of orange shellac in a pint of methylated spirit with ½ oz. of oil of lavender. An ounce of powdered whiting is then added, the whole shaken up and allowed to settle and finally filtered through cotton wool in a glass or paper funnel.

A good one for retouching on is

Sandarac	1 oz.
Oil of Lavender	¾ „
Methylated Alcohol	7 „

Cold Varnishes.—These may be applied by the brush in the cold state, and dry very quickly. Films may be either brushed or dipped in the preparation and then hung up to drain.

Gum Dammar	50 gr.
Benzole	1 oz.

This dries a few moments after application, but does not become hard for some hours unless moderate heat is applied. Another very effective cold varnish for plates or films is made by dissolving 1 oz. of celluloid in 50 oz. amyl acetate. Old film negatives stripped of their gelatine surface may be used for making this varnish.

Water varnish is prepared by pouring a quart of boiling water over half an ounce of borax, and adding by degrees a pound of orange shellac (stirring to ensure rapid melting). If the borax does not suffice to make all the shellac dissolve more is added, a few grains at a time. The solution will keep for a long time, if corked free from dust, and may be used alone; but it is more commonly employed as a cold varnish as follows:

Water Varnish	2 oz.
Ammonia	60 minims.
Methylated Spirit	4 oz.

A practical negative varnish good enough for most purposes, for use either hot or cold, may be manufactured by diluting any good hard spirit varnish procured at oil shops with an equal volume of methylated spirit.

CHAPTER XXII

GELATINO-CHLORIDE PRINTING-OUT PAPER

ALTHOUGH this paper (commonly known to dealers as P.O.P.) is far from easy to manage in a way that will lead to a high standard of success, it is used by the great majority of amateurs. The advantages connected with it are that there is no need to carry out operations in the dark room, and that, as the image prints out, there are no elaborate calculations of exposure. After one or two attempts any person of ordinary intelligence can judge to what density printing must be carried on, in order that the image may survive the loss of colour incident to toning and fixing. Besides this, by varying the light and time of printing, inferior negatives may be coaxed into giving a passable print. On the whole, it adapts itself to the average negative very well.

Manufacture of P.O.P. paper.—Several formulæ are given by various authorities. Of these we will only quote two, those of Mr. J. Barker and Mr. W. K. Burton, the stronger proportions of silver, not necessarily giving the best prints.

1. Gelatine (Nelson's No. 1 and Coignet's)	175 gr.
Ammonium Chloride	18 ,,
Rochelle Salts	50 ,,
Silver Nitrate	75 ,,
Alcohol	4 dr.
Water	5 oz.

Heat to 100° until all has been dissolved and filter.

2. Gelatine	80 gr.
Nitrate of Silver	400 ,,
Ammonium Chloride	80 ,,
Citric Acid	120 ,,
Water	12 oz.

J. W. Church.

BRANDON BRIDGE.

Dissolve the nitrate of silver in 4 oz. of water, and the other constituents in the remainder of the water. Heat the separate solutions to 110–120° Fahr., add together, stirring freely, and filter through a double thickness of cambric. For soft negatives add 45 gr., and for very weak negatives 80 gr. of carbonate of sodium. The emulsion is then floated on a baryta-coated paper, either by hand or the proper machinery. Mr. Burton recommends floating for three minutes on sheets in a room at a temperature of 70° Fahr. Or the emulsion may be poured on in a small pool and spread quickly over the surface with a brush.

Printing.—There are several excellent brands of P.O.P. and, unless some special kind of paper is to be coated to produce an unusual effect, it is hardly profitable to prepare the above emulsions in practice. They can be bought either with glossy, matt, or satin surface, each of value for the particular negative; but it is best in general use to adopt a moderately smooth paper. Place the paper, cut to the proper size, in the printing frame, with the sensitive surface in contact with the film-side of the negative, and add two or three thicknesses of soft paper as padding. Dense negatives may be exposed to the direct rays of sunlight; weaker ones in a less intense light; and very thin ones may be shaded with tissue paper or green glass. Examine from time to time by opening one side of the printing frame, taking precautions that the paper does not shift while doing so or a "double print" may result. The printing must be carried to a degree considerably darker than the tone required for the permanent picture, and a slight darkening in the high lights need cause no anxiety.

Clouds.—We have already made some remarks on this subject in the chapter on landscapes. The print may be transferred to another frame in contact with a suitable cloud negative and masked according to the necessities of the case. Where delicate outlines rise high above the horizon the mask may have to take the form of a print, with the sky line carefully cut out with a sharp penknife. In other cases a piece of blotting-paper may be torn roughly into shape, laid on the printing frame outside the glass, and moved up or down during the course of exposure. Fleecy clouds in a blue sky are often imitated with cotton wool or dabs of green paint on the glass side of the negative. But much judgment and skill is needed in the selection of clouds. They should not be introduced at all unless the sky was cloudy when the photograph was taken, and, unless the artist is quite conscious of the effect he is aiming at, he should be content to print them in very lightly. Many a landscape produced on a sunny day has been ruined by the addition of dark, stormy cloud-effects.

Sunning Down.—By means of tissue paper, or green water-colour paint on the glass side, certain portions of the negative may be protected from further printing, while the rest is allowed to continue to darken and gain in emphasis.

Vignetting.—Special smoked-glass negatives are obtainable which fit into the printing frame outside the ordinary negative, and give to the picture the delicate shading off of the vignette. The same effect is obtainable with the canvas or serrated tissue edged cards pinned or strapped loosely on the wooden upper surface of the frame. Fig. 52 shows a very simple form of card vignette. The aperture is shaped for a portrait (head and shoulders) and is cut out rather smaller than the final vignette is to be; afterwards it is notched as shown and the edges turned up. Fig. 53 is a rather more elaborate device; the opening in the card is larger, and within it two thicknesses of old celluloid film (with the silver fixed out) project towards the centre. The inner thickness is serrated at the edge. For landscapes, vignettes may be made of oval, square, or arabesque shapes according to taste. A piece of flat cork about $\frac{1}{4}$ in. thick might be glued at each corner of the printing frame to raise the vignetting card a little further from the negative and receive the fixing pins. The distance increases the soft delicacy of the vignette.

For this kind of vignetter direct sunlight must be avoided, and the frame shifted several times during printing, or slung by two loops of string from above, so that it will swing to and fro. Vignetting is also done in the camera, especially for enlarging, by placing a black card, with an oval opening of the proper size, about half-way distant between lens and plate. It may be made to fit in the folds of the bellows.

Masks and discs are also employed, especially in producing postcards with ornamental borders. The border negative is usually printed first, and then replaced by the picture negative, with a mask of black paper protecting the portion that contains the border.

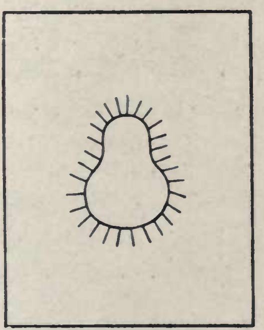


FIG. 52.

FIG 53.

Toning.—When the print is finally taken from the printing frame it must be placed (under pressure if possible) in a place secure from light and moisture to await toning, which process is sometimes delayed for weeks to suit convenience. This practice is a bad one as, however carefully protected from light and air, the whites have a tendency to deteriorate. The toning process consists in adding a thin layer of gold or platinum to the image, improving its chance of permanence and also its colour, which would otherwise be most disagreeable after fixing.

The components of chloride emulsions are not always the same in the different brands of P.O.P., and the directions supplied by the makers should be carefully followed. Some varieties must be placed directly in the toning bath, without any preliminary washing, or the loss of colour will be enormous. Other kinds must be washed for ten minutes before toning. Nearly all are improved by immersion for five minutes in a solution of common salt to transform the free silver salts. Some use a little carbonate of soda to destroy the acidity of the paper.

Gold Toning.—The toning bath will consist of chloride of gold, with some compound to prevent the chlorine from reducing the silver image while the gold is depositing. Two grains of gold will tone a full-sized sheet, $24\frac{1}{2} \times 17$ in., and it is well to place prints in regular batches in the bath with a certain quantity of solution in order to obviate the irregular action of baths of varying strength. A too strong bath tones very quickly, but the prints lose terribly while fixing; a weak bath is too slow, and produces poor, dull pictures.

Acetate Bath.—

Stock Solution.

Sodium Acetate	1 oz.
Gold Chloride	15 gr.
Water	4 oz.

Mix 24 hours before it will be required for use. To tone half a sheet of paper, take 2 dr. of stock solution to 10 oz. of water. A reddish brown colour is reached in about 10 minutes. This is a very economical bath, giving a good brown to blue-black colour in the finished print.

Sulpho-cyanide Bath.—

Gold Chloride	2 gr.
Ammonium Sulpho-cyanide	24 ,,
Water	16 oz.

Mix separately in boiling water, and then add the two solutions together. This bath takes 12 hours to ripen. Some papers will not tone well in the sulpho-cyanide bath; others do better if the proportion of sulpho-cyanide is reduced by about one-half. The directions of the manufacturer should be consulted on this point.

Phosphate Bath (Kentmere).—

Gold Chloride	2 gr.
Sodium Phosphate	60 „
Water	20 oz.

Formate (Wellington).—

Gold Chloride	2 gr.
Sodium Formate	60 „
Water	40 oz.

The two last mentioned should be made up an hour before using. They will not keep.

Borax Bath.—

Gold Chloride	2 gr.
Carbonate of Soda	2 „
Borax	60 „
Water	16 oz.

The borax must be dissolved first in hot water with the carbonate, and the gold added on cooling.

Chloride of gold frequently contains free acid, and should be neutralised with a very little chalk or magnesium carbonate.

Subject to what has been remarked above with regard to the special characteristics of some emulsions, the sulpho-cyanide bath gives the most pleasing colour; tungstate, formate, and phosphate being likely to produce a cold blue-black after prolonged immersion. The toning bath does not work well when warm, and the best tones are usually found in cold weather. Keep the prints continually moving, and do not let the bath get too poor in gold, or the prints may turn yellow in the high lights, and may also give "double tones." As each print reaches its proper tone transfer it to a dish of clean water, replacing it with an untoned one. Five or six prints are enough for the toning bath at any one time.

Platinum Toning.—Before toning the print must be soaked for five minutes in a solution of common salt, in order to free it from silver nitrate, washed, and then transferred to one of the following toning baths:

(1)	Potassium Chloroplatinite	2 gr.
	Phosphoric Acid (sp. gr. 1·120)	40 min.
	Water	8 oz.
(2)	Potassium Chloroplatinite	2 gr.
	Sodium Chloride (common salt)	10 „
	Citric Acid	20 „
	Water	10 oz.

The first bath will give nearly black tones, but the pure blacks of a platinotype paper must not be expected. Platinum toning gives a greater chance of permanence, and, on the whole, better colours than gold toning, especially upon Matt surface papers. The weaker the acid in the bath the lighter the tones, and by varying the amount of acid (citric acid from 2 gr. to 25 gr.) a long range of tints, from sepia to pure black, are obtainable. Before placing in the fixing bath the acidity must be neutralised by immersing the print in a solution of carbonate of soda, 1 oz. to the pint.

To stop Toning.—If toning proceeds too rapidly the action of a gold toning bath may be stopped by dipping the print in a weak solution of sulphite of soda; the carbonate of soda solution at once arrests platinum toning.

Fixing.—The fixing-bath for P.O.P. should not be so strong as for negatives; three ounces of hypo to each pint of water is sufficient for most papers. A small quantity of ammonia facilitates not only the fixing process, but also the subsequent removal of the hypo from the paper. Keep the hypo dish or tank well away from the toning-bath, or yellow stains and untoned patches are sure to result. Any alterations of colour while the print is fixing need occasion no anxiety, as the proper tint will generally return after the paper has been washed and dried.

Combined Toning and Fixing.—There are good reasons for not combining these two operations, if prints to last for any length of time are required. In the long run it does not save much time or trouble, and the operations are far less under control. Usually, to make sure that the prints are properly fixed, the ordinary fixing bath must be used, either before or after the combined bath. We give Mr. W. K. Burton's formula.

Chloride of Gold	6 gr.
Nitrate of Lead	3 "
Hyposulphite of Soda	3 oz.
Water	20 "

Many combined baths are made up with alum and other substances, which tend to decompose the hypo, and may produce sulphide toning. Of course, toning by means of mono-sulphide of silver would be permanent, but whether this would be the sulphide produced is questionable. M. Lumière suggests the following formula, in which the presence of sodium bisulphite lye will prevent the decomposition of the hypo.

Hyposulphite of Soda	5 oz.
Sodium Bisulphite lye	100 minims.
Lead Acetate	20 gr.
Alum	400 "
Gold Chloride	6 "
Water	20 "

Dissolve the hypo in the greater part of the water, add the bisulphite and lead, and then the alum dissolved separately in a little water, and lastly the gold in a solution.

Developing P.O.P.—These prints may be very easily developed, and a few years ago the process was very commonly practised. The paper must be kept as far as possible from daylight before exposure, and the subsequent procedure should take place by artificial light. Print only until faint detail is visible in the half-tones, or, as some suggest, the faint image given by two feet of magnesium ribbon burnt close to the printing frame. Wash well before placing in the following developer:

Hydroquinone	15 gr.
Sodium Sulphite	60 "
Caustic Soda	30 "
Water	10 oz.

Mr. Stanley C. Johnson recommends placing the print direct from the frame for five minutes in a 6 gr. per ounce solution of potassium iodide, and for chestnut tones advises

Pyro.	15 gr.
Glacial Acetic Acid	15 minims.
Alcohol (90 per cent.)	¼ oz.
Water	9 ,,

For violet tones

Pyrocatechin	2 gr.
Sodium Acetate	10 ,,
Water	20 oz.

followed by immersion in any ordinary combined bath before washing. Care must be taken not to carry development too far, as the print will darken considerably while in the toning bath.

Washing and Drying.—When fixation is complete, which except in cold weather will be in about fifteen minutes, the prints must be washed for at least an hour. It is not sufficient to lay them at the bottom of a dish, even if water is slowly percolating through. The hypo salts are heavy, and tend to lie at the bottom, and if the prints are left there they will simply continue to retain these salts, one of which is only slightly soluble. Some of the patent washers are excellent, and keep the prints in constant motion. A simple device is to transfer the prints every few minutes to a second dish, changing the water on each occasion.

Drying.—An alum or formaline bath is important for gelatine prints, especially if they are desired with a fine glaze. This glaze is obtained by squeegeeing them face downwards on a pulp or ferrotype plate. Lay the prints in position on the prepared surface, cover them with two thicknesses of hard blotting-paper, and roll them well. No attempt must be made to remove the prints until they are quite dry. If plate-glass is used as a substitute for ferrotype, the surface must be waxed with a solution of any fine wax (composite candle will do) in benzole. Rub a little carefully on the surface of the glass and polish it off with a fine duster. Prints that do not require a glazed finish may be blotted off in clean hard blotting-paper, to remove the superfluous moisture, and then hung up to dry.

The utmost cleanliness and care is necessary in using printing-out papers. Stains, yellow high lights, and other blemishes may generally be traced to impure chemicals or imperfect fixing. Finger marks on the sensitized surface will betray themselves by uneven toning.

CHAPTER XXIII

COLLODION, ALBUMEN, AND OTHER SILVER PAPERS

Collodio-chloride Papers.—A collodion printing-out paper was introduced as early as 1865, by Mr. G. Wharton Smith, but gradually fell into desuetude, partly owing to difficulties of manufacture, partly because the thoughtless habit of breaking the grain of papers, in order to make them lie flat after first drying, produced ugly cracks on the surface. It has lately been revived, and, if treated with care, the exquisite surface and delicacy of detail characteristic of this paper should render it once more popular. It is not easy to prepare, since from unknown causes the nitrates, especially nitrate of silver, separate from the emulsion and crystallise on the surface. Sir W. Abney has proposed the following emulsion through which he afterwards passes ammonia to form ammonium nitrate, adding afterwards a small quantity of silver nitrate in the proportion of about eight grains to the ounce of emulsion.

1.	Silver Nitrate	1 dr.
	Water (distilled).	1 ,,
2.	Strontium Choride	64 gr.
	Alcohol	2 oz.
3.	Citric Acid	64 gr.
	Alcohol	2 oz.

To every two ounces of plain collodion add thirty drops of No. 1, previously mixed with 1 dr. of alcohol; then add 1 dram of No. 2 shaking well; lastly half a dram of No. 3. In a quarter of an hour it is fit for use.[1]

[1] *Note.—Instruction in Photography.* p. 529. 1905 Edition; Legros *Autotypie.* Paris 1887.

The collodio-chloride papers may be toned in the same baths as gelatine papers, and may also be developed. But the caution about observing makers' formulæ is even more important, the necessary proportion of gold varying with each emulsion.

Albumen Paper.—For some purposes, and especially for good plucky negatives, albumenised paper is to be preferred to gelatine paper. The detail in the shadows is far superior and the toning process seems to go on more smoothly with less danger of double tones. The chief disadvantages are that it does not keep well after sensitising, and that, if an excess of albuminate of silver is formed, the print is liable to fade. But the latter defect will not arise, if there is sufficient of soluble chloride salts mixed with the albumen, the chloride of silver forming much more rapidly than the albuminate.

Albumenising the Paper.—It is usual to take fresh eggs for the albumen, though some assert that stale shop eggs give a brighter and more even coating. A large English egg will yield an ounce, foreign eggs from $\frac{5}{8}$ to $\frac{7}{8}$ of an ounce, of albumen. Take

Ammonium or Sodium Chloride	80 gr.
Spirits of Wine	2 dr.
Distilled Water	2 oz.

and when these are dissolved add 7 oz. albumen, and beat up with quills or an egg whisk for about 20 minutes. Filter through a sponge or wad of cotton-wool and the mixture may then be poured into a flat dish.

Take the paper (Saxe or Rive is the best) and holding it by two opposite corners, so bend the sheet that the middle first touches the albumen. Spread carefully on the surface, taking care that none flows over the edges on to the back of the paper. After about a minute lift up the paper very gradually by one corner. If there are bubbles, break them with a camel-hair brush, and float it again until a uniform coating is secured. Then hang it up by two clips in some dry place, where it will not be exposed to dust. Double albumenised paper is made by drying on a bath of spirit and then re-coating with the same mixture as before. The proportions given will coat about a quire of paper.

The Sensiting Bath.—Ready-coated albumen paper is still kept in stock by the leading firms, both in the unsensitised and sensitive states; but the latter should only be bought when guaranteed fresh, and must be quickly used. The paper may be sensitised at home by making up the following bath:

Nitrate of Silver	1 oz.
Sodium Nitrate (pure)	½ "
Loaf Sugar	30 gr.
Water	12 oz.

Float the paper, albumenised side downwards, on this bath in just the same way as was directed above for the albumenising process. Lift the corners one by one, and break any air bells that may be formed with a glass rod. Float for about four minutes, then hang up once more by clips to dry, but this time away from any actinic light. Rapid drying in a warm cupboard will preserve the brilliancy of the surface.

The above bath is calculated for the use of amateurs, who will only have a few sheets to sensitise. For larger quantities, the bath recommended by Mr. H. N. King is one of the best. Prepare two separate solutions.

A.	Nitrate of Silver	2 oz.
	Sodium Nitrate (pure)	1 "
	Loaf Sugar	50 grs.
	Water	25 oz.
B.	Nitrate of Silver	2 oz.
	Sodium Nitrate	1 "
	Loaf Sugar	60 gr.
	Water	10 oz.

Use Solution A with about ¼ oz. Solution B, for sensitising the first four sheets of paper. After every four sheets add about ¼ oz. of Solution B, rock the whole well, and proceed to sensitise the next 5 sheets, and so on. By this means the bath will be always kept at about the same strength. Dust and scum on the surface of the bath may be removed by drawing a piece of pure chemical blotting paper or filter paper across the surface. A little kaolin kept in the bottle will always keep it clear. If the paper is required to be kept for some time it is usual to draw it slowly through distilled water to which a little citric acid has been added.

Measles.—A disagreeable outbreak after printing of red spots, which do not tone to the same colour as the rest of the print, is known as "measles." It is generally attributed to the lack of any substance with which the chlorine can combine when liberated from silver chloride during printing. Hence it attacks the albuminate. There should be a little free nitrate of silver left in the paper by the sensitising process. Paper that has been acidified for keeping purposes should be exposed to the fumes of ·880 ammonia before printing. Or such paper may be kept between sheets of blotting-paper, which have been dipped in a 5 per cent. solution of potassium nitrite and then dried. Albumen paper should always be kept under pressure until time of using, and in hot climates must not be allowed to get too dry.

Toning.—Albumen papers need not be printed quite so deeply as gelatine papers; the loss in the toning bath is not so great. The paper for prints from a given negative should always be cut the same way out of the sheet, because paper shrinks during the long immersion in water, and the shrinkage is always greatest in the direction of the fibre. When the high lights take on a pink tinge, and the shadows show signs of bronzing, remove from the printing-frame, wash until the milky deposit ceases to come away, and immerse in the toning bath.

Acetate Toning Bath.—

Gold Chloride	15 gr.
Sodium Acetate	1 oz.
Water	20 „

For use take 1 oz. of this stock solution and make up with water to 8 oz. to tone one sheet of prints. Our own way of mixing the stock solution is to first dissolve the acetate in 10 oz. of water in a pint bottle, and drop the 15 gr. tube of gold into the bottle. A brisk shake will break the tube against the side of the bottle, and the remainder of the water may then be added. This toning bath will keep for months if protected from strong light, but must not be used within twenty-four hours of mixing. It will give rich, warm tones.

Phosphate Toning Bath.—

Chloride of Gold	1 gr.
Phosphate of Soda	20 „
Water	8 oz.

The phosphate bath gives deep purple tones, but must be used very shortly after it has been prepared.

Fixing Bath.—Wash the prints after toning in two changes of water, and then fix for ten minutes in

Hypo	4 oz.
Water	20 „
Ammonia	20 min.

If blisters appear at any stage introduce a little chloride of sodium (common salt) into the next washing water. The subsequent washing and drying are the same as for gelatino-chloride papers.

Plain Salted Papers.—There are several receipts in common use for sizing and sensitising these home-made papers. A good pure unsized paper, free from all traces of iron, must be taken for the foundation, either Whatman's, Saxe's, Rive's, or Joynson's. Float on one or other of the following sizing baths:

(1)	Gelatine	120 gr.
	Ammonium Chloride	200 „
	Water	20 oz.

The gelatine is first swelled in cold water; then the remainder of the water is added warm with the chloride, and heat applied until the gelatine is dissolved.

(2)	Gelatine	20 gr.
	Sodium Chloride	30 "
	Water	5 oz.
(3)	Arrowroot	90 gr.
	Ammonium Chloride	60 "
	Water	10 oz.

Make up the arrowroot into a paste with an ounce of cold water, and dissolve the rest with the chloride in hot water. The paper must be floated for three minutes on one or other of these sizing baths while they are still warm, and then hung up to dry.

Sensitising Bath.—This may be either the bath given for albumenised paper, which will be the best for use with sizing solution No. 1. But almost equally good effects can be got with those given below.

(1)	Nitrate of Silver	90 gr.
	Water	2 oz.

To which sufficient ammonia has been added drop by drop until the precipitate at first formed has been redissolved.

For Keeping Purposes.

(2)	Nitrate of Silver	100 gr.
	Citric Acid	30 "
	Water	2 oz.

Distribute the sensitising solution evenly over the paper with a broad camel-hair brush, or float in the manner given under albumenised paper for three minutes. Then dry in the dark.

Porous papers require rather more gelatine (say one-third more) than hot-pressed papers. These plain, salted papers tone well in the sodium-acetate bath given above, but the best effect, especially with drawing papers, is obtained with Clarke's platinum-toning formula:

Potassium Chloroplatinite	10 gr.
Nitric Acid	5 min.
Water	25 oz.

The fixing bath may be the same as that given for albumen paper. Combined toning and fixing baths (which we do not recommend with albumen) work fairly well with these papers.

Resinised Papers.—The late Mr. Henry Cooper communicated to Sir W. Abney a printing process, the results of which have a character of their own, lacking the gloss of albumen. If printed deeply and toned in acetate this paper has almost the appearance of fine old porcelain. Coat with the following:

Frankincense	10 gr.
Mastic	8 „
Calcium Chloride	8 „
Alcohol	1 oz.

The sensitising bath consists of 60 gr. silver nitrate to the ounce of water, with as much gelatine added as it will bear at 60° Fahr.

Self-toning Papers.—Several papers of this class have been placed on the market during the last few years, and some formulæ have been published. Only the very recent brands, however, are satisfactory, either for their toning or keeping qualities, and the manner in which the gold is preserved in contact with the other ingredients is of course the makers' secret. The Paget Collodio-chloride, the Ilford Kalona, and the Kodak Solio self-toning papers will all be found good. The instructions in each case differ considerably, but as a rule such papers, after very deep printing, are placed direct in a weakly alkaline bath, and then fixed in the ordinary hypo bath, a variation in tone being obtained by a short stay in a weak solution of common salt.

CHAPTER XXIV

PLATINOTYPE

NO photographic operations can be termed easy in the sense that they allow much margin for careless working. Some, however, are simpler than others, and amongst these must be reckoned the platinum process. The developing and fixing solutions are elementary and the directions few in number. If the latter are faithfully obeyed, success follows as a matter of course; and the results more than compensate for the time and trouble involved in their achievement. It is a case of little toil, less anxiety, and much reward; short exposures, quick development, and rapid drying, all ending in a print full of tone and atmosphere, which is absolutely permanent in a metal more invincible than any other known.

The principle of the platinotype process consists in the reduction of a ferric salt to the ferrous condition under the action of light, and its subsequent action on certain salts of platinum, which it leaves in the black metallic state. It is not economical or advisable for the amateur to prepare his own paper, the number of preliminary solutions being very numerous and needing much variation. The simplest formula is one given by Pizzighelli and Von Hubl:

A.	Ferric Oxalate	120 gr.
	Oxalic Acid	8 ,,
	Water	1 oz.
B.	Potassium Chlorate	2 gr.
	Solution A	1 oz.

Which must be mixed and kept carefully in the dark, all the ferric salts being exceedingly unstable.

C.	Potassium Chloroplatinite	240 gr.
	Solution A	$2\frac{3}{4}$ oz.
	Water	$3\frac{1}{2}$ "

A sensitiser for normal prints of good deep black colour.

D.	Potassium Chloroplatinite	240 gr.
	Solution A	$1\frac{3}{4}$ oz.
	Solution B	1 "
	Water	$3\frac{1}{2}$ "

A sensitiser producing brilliant prints from fully exposed negatives.

E.	Potassium Chloroplatinite	240 gr.
	Solution B	$2\frac{3}{4}$ oz.
	Water	$3\frac{1}{2}$ "

For weak negatives.

Potassium chlorate has the effect of increasing contrast by oxidising a small proportion of the platinite into a platinate. A paper well sized, either with gelatine or arrowroot, is sensitised with one or other of the above solutions C, D, or E. Arrowroot tends to give brightness to the image, but gelatine acts somewhat to the detriment of the tone. It is usual to brush the sensitiser over the paper for three minutes or more, after which it is allowed to dry hung up in a room warmed with a laundry stove.

Another formula was given by Mr. A. J. Jarman, in the *Camera*, for Whatman's paper sized with arrowroot:

A.	Citrate of Iron and Ammonia	350 gr.
	Water	5 oz.
B.	Potassium Chloroplatinite	225 gr.
	Hot Water	5 oz.
C.	Saturated solution of Oxalic Acid.	
D.	Lead Nitrate	300 gr.
	Hot Water	5 oz.
E.	Potassium Chlorate	60 gr.
	Water	5 oz.
F.	Take of A solution	1 oz.
	E solution	2 dr.

Sensitising is accomplished with: A, 1 oz.; B, 1 oz.; C, 4 drops; D, 1 dr.; F, 2 dr. with four or five drops of gum-arabic solution. Brush on two coats with drying between, and print rather deeply.

Printing.—The paper is packed in tin calcium tubes, and must always be kept in these, as the slightest exposure to damp before using will spoil it. Some papers which have accidentally become damp may be partially restored by baking in an oven at 100° Fahr., but prevention is better than cure. Even when placed under the negative a water-proof pad, such as a piece of old celluloid or oil sheet used for letter-copying books, is advisable behind the usual paper padding. CC heavy stout paper is the best quality for beginners, and the appearance will greatly be improved by a margin masked with black paper, although this is, of course, not necessary for success with platinum paper. Printing is complete in about a third to a half the time required for a silver print, the image appearing of a greenish colour on the yellow ground, and a little practice is therefore essential before the exact degree to which exposure should be carried can be ascertained. Unlike silver printing, very little difference in the character of the image is secured whether the light be full sunlight or comparatively dull. Hard negatives gain nothing from sunlight, and feeble negatives printed in subdued light do not gain in value. On account of the great sensitivity the progress of printing should always be examined in artificial or at least subdued light.

Development by Hot Bath.—The hot bath is not very widely used nowadays, except for some sepia papers or for prints that are lacking in contrast. It consists of oxalate of potash in a solution of 120 grains to the ounce of water, which is heated at time of development to about 140–160°, and the print brought face downwards over the surface of the water. Draw it rapidly backwards and forwards over the solution to prevent bubbles, and then lift it up. Development has taken place at once like a lightning-flash, and the print must be rapidly transferred to the fixing bath—

Hydrochloric Acid	1 oz.
Water	60 „

—where it must remain for ten minutes and then pass into a second fixing, or rather clearing, bath of the same composition, and lastly into a third. These acid baths serve to remove the superfluous iron salts, and the paper may afterwards be rinsed for a short time and dried. The developing solution may be employed for several prints in succession.

Sepia papers frequently contain a mercury salt, and are often much more sensitive than the black. They continue to be sensitive even after development until thoroughly cleared; and they must be protected even more carefully from damp. The developer recommended by the manufacturers should be used with these papers, or a little mercury chloride added to the usual developer. Development is carried on in the hot bath at a temperature of 160°.

Cold-Bath Development.—The colder the bath, the colder the image, and conversely the warmer the bath the warmer the image. So, even with cold-bath papers, it is occasionally worth while to warm the developer. But given a negative of reasonable gradation, the best platinum prints are those developed cold. Compared with these, hot-bath prints often have a dull, flabby appearance, which is partly due to the size soaking off the paper.

The ordinary developer for the cold bath is

Potassium Oxalate	1 oz.
Potassium Phosphate	½ "
Water	10 "

Dissolve in hot water and allow to cool before using. Or for warmer blacks:

Potassium Oxalate	1 oz.
Zinc Oxalate	175 gr.
Water	10 oz.

These developers may be used repeatedly, but must be rejected when they become of a dirty greenish tint. Immerse the print from the frame face downwards in the solution drawing it backwards and forwards, and then examining to see whether the image is appearing. Development is slower than with the hot bath and allows time to save an over-exposed print by quick transfer to the acid bath. For most papers the developer should be neutral, but with Ilford Platona, for which the first of the two formulæ is recommended by the makers (but diluted to 1 in 14 instead of 1 in 10), the developer works better if rendered acid by the addition of, say, 30 grains oxalic acid. Damp paper develops somewhat brown and "mealy."

According to Dr. Jacoby a developer compounded as follows will give sepia tones on an ordinary cold-bath paper. Development will occupy about five minutes.

Potassium Oxalate	200 parts
Ammonium Monophosphate	50 ,,
Cupric Sulphate	2 ,,
Water	1000 ,,

Owing to the slower and steadier action of the cold bath there are time and opportunity for local development. The paper may be laid upon a sheet of glass and the parts which it is desired to intensify brushed over with a stronger solution of oxalate in glycerine. Other portions may be retarded by painting with plain glycerine.

When development is completed the print is transferred direct to the clearing solution, and the subsequent procedure the same as the hot bath.

Under-printed pictures may sometimes be coaxed into appearing by raising the temperature of the developer; the time of development is shortened thereby, and the print loses its pure black effect, becoming brownish by slow degrees. On the contrary, if a print has by any accident been allowed to remain in the printing frame so long that it has practically "printed out," all that can be done is to place it directly into the fixing bath without development. Of course it will never be a very creditable print, but may serve to file as a proof of a negative.

Acid Baths.—These must be replaced from time to time, especially the third, which ought never to be otherwise than quite clean. A good way is to throw away No. 1 after each batch of prints, promoting the second bath to office as No. 1 and making up a new solution for No. 3. A little soda is sometimes added to the subsequent washing water in order to neutralise the acid in the paper, but hydrochloric acid is very soluble and will soon disappear. Hard washing-water sometimes leaves a deposit on the paper, which must be wiped off with a soft rag or cotton-wool.

Toning.—It seems to us somewhat absurd to tone platinum prints, destroying very much of their distinctive character. Even the sepia tints obtained by the special developer are scarcely attractive in comparison with pure black. A method of uranium toning is given by Von Hubl, but there are some doubts whether it is permanent.

A. Uranium Nitrate	48	gr.
Glacial Acetic Acid	48	minims.
Water	1	oz.
B. Potassium Ferricyanide	48	gr.
Water	1	oz.
C. Ammonium Sulphocyanide	½	oz.
Water	1	oz.

These solutions must be kept separately. For use take ¼ oz. of A, B, and C and add 25 ounces of water. After fixing and thorough washing the print is placed in a dish containing the toning mixture, and rocked continuously, till the desired tone is obtained, or a little longer, as the tint will dry out rather colder than it appears while wet. A little weak acetic acid is recommended for the first washing water after toning. By substituting ammoniated iron alum for uranium nitrate the colour becomes blue instead of black, but this is rather an expensive way of producing a blue print.

Intensification.—A feeble image may be intensified by the deposit upon it of a further layer of platinum.

A. Sodium Formate	45 gr.
Water	1 oz.
B. Platinum Perchloride	10 gr.
Water	1 oz.

At time of using take 15 minims of A and B with two ounces of water. After intensification the print has only to be washed and dried.

Dolland's Intensifier.—A neutralised solution of gold two grains to the dram, is just acidulated with hydrochloric acid and then spread over the print, which has previously been covered very evenly with a coating of glycerine applied with a sponge or brush. When intensification is adjudged complete the print is well washed and plunged for a moment or two in a metol or rodinal developer of moderate strength. After washing and drying the strengthened image will show itself as a rich black, about the permanence of which no doubts need be entertained.

Development with Platinum.—For a home-made paper in which the platinum salts are introduced after development, and one which is both cheap to prepare and needs no special protection, the Joé iron process is to be recommended. Any good drawing paper, sized with arrowroot or agar agar, is sensitised by brushing over with the following:

A.	Ferric Oxalate	300 gr.
	Oxalic Acid	30 ,,
	Lead Oxalate	15 ,,
	Water	3½ oz.
B.	Mercury Bichloride	75 gr.
	Water	3½ oz.

Take of A 25 parts, B 1 part.

Dry without application of heat in the dark room and print in a good light until the picture shows all the details effectively; then develop in

Potassium Oxalate	½ oz.
Potassium Phosphate	¼ ,,
Water	5 ,,

to which immediately before use is added for every half-ounce 5 grains of potassium chloroplatinite dissolved in, say, 30 minims water. Fix in the usual hydrochloric acid bath.

Baron Van Hubl remarks on this process that it is but rarely used, but that it deserves the fullest consideration, as it exceeds the usual one in the beauty of the results and the ease with which it is manipulated.

CHAPTER XXV

BROMIDE AND GASLIGHT PAPERS

ALL the papers described hitherto have been of a kind needing daylight, or an electric light of high actinic value, to produce satisfactory results; the image also becomes fully visible and complete during exposure under the negative. We now have to consider a series of papers, sensitised with silver, in which the image does not print out, and which require only to be exposed to a very moderate light, even a wax candle or a lucifer match being generally sufficient.

Bromide Papers.—These are papers coated with an emulsion in which bromide of silver is the principal haloid salt. The vehicle may be either collodion or gelatine, but the latter continues to be exclusively employed, especially since the introduction of the bromoil and ozobrome processes. The emulsion is of similar nature to that used for coating gelatine plates, but must not be ripened, and the proportion of gelatine is rather large. The following is a typical formula after Dr. Eder:

Gelatine	80 gr.
Ammonium Bromide	30 "
Water	1 oz.

A few grains of potassium iodide may be substituted for part of the bromide. The gelatine after prolonged soaking is dissolved with the bromide at a temperature of 130–135° Fahr.; and 30 gr. of silver nitrate dissolved in an ounce of water at the same temperature is added by degrees, the mixture being meanwhile well stirred or agitated. When thoroughly incorporated it is allowed to set, broken up, squeezed through thin canvas, and washed in three or four changes of water. Lastly, the emulsion is redissolved at a temperature of about 130° Fahr., and coated on some pure paper (Saxe or Rive's), without much glaze upon it. The coating process will be greatly assisted if a few drops of glycerine are added after melting.

Printing.—All operations with bromide paper, except exposure, must be conducted in the dark room, illuminated only by yellow or orange rays. There are many varieties of this paper sold, varying from very rough to smooth or glossy, the rough papers being most suitable for enlargements or large negatives. Most negatives may be adapted to this paper. Very hard ones should have short exposure very close to the source of light, soft negatives must have longer exposure at a distance of two or three feet. Even illumination of the whole printing surface is important. Practice soon enables the operator to gauge the time of printing and distance from the burner suitable for each negative; doubling the distance quadruples the length of exposure necessary. The light for printing may be either a gas-burner, an oil-lamp, or even a candle. Daylight is too rapid, 5 sec. often producing reversal. At 2 ft. from an ordinary incandescent burner the time of printing will probably be 15–30 sec., but it is advisable to test with narrow strips under an average negative before printing a batch. Some difficulty may be experienced at first in deciding which side of the paper is coated with emulsion, and must therefore be in contact with the negative, especially by the light of the yellow lamp. If the paper is laid on the palm of the hand the coated side will curve inwards; and if a corner is touched by the damp finger it will betray a slight stickiness.

Development.—Returning to the dark room, remove the print from the frame and place for 1 min. in clean water. Transfer to the developing dish and pour on the developer, taking care that the paper is well covered. Rock the dish for a minute or so, when, if the time of printing has been correctly gauged, the image will begin to appear. As soon as the details in the half-tones are faintly visible pour the developer back, and allow the print to continue gaining strength in the empty dish. When the required tint is *nearly* attained flood with three changes of water, and then transfer to the fixing bath of from 3 to 4 oz. of hypo to the pint of water.

Developers for Bromide Prints.—Nearly all the developers given for plates are equally suitable for bromide papers when diluted to half their strength with water. The best for black tones are hydroquinone, eikonogen, metolquinol, and glycin. Rodinal and amidol are also good. A few drops of bromide solution should be added with most of these to avoid degradation of the high lights. Pyro is tabooed by most workers, but we have obtained good brown tints, and the acid alum clearing bath will remove all stains.

Ferrous Oxalate.—This developer is the traditional one for bromide papers, but we do not recommend it unless a very large amount of work of this kind is done. It involves a good deal of trouble, but gives bright, sparkling pictures and grey half-tones.

A.	Potassium Oxalate (neutral)	5 oz.
	Ammonium Bromide	6 gr.
	Water	20 oz.
B.	Ferrous Sulphate	1 oz.
	Sulphuric Acid	5 minims
	Water	3 oz.

At time of using pour 1 oz. of B into 6 oz. of A. The oxalate must not be poured into the iron solution, or a thick yellow precipitate of ferrous oxalate will form. After development wash the print in two changes of a solution of citric acid, 30 gr. to every pint of water, and then in three changes of pure water before fixing. Otherwise the iron salts will become insoluble and stain the print a pinkish yellow colour.

Prints from an Unfixed Negative.—The bromide printing process has this convenience over any other, that, if a proof

Printed on
ILFORD P.M.S. BROMIDE
Paper.

is wanted in a hurry, it may be taken from a negative within a minute after development. Wash the negative well, lay it face upwards in a dish of clean water, and bring in contact with it a piece of bromide paper of the same size. The two are squeegeed together, and then exposed in the printing frame; the exposure being about four times as long as would be the case with a dry, properly fixed negative. Bromide prints may be reduced and intensified in just the same way as ordinary negatives, except that the solutions are rendered more dilute for the former. Local reduction or intensification is easily accomplished by means of a brush dipped in a solution of copper bromide with glycerine. Blisters may be cured by the alum or formaline baths given under development of plates.

Belitski's Reducer.—If the ferric salt can be conveniently obtained, this reducer surpasses all others for bromide prints. No stains are likely to result from its use—in fact it will often remove developer stains—and it does not alter the original colour of the print. One fault is that it must not be exposed to daylight, but keeps for a long time in the dark.

Potassium Ferric Oxalate	50 gr.
Sodium Sulphite	40 "
Water	5 oz.

Add 10 gr. of oxalic acid when the above are dissolved, stir well, and decant off the green solution, to which must then be added about 250 gr. of Hypo.

Toning Bromides.—Bromides may be toned with uranium, copper, iron, and other methods, most of them rendering the permanence of the print subjected to them very questionable. The sulphide toning process, converting the silver image into the practically unalterable silver sulphide, bears at present a good reputation. A hot bath, which will serve for several kinds of paper, is made up as follows:

Hypo	1½ oz.
Alum	80 gr.
Water	10 oz

The bath is made up with hot water, and 5 mm. of nitrate of silver solution are an improvement, serving as a restrainer. The solution should be allowed to cool and then warmed again to 120° Fahr. for use. If any precipitate settles on the prints it must be wiped off with cotton wool. Warm brown tones are given.

In the Kodak formula for sepia tones, 1 oz. hypo is dissolved in 7 oz. water at 135° Fahr., and 130 gr. alum added by degrees while still at the same temperature. The liquid will be milky, but must not be filtered. After the prints have been fixed and washed, they should be placed in a saturated solution of alum for ten minutes and allowed to dry. The actual toning is carried on by immersing the prints in an iron dish containing the cold hypo-alum solution, which is then raised to 120° or 125°, and kept at that heat for twenty minutes, or until the desired tone is obtained. The fumes of these hot alum hypo baths are very injurious both to dry plates and papers, and this toning process should not be carried on in any apartment where they are stored.

Bleaching Process.—Bleach the print in

Potassium Bichromate	10 gr.
Hydrochloric Acid	5 min.
Water	1 oz.

Wash with several changes of water until yellow stain is discharged; a little alum will hasten the effect. Then either leave to print in the sun or redevelop with either rodinal or amidol. The brown image may then be toned in any ordinary gold toning solution, after which the print may be reduced in the fixing bath if necessary.

Alternative Bleach for Sulphide Toning.—Bleach the print in

Ammonium Bromide	50 gr.
Potassium Ferricyanide	150 „
Water	10 oz.

Wash well in several changes of water, and then tone to tint desired in a solution of pure sodium sulphide 15 gr. to the ounce of water.

Platinum Toning.—Bromide prints (but not gaslight prints as a rule) may be toned in a solution of platinum perchloride. They lose density to a considerable degree while under treatment, and must therefore be allowed to over-develop. The colour will vary according to the proportions of platinum salt and acid in the toning bath. For sepia tones:

Platinum Perchloride	2 gr.
Hydrochloric Acid	60 min.
Water	10 oz.

Gaslight Papers.—A series of new papers, known under such names as "Velox," "Gravura," "Slow Contact Paper," etc., etc., have been gradually taking the place of bromide paper for contact printing by artificial light. The principle of most of these is an emulsion consisting chiefly of the chloride and other salts of silver which are scarcely sensitive to any rays of light except those between F and H on the spectrum, viz. the blue and violet. They are nearly all white in colour, and not of creamy tint like the bromide papers. These papers therefore do not need the use of a dark room, and may be manipulated within a few feet of the gas-burner by which the picture is printed, such light being comparatively poor in blue and violet rays. The most convenient arrangement is to shelter the developing dish behind a large sheet of cardboard or other light screen on the table, say, six feet from the source of light.

There are many ways of working these papers, and it is not easy to give directions that will apply alike to all the brands that have attained to popularity. Some photographers prefer to give a very long exposure to light—two or three minutes—and develop in the much-diluted formulæ adopted for bromide papers. By this means it is possible to secure very great softness of detail, and also a range of colours from light brown to rich chocolate, black, and even blue. The more common practice is to expose for a shorter time and use a stronger developer.

Development.—The development of gaslight papers is much the same as for bromides, except that the developer must not be poured off the print until it is ready to be transferred to the fixing bath; the developer will oxidise in the paper if exposed to the air. Development is often complete within a minute, when the liquid must be poured off and the picture very quickly rinsed in water. The developer must always contain a small proportion of bromide solution. Two typical formulæ are given, the first that for the Ilford, the second for the Gevaert gaslight papers.

(1) Metol	5 gr.
Sodium Sulphite	½ oz.
Hydroquinone	20 gr.
Sodium Carbonate (crystals)	½ oz.
10 per cent. solution Potassium Bromide	10 min.
Water	10 oz.

(2) For warm tones. The time of exposure may be prolonged or curtailed, in order to obtain a range of colours.

Stock Solution.

Glycin	1 oz.
Sodium Sulphite	2½ ,,
Potassium Carbonate	5 ,,
Water, distilled and hot	4 ,,

Dissolve the sodium sulphite first, then add the glycin, and lastly the potassium carbonate in small quantities as the mixture froths up. A 20-oz. measure should be used for the above quantities. The result is a liquid of creamy appearance and consistency, which must be shaken before use. To develop take

Stock solution	½ oz.
Water	15 ,,
Potassium Bromide (10 per cent solution)	7 drops.

Rodinal is also a favourite developer with gaslight papers in the proportions of 1 to 30 or 50.

Phosphate Papers.—These papers, while produced and completed with a rapidity greater than the ordinary gaslight papers, have all the appearance of gold toned P.O.P.

"Ensyna," the earliest of these, can be finished off ready for drying and mounting in about six minutes, divided as follows:

Exposure	about 30 sec.
Water bath	1 min.
Development	2 ,,
Fixing	30 sec.
Washing	2 min.

The film is very soluble, hence the short time allowed for fixing and subsequent washing.[1] The tones may vary according to length of exposure from engraving red, brown and sepia to blue-black; over-exposure merely imparts a warmer tone to the print.

The Paget Phosphate Paper is developed with an acid metol developer, the proportions of which are varied to increase contrast or to alter the tones which may range from blue-black to purple and sepia. The prints undergo no alteration of tone in fixing, which is rapidly completed, and the last washing need not occupy more than half an hour. When fully exposed, the tones are similar in appearance to those produced by toning P.O.P. with gold.

[1] Further experiments have shown that a more prolonged washing in running water is necessary to eliminate hypo entirely from the paper. A weak solution of potassium persulphate would, however, obviate this.

CHAPTER XXVI

THE CARBON PROCESS

WHEN a bichromate salt is mixed with an organic substance soluble in water, like gelatine, the latter has a tendency to absorb oxygen from the former, and also to become insoluble; this action is enormously accelerated by exposure to light. The carbon process, and various other processes allied to it are based on this principle of the hardening of bichromated gelatine under the influence of light. Colouring matter is mixed with the gelatine, which is spread over a sheet of paper and exposed under the negative; after which the unexposed gelatine is washed away, leaving an image in pigment similar to that used by the painter.

Printing in carbon is very simple and well adapted for the amateur worker. Except for sensitising, no chemicals are necessary, the developing agents being hot and cold water. There are no deleterious solutions requiring prolonged washing. The image is in good mineral pigment, capable of surviving the paper on which it is supported, and the various stages follow readily and are easily acquired. Bichromated gelatine is sensitive to the green rays of the spectrum; carbon tissue, therefore, needs only half the exposure of most printing-out papers. There are only two difficulties—that the paper will not keep for more than a fortnight after being sensitised, and that correct exposure cannot be judged by examination of the print itself.

Carbon Tissue.—The pigmented tissue is rather troublesome to prepare, the proportions differing considerably, according to the season of the year, and according to the particular colour. An average mixture may be

Water	8	oz.
Gelatine	$2\frac{1}{2}$	,,
Soap	120	gr.
White Sugar	140	,,
Dry Colour	80	,,

The soap and sugar are dissolved in the water and the gelatine soaked till soft, when it is melted over a water bath. Meanwhile the pigment is ground up in a mortar or mill with some of the jelly; lastly the whole is stirred together and filtered, when it is ready for coating on the paper. The tissue may be obtained in all desired colours, ready cut to size from the leading manufacturers. It can only be supplied in the sensitive state by special order, owing to the fact that it must always be used within a fortnight after sensitising.

Sensitising.—Float the tissue face downwards in a wide dish containing sufficient solution of bichromate of potassium (1 oz. bichromate to 20 oz. of water) which should be nearly neutral, although many contend that the tissue will keep better if rendered alkaline with a few drops of ammonia. Agitate the dish to remove bubbles, lift and examine after a minute, and if any air bells remain sweep them away with a brush. Three minutes will be sufficient, after which the sheet may be squeegeed face downwards upon a clean sheet of glass or ferrotype, and dried in some safe cupboard free from chemical fumes or light of any kind. Tissue prepared at night should be dry and ready for use the following morning. Tissue must always dry quickly or it will be found to get tough.

Printing.—Before being placed in the printing frame the negative must have a "safe edge" formed on it with a border of black varnish or black paper round the margin about a quarter of an inch wide, to prevent the pigment from splitting at the edges during development. A soft and pleasing effect is got by making this safe edge on the glass side of the plate. It is not very easy to detect any change during exposure. With light colours, such as Bartollozzi red, the faint outline of the image becomes visible; some printers claim that by breathing gently on the tissue they can tell when it is sufficiently exposed. Ordinary mortals must be content to work by an actinometer. Any good negative, with fair contrast and gradation, will give passable results on carbon paper.

If a print is removed prematurely from the printing frame and put away in the dark, the action will continue and after a few hours be found sufficient for development. Curiously enough also, if a fully exposed print is compressed in the copying press, in contact with a piece of sensitised tissue, a second image may be secured, though of course a reverse in direction. Probably the reason of this phenomenon is that certain of the subsalts, particularly the quadruple chromate chromic oxide, exercise a diffusive action through the comparatively moist layers of gelatine.

Development.—The tissue must be developed, either by artificial light, or in a room protected by blinds, or otherwise, from strong daylight. The face of the tissue has become practically insoluble and, in order to develop it, we must transfer it to another surface and meanwhile remove the soluble pigment at the back of the film. This surface is termed the temporary support, and may be either a polished zinc plate, glass, or prepared paper according to the surface desired. The zinc plate, if employed, must be very smooth and especially free from scratches, each one of which would betray itself on the final print. The flexible temporary support is the best for many reasons—a smooth shellac-coated paper, which some hours before use is coated with a waxing solution.

Resin	18 gr.
Yellow Beeswax	6 ,,
Spirits of Turpentine	1 oz.

or celluloid sheets rubbed over with a piece of flannel steeped in

Spermaceti	20 gr.
Benzole	1 oz.

or, in default of these, common rubber solution will do. Remove the print from the printing frame and place face downwards in cold water, with a piece of flexible support of rather larger size. When the tissue begins to uncurl and float flat the two surfaces are brought into contact under water, and squeegeed together on a plate glass or other level surface, after which they are laid between blotting paper for about a quarter of an hour, or longer if desired, with a weight, such as a large book, over them.

At the proper time the print is placed once more in water heated to a temperature of 100° to 110° Fahr., which will soften the gelatine. As soon as the coloured gelatine begins to ooze out at the edges of the paper, the latter may be carefully lifted off, and the dish rocked steadily to assist dissolution of the mass of unexposed tissue. Warmer water may be applied, if the tissue fails to loosen sufficiently to release the paper ; but the water must never be of higher temperature than is just sufficient to develop the print, or a weak, feeble image will result. The backing paper must always be removed *under* water, and should come off spontaneously when one corner is lifted between the finger and the thumb.

When the picture is satisfactorily developed, wash the print in cold water, and then for five minutes in a dish containing a 5 per cent. solution of alum to harden.

Final Support.—The final support may be of paper, wood, or any similar material. The surface must be larger than the print, and should be coated with a weak solution of Nelson's gelatine 1 oz., water 20 oz., to which has been added either 1 oz. of chrome-alum solution or enough bichromate of potassium to colour the whole a clear yellow colour. The support after coating is exposed to the light. These supports, like the rest of the materials for the carbon process, may be obtained commercially.

When the print attached to its temporary support is dry, or at any subsequent time, it is once more placed in warm water (110° to 120°) with the permanent support, which has been previously soaked just long enough in cold water to render the surface slimy to the touch. Bring the two together, avoiding air-bubbles, lift them out, squeegee between blotting boards, and leave them to dry. When dry the temporary support will peel off, leaving the print in its permanent position.

Single Transfers.—This process is simpler, and is resorted to when the owner is willing to disregard the fact that the final print will be a reversed picture, or when a reversed negative has been prepared for the purpose. Such a negative is most essential as a saving of time whenever a large number of prints are required. Film negatives are therefore advantageous for carbon work. The tissue when taken from the frame is brought into contact under water with the permanent support, which for single transfer purposes should contain a rather larger proportion of chrome alum than the amount given for preparing the final support as above. Development then proceeds in the same way as with the double transfer, except that after the alum bath the print is rinsed in cold water for a short time, and all is then complete.

Tissue may be obtained in a great variety of colours, but the most useful are engraving black, engraving brown, sepia, and red chalk. Fine effects may sometimes be obtained by using a coloured base for the final support.

Carbon Transparencies or Lantern Slides.—Glass plates, free from scratches or marks, are cleaned thoroughly with powder and acid, and then coated with

Nelsons' No. 1 Gelatine	¾ oz.
Water	20 ,,
Potassium Bichromate	30 gr.

When dried they are exposed to light until the coating is insoluble. Or, dry plates are freed from silver in the fixing bath, and hardened in a 2 per cent. bichromate solution, when they are ready to be used as supports in the single transfer process. Special transparency tissue is manufactured for this purpose. Carbon lantern slides, if not overprinted, have the advantage of crisp detail as well as permanence.

Three-colour Carbon Prints.—Tissues of the proper colours—yellow, blue, and pink—are supplied by the makers. The tissue may be sensitised in a bath of one part 10 per cent. bichromate solution and one part methylated spirit, and squeegeed under blotting-paper on to ferrotype sheets. Drying may, if necessary, be accelerated by heat. The yellow tissue will take about twice as long to print as blue, and the pink about one and a half times the yellow, but in all three colours the image will be more or less visible.

When the tissues have been separately developed on their temporary support, the yellow is transferred first to the final mount, and adheres without special treatment. A thin coating of Nelson's gelatine (gelatine 30 gr., water 1 oz.) must then be laid on, then the blue print, then another coating of gelatine, and finally the pink print. The register must be secured by needles passing through holes at measured spots in the temporary supports. This precaution is of course unnecessary with the transparent celluloid temporary supports introduced by the manufacturers of carbon tissue.

Glazed Surface Prints.—The tissue must be somewhat underprinted, as its depth will be increased by the action of the collodion. On removing from the printing-frame, coat the tissue with a thin solution of enamel-collodion and transfer as usual to temporary support. The enamel must be very evenly laid on; inequalities will show as markings on the finished print.

Difficulties and Defects.—If the print, or part of it, refuses to adhere to the support it is probable that grease of some kind has found its way into the dishes, and so reached one or other surface. Spots are produced either by dust or bubbles, especially in under-exposed prints. Such spots, if not too numerous, may often be filled up with a fine brush and melted tissue of the right consistency. Over-exposure and under-exposure may to a great extent be compensated for by the use of hotter or colder water in development; but greatly over-exposed tissue will generally cockle up or leave the paper in uneven patches. Tissue which has been sensitised for more than a fortnight is usually worthless Care and exactness are as necessary in the carbon process as in those involving a series of chemical reactions.

Ozotype.—This is a variation of the carbon process invented by Mr. T. Manly, and is founded on the property which an image on a bichromated surface has of inducing insolubility in gelatine when pressed into contact with it. A special sensitising solution (protected by patent), containing bichromate and manganous salts, is spread evenly with a broad hoghair brush over any suitable drawing paper, and then hung up to dry in a place free from damp or actinic light. The sensitised paper does not keep unless enclosed in chloride of calcium tubes or boxes, like platinotype paper. When exposed under the negative a brown image prints out to the required depth, and no actinometer is therefore necessary. All details ought to be visible except light clouds.

The print is next washed in cold running water until the margin covered by the rebate of the printing-frame is quite clean and white, but care must be taken not to wash too long, or the brown image will lose in strength. The exact time of washing may be from 6 to 10 minutes in summer, and from 20 to 30 minutes in winter. After washing, the further operation of pigmenting may be deferred if necessary for months.

Pigmenting.—When ready for pigmenting, the print is placed face downwards in a special acid bath in which the pigment plaster has been soaking for from 30 secs. to a minute. The two are brought quickly into contact face to face, and squeegeed together, as in ordinary carbon paper. Development and subsequent operations are the same as with single transfer carbon, which this process indeed greatly resembles, except that the picture is not reversed, and an ordinary negative can be used.

The acid bath is made up as follows:

Stock Solution.

Warm Water	10 oz.
Sulphate of Copper (pure)	20 gr.
Glacial Acetic Acid	5 "
Glycerine	4 "
Hydroquinone	4 "

Working Bath.

Concentrated solution	4 dr.
Water	40 oz.

The diluted bath will keep for three days, and may be used for any number of prints in succession. The stock solution will keep for many months.

Ozobrome.—This is a further invention of Mr. Manly, by means of which an ordinary bromide print may be converted into a carbon print. A piece of carbon tissue is soaked until saturated in a patent pigmenting solution containing potassium bichromate, potassium ferricyanide, and a bromide salt. It is then squeegeed into contact with the bromide print, which has been previously hardened, either by alum or formaline. A chemical reaction takes place between the silver image and the ferricyanide, the bichromate salt is deoxidised, and ultimately a chromate image is formed which penetrates well into the tissue. After being left in contact under blotters for about 20 minutes the whole is developed at a temperature of 110°, like an ordinary carbon. Lastly, the bleached silver image may be fixed out in the ordinary hypo bath, or redeveloped if required to give greater intensity to the picture.

Transfer Process.—An alternative method is to place the bromide print with the pigment plaster adhering to it in cold water, and separate them from each other by carefully and steadily pulling at the former. The pigmented paper holding an impression of the silver image may now be pressed into contact with a fresh support and developed in warm water in the usual way. The original bromide print may be redeveloped, and used again as a matrix for a succession of prints.

The process, especially in the first form, is an exceedingly valuable one for improving the appearance and increasing the chances of permanence of bromide paper enlargements. Many variations may be suggested. For instance the bléached silver image, instead of being redeveloped, may be sulphide toned in a solution of sodium sulphide 300 gr., water 20 oz., or toned to any desired colour; and being protected from the atmosphere by the semi-transparent layer of hardened gelatine, is almost everlasting.

W. H. Roge

GUM-CHROMATE PRINT.

CHAPTER XXVII

THE GUM-BICHROMATE PROCESS

"QUOT homines tot sententiæ" is apparently the motto of all who adopt and recommend this very beautiful process. It is almost outside the range of ordinary photography, beyond the fact that it commences with a negative from which an image is printed in bichromated gum or fish glue. The after-manipulations are at the particular artist's will. We might term it a "go as you please" process, so diverse are the directions given by its numerous devotees.

Preparing the Paper.—Almost any substantial kind of paper is suitable as the foundation of a gum print provided it is not too heavily sized. An even grain is necessary unless the pictures are large and not likely to suffer by the straw lines and other watermarks. Whatman's and other drawing papers in different qualities, rough or smooth, or the grained papers used for water colours, will be the most serviceable. A paper that will not expand and contract in an irregular manner is also an important consideration. Mr. James Packham commences by sensitising his paper with a 10 per cent. solution of bichromate of potassium, immersing it for about 2 min., after which it is dried. The subsequent gum pigment is then applied in unsensitised state. Other workers prefer to mix the bichromate with the pigment, while yet a third-class coat the paper with gum pigment before sensitising. Mr. A. W. Hill sizes the paper first of all with Le Page's liquid glue, watered down with five times its bulk of water, and applied with a broad varnish brush.

The Gum Pigment.—This is usually compounded of 1 oz. of pure gum arabic in tears, and 2½ oz. of water. To avoid impurities the gum should either hang in the water in a muslin bag or be strained from woody impurities when dissolved, which will probably be at the end of twenty-four hours. Most readers are well aware that it is not possible to mix colours directly with any vehicle. A quantity of dry colour in powder must be laid on a slab and carefully ground up with a palette knife into close association with a few drops of the gum, after which it is worked up with a brush into a mixture with the remainder of the gum solution. The proportion of pigment to be used in each case varies with the worker and also with the colours employed. Mr. J. C. S. Mummery, one of the most successful and eminent exponents of the process, takes 40 gr. ivory black and 8 gr. burnt sienna to 1 oz. gum solution and 1 oz. sensitiser. Others are content with as little as 12 gr. to the ounce of gum solution. Until the beginner has mastered the elements, and can strike out his own independent line, we should advise about 36 gr. to the ounce of solution. A great range of colours is available for practice, but the easiest are vegetable black, burnt sienna, Vandyke brown, and the ochres.

Coating the Paper.—Lay the paper on a drawing-board, pin down the corners, and spread the coloured gum evenly over the surface of the paper. If the paper expands from moisture unfasten the pins and stretch it flat before refixing. The gummy surface must be still further levelled, either by going over it with a very broad brush, a leather lithographic roller, or, as some find better still, rubbed in with a piece of soft muslin rolled up into a ball. If the sensitising solution has not been mixed up with the gum this must be applied as soon as the surface is dry. It will consist of a 10 per cent. solution of potassium bichromate with about a dram of ammonia. But if more advanced work is likely to be aimed at, and especially multiple printing, the sensitising solution should always be mixed with the gum pigment.

Exposure.—This must ultimately be by sensitometer, and will vary considerably, not only according to the actual actinic power of the light, but according to the colour of the pigment. An actinometer may be used; but the image ought to be visible to some extent, at any rate in the shadows, unless the pigment has been laid on too thickly. Under-exposures are practically worthless; over-exposures may to a certain extent be reduced by a weak solution of sodium hypochlorite.

Development.—Lay the print face downwards in a wide dish of cold water and leave it to soak for 10 min., when it may be lifted out while the water is changed, and examined to see if any portion of the pigment is dissolving out with the bichromate. After the second change of water, it may be dealt with face uppermost, unless these operations are taking place immediately under a brightly lighted window. Gently rocking the dish will probably remove most of the soluble colour, but if portions of the high lights prove obstinate in unveiling they may be delicately persuaded with a soft camel-hair mop brush. If the image is well exposed and fully set, the brush will come in useful in freeing other parts of the picture, as the worker gains more confidence and skill. Frequent changes of water, followed by an alum bath, will remove all traces of the bichromate stain. Warmer water is sometimes employed when the weather is cold, or when portions of the picture cannot be cleared by any other means. For delicate manipulations the print may be laid on a glass slab.

Multiple Gum.—For the higher Art purposes of the gum process more than one printing, either in the same, or in several different colours, is desirable. It is of the first importance that the paper selected for double printing be one which will not shrink or stretch seriously after prolonged treatment under water, and, before attempting any ambitious essay, a sample of paper should be tested by pricking distances on it and examining after soaking and drying. A coat of size, made by dissolving 1 oz. of gelatine in 20 oz. of water, should be brushed over the selected sheet and then hardened with chrome alum, or, better still, formalin.

The simplest application of multiple gum is the printing in of clouds, which may be done by spreading a very thin, weak coating of pigment in the upper portion, printing under a cloud negative, and developing. When dry, the pigment can be laid on in its full strength, and the foreground and other features of the landscape printed and developed. Figures can be printed into a scene which lacks them; overlapping is no serious matter to the gum artist, who, with his brush, can correct any anomaly on the wet print.

Where several colours are to follow one another by successive printings and developments a special printing frame will be required in order to secure exact register. Or, instead of the printing frame, the sensitised paper may be laid on an ordinary drawing board, then the negative, face downwards, secured in position by four pins, one on each edge of the glass, and the exposure decided by the actinometer. If the pins are invariably stuck through the same holes in the paper there need be no fear of any serious irregularity. To enable the paper to withstand repeated sensitising and soaking there must be a good substratum of size.

The Colour Scheme.—For a few suggestions on this matter we are indebted to a very successful worker, Mr. M. Richard Witt, who recently read a paper on "Gum Bichromate in Colour" before the Photographic Society of Philadelphia. Mr. Witt suggests three colours:

Indian Red or Venetian Red,
Medium Cadmium Yellow,
Indigo, or Prussian Blue.

In our colour scheme we must avoid too vivid a colouring, or the result, in combination with the photographic sharpness of detail in our negative, will be nothing but a chromo. The result desired should be more in the nature of a colour suggestion or an arbitrary colouring not necessarily approaching the colours in the original landscape. It does not imply because the sky is blue or the grass is green that we should make our sky a brilliant blue or our grass a vivid green, for, as a matter of fact, the sky is more often any other tint than blue, and grass is not always green ; a cluster of trees in midsummer will show a variety of tones besides the deep green of the foliage, and so on. Should the beginner, however, wish to try for an actual reproduction of colours, we might take for example a conventional subject, such as a sunlit landscape in August, with fleecy clouds in the sky which occasionally obscure the sun, casting a soft glow over the country. In such a case it should first of all be remembered that we must not have a muddy, heavy sky, so that in our first coat, red, this pigment is entirely taken out of the sky, except for a faint deposit in the light shadows cast by the convolutions of the clouds ; a fairly good deposit is left in the trees, particularly in the trunks ; it is brushed out considerably from the grass, and if we have any water in the picture, a *very* thin coating is left there as a basis for the ripples.

The second coat, yellow, is also almost completely removed from the sky, except in the clouds, where a slight deposit should be left. In the trees we again leave a fairly good deposit, particularly in the trunks, and we leave a good, strong deposit in the grass for the representation of the diffused sunlight. The water should retain a very thin deposit of yellow.

The third coat, blue, is then put on for the finish, and here it is well to state that one coat of blue is rarely sufficient. It nearly always requires two coats of this colour to finish the picture. The first one is usually too light to give the desired effect. It may occur to the worker that one good, heavy coat would be sufficient, but this theory does not work out in practice. It is only a waste of pigment. Two somewhat thinner coats, or even three, will be found to be more effective. It is a rather difficult task to describe the development of the coating of blue. If the first printing of this colour has been properly accomplished, enough may adhere to the sky and water portions of the print to give these their proper proportion, and, of course, where the blue covers the yellow patches left in the sky we shall have greenish-looking spots; these should be carefully uncovered with a thin, soft stream from the hose or by careful brush work, but sufficient blue should be left to strengthen the effect of the cloud convolutions.

The water then receives our attention, and when we have taken off sufficient pigment to give us a slightly flatter tone than we have in the sky (this is helped by the deposit of yellow left from the previous printing), we then turn to the remaining portion of the picture, and, after washing out some of the excess blue from the trees, but not all, we give our attention to the grass, and note with pleasure the appearance of the yellow sunlight effect as we gently wash off the top colour. As we proceed with this we may find that our sky is too blue, so that we shall have to reduce its vividness still further; in fact, it is necessary to observe constantly the effect of the last coat or coatings over the entire print, so that our finished picture will represent a harmonious effect. This point should really be emphasised; but, in order to secure a pleasing result, the three colours must be properly blended and at least a trace of each should be combined with the other two in every part of the print.

For further particulars, especially on the artistic side, we must refer the reader to *Photo-Aquatint*, by Alfred Maskell; *Practical Gum Bichromate*, by J. Cruwys Richards; or to *Les Procédés d'Art en Photographie*, by MM. Demachy and Puyo.

Artigue's Paper.—A variety of gum paper, which may be obtained ready-coated, requiring only to be sensitised before use. The vehicle is supposed to be a mixture of albumen and gum solution. Papier velours shows an extremely fine and delicate surface of velvety black, the coating being so thin as to be almost transparent and easily wiped off the paper by a stroke of a moist finger. From this fine, easily soluble layer of pigment arise the special qualities of the paper.

It is usual in sensitising to float the paper face upwards on the sensitising solution—a 5 per cent. solution of potassium bichromate with a few drops of ammonia. The sheet must remain in the dish until the sensitiser is judged to have penetrated through the back, no liquid being allowed to fall on the prepared surface. One minute is about sufficient. If very great care is exercised, both in immersing and drying, so as not to injure the sensitive surface, there is no reason why it should not be dipped like other papers of the kind. Drying must take place in a room where there is a fire and where the walls are dry.

Exposure is timed by an actinometer, although, owing to the transparency of the film, details are visible on the back, and development may follow immediately in water at the ordinary temperature—or in winter at 80° Fahr. The image will often develop of itself, without any attention greater than rocking the dish. But if this does not suffice we must adopt Mr. Alfred Maskell's sawdust developer. A thick soup of finely ground sawdust is prepared in a wide earthenware pan. The paper is laid on a sheet of glass just above the pan, and a quantity of the sawdust mixture poured over it from a coffee pot or other utensil with a rather wide spout. At first only the lighter particles from the top of the mixture in the pan should be taken ; afterwards by dipping down, it may be taken thicker. This very soft rubbing seems exactly the right degree of force to use on the delicate surface of an Artigue print.

It was at one time thought that Artigue's paper would supersede carbon. There is no transfer, no temporary support, no hot water, nor any other of the special difficulties and complications of carbon. But, somehow or other, it has not " caught on " with the amateur, and is now rarely seen in this country.

CHAPTER XXVIII

OIL PROCESSES

OIL and water will never agree; they repel each other. Consequently, if a sheet of paper or a glass plate is coated with a bichromated gelatine, exposed under a negative and then soaked until the unchanged gelatine is heavily charged with water, any pigment of greasy nature will adhere only to those parts of the print which, being insoluble, have absorbed no water. Here we have the foundation of another method of printing photographs which admits of all the variations and individual treatment characteristic of gum-bichromate.

Gelatine Paper.—Several ready-prepared papers may be had specially suited for oil pigmenting, and these ready-made papers are far preferable for the beginner unversed in the many difficulties and uncertainties of gelatine. We ourselves often revert to the lithographic transfer papers of Albert & Husnik, obtainable from Messrs. Winstone, of Shoe Lane, E.C. Or a good cartridge or drawing paper may be coated with this solution:

Amber Gelatine (Nelson's or Coignet's)	1 oz.
Sugar	90 gr.
Water	10 oz.

Soak the gelatine for about twelve hours, add the sugar, melt in a jar over a hot plate or in a *bain-marie*, pour in a few drops of chrome alum, and strain through muslin. When the paper is dry float a second time, taking care that the coating is as evenly applied as possible. Some prefer to lay the paper on a perfectly level glass plate, and pour on the melted gelatine, using about 2½ ounces of solution for a sheet

Hy. P. Maskell.

TEA TIME.

16 by 13 inches at a temperature of 75° Fahr. The paper may be made wet with warm water before coating, and in about an hour should have set sufficiently to be hung up to dry. If floated dry on the gelatine, the coating will set immediately. Under either condition bubbles or bare places must be corrected.

Sensitising.—When required for use the prepared paper is immersed for three minutes in

Potassium Bichromate	1 oz.
Potassium Ferricyanide	120 gr.
Water	10 oz.
Methylated Spirit	5 "
Ammonia	10 min.

and then drained and squeegeed on a ferrotype under blotting-paper to secure an even surface, and put away to dry on its support. Or, for rough work, the sensitised sheet may be simply hung up to dry in the dark room. The sensitised paper will keep for about a week, or longer if under pressure and protected from changes of temperature. M. Demachy sensitises by laying the gelatined paper on a sheet of thick blotting, and brushes it over with a two-inch flat hog-hair brush dipped in the solution, this device enabling the paper to be dried within about half an hour. The other method, however, secures an image penetrating far more deeply into the film.

Development.—The image prints out quickly under the negative, and in summer all details will be visible in about three minutes. Under-exposure gives too great contrast; over-exposure will mean the veiling of the high lights. When printing appears to be of sufficient depth, the paper is removed from the frame and washed in cold water till all traces of bichromate are removed. About twenty minutes in three changes of water will accomplish this. It can then be placed in warm water, say at 90°, to develop the grain. Lift at intervals, blot off a portion, and see if the picture is well in relief. If not, warmer water must be applied. The exact temperature at which sufficient water is absorbed will vary with the kind of paper and the time of the year. With Albert paper in winter we have sometimes used water at 200° Fahr., to which a little ammonia has been added. But, as a rule, water at 100° is sufficient. In summer even at this heat the gelatine will be rendered too brittle. Caution is necessary until experience can adjust these little difficulties.

Pigmenting.—Lay the fully-soaked print, protected by a piece of hard blotting, on a glass plate or slab, blot off superfluous moisture from the surface, and apply the pigment. A very solid hog-hair brush, with the ends of the bristles cut and ground level, is the favourite tool, but some use a pledget of cotton wool for dabbing the colour on, while one enthusiast of our acquaintance declares that the ideal "dabber" is the ball of the human forefinger. A dabbing motion is the best for getting the pigment well on and cleaning it off the high lights. Apply very little pigment at first, increasing the thickness by degrees especially where greater contrasts are aimed at. The actual pigment may be composed of lithographic ink thinned with turpentine, or ordinary oil-tube colours, such as are used for oil-painting, mixed with a little copal oil and then thinned with turpentine. As the turpentine evaporates so will the power of strengthening the shadows and clearing the high lights increase. A harder ink for greater contrasts is obtained by adding a drop or two of some oil varnish. If the high lights refuse to clear, sponge the picture gently with warm water, or dip it once more into warm water. But this must not be done until the best part of the turpentine is evaporated from the ink, or it will run. In order to secure this steady evaporation, oil prints should only be pigmented at a temperature of 65°; in winter there should always be a fire.

When the whole image has taken the ink, the picture may be touched up with a finer brush, removing excess of ink, clearing high lights, and adding more colour in places that seem to require such treatment. Lastly it is dipped once more into cold water, and clipped to a board to dry. If allowed to dry in a loose condition it will roll up and become unmanageable, probably smeary. When the gelatine surface is dry the ink is still capable of absorbing any metallic dusting powder, gold, silver, or bronze, if such things appeal to the taste of the producer. They are laid on usually from a pepper castor, and the excess brushed away with a soft camel-hair brush.

Some photographers with a talent for oil-painting use various colours on the same print, and find that they are able to manipulate the film with ordinary brushes.

Husband's Papyrotint.—This is a modification of the ordinary oil process, and is a revival of an old method of making photolithographic transfers, first introduced by Sir W. Abney. There is no great difficulty in the actual printing and development, in fact it is much easier, and requires much less manual skill than oil printing as generally understood. For the amateur it has this drawback, that the paper must be manufactured at home; it has proved to be so perishable, even before sensitising, that it cannot be stocked as an article of commerce.

The Paper.—A cartridge or drawing paper is floated on a bath consisting of

Gelatine (Nelson's Flake)	8 oz.
Glycerine	1½ „
Common Salt	2 „
Water	50 „

Soak the gelatine for twelve hours, then melt under heat, but do not raise the temperature much above the point at which the gelatine is dissolved. Avoid getting bubbles on the surface of the paper. Dry the paper at a temperature of 85°–90°, and afterwards keep in a dry atmosphere. Not more should be made at one time than will be wanted for use during the next two months. Sensitise as follows:

Potassium Bichromate	1 oz.
Common Salt	½ „
Potassium Ferricyanide	120 gr.
Methylated Spirit	5 oz.
Water	25 „

and squeegee on a ferrotype under blotting-paper, or dry at a temperature of 80°—of course in some place secure from actinic light.

Development and Pigmenting.—Operations will be simplified considerably, if a piece of paper much larger than the negative is used for the print, allowing of a "safe edge" about a inch and a half all round the picture. The negative may be put under plate glass in a large printing frame, and this edge protected by a mask of black paper. Printing is soon accomplished; the image will print out a brown or even chocolate colour upon the yellow ground. When this is attained remove the print and let it soak in cold water for ten minutes; next it may be transferred to lukewarm water 80°–90° or, if very bright prints are required, at still higher temperature; but care must be taken not to expose the gelatine to a heat which will cause any part of it to leave the paper support. When the grain appears sufficiently coarse (which can be ascertained by lifting from the water and blotting off some portion) lay the print on a glass plate and blot off superfluous moisture.

Meanwhile a small quantity of lithographic ink, or oil colour with copal oil and a drop or two of varnish has been deposited on a dry glass plate to serve as inking slab. Mix with a palette knife two or three small dabs of oil colour or ink about the size of a pea on the inking slab, pour on a little turpentine to thin the mixture, and distribute the ink evenly well over the slab by means of a gelatine roller, such as is used in the printing trade. As the turpentine evaporates, the ink on the slab will assume a velvety soft appearance, and respond with a characteristic tacky sound to the action of the roller backwards and forwards. It is then ready for use.

The roller, duly charged with ink, is now rolled with a steady even motion backwards and forwards over the gelatine print, upon which it will leave a film of ink—at first over the whole picture impartially, but the high lights will gradually whiten. Do not use too much ink, but feed the roller with fresh ink if the image is too pale in colour. Slow rolling deposits ink upon the image; faster rolling clears the picture. A very little practice will make perfect in the mysteries of inking up.

When the papyrotint is satisfactory, soak for a minute or two in an alum or formaline bath, and hang up to dry.

Bromoil.—The conversion of a bromide print into an oil print. Glossy-surfaced prints are not often successful, and the print should be of recent development. It is first bleached in a solution compounded very much as follows:

Potassium Ferricyanide	4 gr.
Potassium Bromide	18 ,,
Potassium Bichromate	18 ,,
Alum Ammonia	36 ,,
Hydrochloric Acid	60 ,,
Water	4 oz.

We give this formula of Mr. A. H. Garner's, in order to show the chemical reaction.

It has been claimed, however, that the above is a breach of Mr. T. Manly's patent, and it would perhaps be better to use the following variation, as no one should begrudge this gentleman the lawful reward of his investigations:

Ozobrome solution	4 oz.
Potash Alum 10% solution	4 ,,
Citric Acid 10% ,,	1 ,,
Water	20 ,,

after which it is soaked in a 5 per cent. solution of sulphuric acid until the high lights of the picture appear in relief, which will generally happen within five minutes. The image is then fixed out in an ordinary fixing bath, but this is not absolutely necessary, unless the pigments to be employed are of so light a colour that the silver when darkening would spoil the effect. In summer the image will occasionally show itself in relief without the use of the acid bath.

After washing, the bleached print is ready for pigmenting, which is done in much the same way as with ordinary oil prints, or even with the roller employed for papyrotints.

Ordinary Robertson's medium may be mixed with tube colour and dabbed, smudged, or "hopped" on with the usual smooth brush, or with a soft muslin or cotton-wool dabber according to the skill of the particular artist. With finer brushes it is not difficult to touch in light effects in colour. The bromide image remains in faint yellow as a guide, and we have seen some excellent bromoils of spring flowers and the like subjects of not too complicated nature executed in two or three colours.

If any mistake is made and the effect is unhappy we can wipe the picture off with a little benzole, wash in water, and start afresh, so long as no ink has been allowed to get at the paper on the back of the print. Elaborate directions as to the laying on of the oil pigment, of devices for increasing light and shade, and of other instruments which may be enlisted into service, we are not called upon to append here. Bromoil, like gum-bichromate, is an art process, and one which affords the individual worker an opportunity to mature devices for himself and to apply them in his own way. A little practice, and perhaps a few spoilt prints, are not a heavy price to pay, if the experience gained eventuates in productions combining success with the higher quality of originality.

Manufacturers are beginning to label the bromide papers most suitable for conversion into bromoils. Ilford rough, Ilford, or Wellington carbon; Barnet ordinary or rough present little difficulty. The latest advice can generally be obtained when purchasing the ozobrome solution from the Ozotype Company, who from time to time publish new directions for the more economical management of the process. A simplified bleaching bath lately suggested by the company consists of

Ozobrome solution	1 part
Hydrochloric Acid (pure) 1 per cent. solution .	5 parts
Water	4 "

To make up the hydrochloric acid solution take 2 drams fluid (sp. gr. 1·16) to 25 oz. water. In one to three minutes the print will become a faint yellow colour and may then be placed direct into the fixing bath :

Hypo	2 oz.
Ammonia	1 dr.
Water	20 oz.

where it must remain from two to six minutes according to the original hardness of the bromide emulsion, which can be gauged with sufficient accuracy by the time the image takes to bleach. After a wash of three to five minutes it is ready for inking up.

According to experts, the bromide prints which make the most successful bromoils are those developed with amidol, or hydroquinone combined with metol.

CHAPTER XXIX

MISCELLANEOUS PRINTING PROCESSES

Cyanotype or Blue Prints.—

A.	Ferric Ammonium Citrate (green)	1 oz.
	Water	4 „
B.	Potassium Ferricyanide (Red Prussiate)	160 gr.
	Water	4 oz.

Or, if the brown citrate is used, substitute:

A.	Ferric Ammonium Citrate (brown)	300 gr.
	Water	4 oz.
B.	Potassuim Ferricyanide	½ oz.
	Water	4 oz.

Mix equal parts of A and B just before use; float the paper for three minutes, or apply with a brush or sponge. Print till the shadows show a bronze colour, and develop by soaking in three or four changes of water. To intensify immerse for five minutes in a solution of

Ferric Chloride	1 dr.
Water	20 oz.

Brighter colour and better detail may be got by the following sensitiser:

A.	Ferric Ammonium Citrate	1 oz.
	Gum Arabic	80 gr
	Water	4 oz.
B.	Potassium Ferricyanide	180 gr.
	Water	4 oz.

A few minims of bichromate of potassium are sometimes added, if the paper has to be kept before use.

Toning Blue Prints.—Bleach in 5 per cent. solution of ammonia or carbonate of potash until image has nearly faded, and then transfer to a 5 per cent. solution of tannic acid, which will give a colour varying from brown to black.

The blue image may also be converted into a silver image with 2 per cent. solution of nitrate of silver, and then be developed with any ordinary plate developer in dilute form.

Pellet's Process for copying line drawings. (Blue lines on a white ground.)—

Gum Arabic	360 gr.
Sodium Chloride	45 ,,
Tartaric Acid	60 ,,
Ferric Chloride	120 ,,
Water	$3\frac{1}{2}$ oz.

or

Gum Arabic (20 per cent solution)	20 parts
Ammonio Citrate of Iron (50 per cent. solution)	8 ,,
Ferric Chloride (50 per cent. solution)	5 ,,

Mix a few hours before required, and use when clear. Coat evenly on well-sized paper and dry in the dark. The yellow image is developed in a saturated solution of potassium ferrocyanide (yellow prussiate of potash), washed and fixed in hydrochloric acid 1 in 20.

Black lines on White Ground.—

Gum Arabic	180 gr.
Ferric Chloride	180 ,,
Ferric Sulphate	60 ,,
Tartaric Acid	30 ,,
Water	3 oz.

Dissolve the gum in the water, and then add the other ingredients (ferric chloride last). The image will appear of greenish-yellow tint and must be developed in

Gallic Acid	1 dr.
Methylated Spirit	2 oz.
Water	6 ,,

Afterwards wash in three changes of water.

Kallitype.—Coat any pure drawing paper with a solution of

Sodium Ferric Oxalate	180 gr.
Water	2 oz.

Print till shadows are visible and then develop in

Silver Nitrate	10 gr.
Citric Acid solution	5 min.
Water	1 oz.

Another sensitising formula is

Sodium Citrate of Iron	180 gr.
Potassium Oxalate	60 ,,
Water	2 oz.

Develop in

Silver Nitrate	10 gr.
Potassium Oxalate	80 ,,
Water	1 oz.

Render alkaline with ammonia sufficient to redissolve precipitate. This will give black tones. For brown tones substitute borax 60 grains for the potassium oxalate of the developer.

Indian Ink Process.—Float Rive's or similar drawing paper on

Ferric Chloride	30 gr.
Citric Acid	30 ,,
Water	2 oz.

Print under a negative till the picture becomes visible and then develop in a solution of gelatine containing Indian ink, or any other water colour. The coloured gelatine should adhere only to these parts where the light has acted.

Primuline.—This dye has the property of becoming sensitive when nitrated by nitrous acid, and the process founded upon it, also called Diazotype, was discovered by Messrs. Green, Cross and Bevan in 1890. Paper, or any textile fabrics which are free from starch are dyed in a solution made by boiling 150 grains of primuline in 10 ounces of water, a glass flask being employed for this preliminary process.

The fabrics are kept for about ten minutes in motion immersed in the hot dye, and washed in cold water and dried.

Sensitising is done in the dark room with the following bath:

Sodium Nitrate	50 gr.
Hydrochloric Acid	2 dr.
Water	20 oz.

until a uniform reddish brown colour appears, when the fabrics are rinsed in cold water, dried without application of heat and exposed under a negative, until the image is visible.

After a preliminary rinse and wring out, develop in one of the following solutions, according to colour required:

Brown

Pyro	60 gr.
Water	10 oz.

Black

Eikonogen	60 gr.
Water	10 oz.

Purple

Naphthalamine	60 gr.
Hydrochloric Acid	1 dr.
Water.	10 oz.

Red

β Naphthol	50 gr.
Caustic Soda	60 „
Water	10 oz.

Postcards.—A number of the formulæ given in various parts of this work may be applied to the home preparation of picture postcards. Under this heading we supply one or two methods for utilising in photography the ordinary postcards sold by stationers in penny packets.

(1) *Plain Cards.*—Soak the cards for about a minute in

Sodium Chloride	50 gr.
Water	5 oz.

and dry on a newspaper before the fire; then sensitise the portion that is to receive the print by spreading on with a brush or pledget of cotton-wool a solution of

Nitrate of Silver	90 gr.
Citric Acid	2 ,,
Water	2 oz.

Dry rapidly in subdued light, and print under a masked negative. Print deeply, tone in the acetate gold bath, and fix in the usual hypo bath.

(2) *Plain Cards.*—The following is recommended by Mr. C. A. L. Pearson in the *Camera*:

Silver Nitrate	80 gr.
Tartaric Acid	40 ,,
Citric Acid	15 ,,
Ammonia	quant. suff.
Potassium Bichromate (solution 10 gr. per oz.)	4 drops
Water	1 oz.

Dissolve the silver in a portion of the water, add tartaric acid, and stir with glass rod. Then add the ammonia until the precipitate at first formed is redissolved, then bichromate solution with more ammonia, if the red precipitate does not redissolve on stirring, and lastly the remainder of the water. Keep in a stoppered bottle away from light. Paper sensitised with this solution should be printed rather lighter than is required for the final effect, as the image afterwards darkens. Dip for a few seconds in a 2 per cent. solution of common salt without washing, and fix for ten to fifteen minutes in a strong hypo bath.

(3) *Gelatine Emulsion* (J. Barker).—A yellow glass bottle is recommended for the preparation of the emulsion with which the cards are to be coated.

Gelatine (Coignet's No. 1)	40 gr.
Barium Chloride	8 ,,
Nitrate of Silver	20 ,,
Methyl Alcohol	½ dr.
Water	1 oz.

Pour in the distilled water, then add the chloride and the gelatine; let them soak for half an hour and warm to about

95° Fahr. When the gelatine is dissolved add the silver, shaking until dissolved, and then the alcohol. Keep for half an hour at 95°, and then coat paper. The salting may be altered to suit conditions, highly salted emulsions being naturally suitable for rich tones and dense negatives. Pour a small pool in the centre of the paper and spread quickly over the surface with a brush. This emulsion tones excellently in the sulphocyanide combined bath; and we have got good results with the acetate and other toning mixtures.

Photo Sculptures.—Take

Sheet Gelatine	5 oz.
White Sugar	2 "
Water	14 "

Soak the gelatine in the water till soft, add the sugar and apply heat sufficient to dissolve, stirring frequently. Coat as thickly as possible on glass plates or paper. (Winstone's thick, lithographic, photo-transfer paper will give considerable relief, but the skilful operator may get a thicker coating of the gelatine on glass, especially if he glues a margin of paper round the edges.) Sensitise in a 7 per cent. solution of potassium bichromate, to which enough ammonia has been added to give a light yellow colour. To accelerate drying, methylated spirit may be added. Dry in a warm room away from light and expose, under a suitable negative, till the details are well out.

Development is accomplished by prolonged soaking in water until the maximum relief is reached. In winter tepid water is necessary, and the transfer paper will generally require warm water with a little ammonia before the gelatine becomes highly absorbent. When ready the swelled print is laid face upwards on a piece of level plate glass, superfluous moisture blotted off, and a wooden frame placed round it to act as a rim.

Take a suitable quantity of Brucciani's fine plaster of paris, stir in water till of the consistency of a thin cream, and continue stirring till the mixture shows signs of beginning to set, when it must be poured quickly into the mould formed by the wooden frame, and flatted over with a palette knife or glass plate. After about half an hour the plaster cast may be lifted off and dried. This cast is a reverse, and the final relief must be made from it. To accomplish this the plaster matrix is warmed on a hot plate or in an oven for some time, and the surface made to absorb a considerable amount of paraffin wax, the best method being to dip it into a vessel containing the melted wax. A new rim of wood is laid on it, and the plaster poured on. In making the permanent cast a spoonful of sodium silicate or 50 per cent. of alum solution may be used in the mixing water.

More delicate detail is attained, if the first cast on the gelatine is made of soft wax, by melting up ordinary wax candles in a saucepan. On this wax matrix the final plaster is poured, and the wax detached by the application of heat. Negatives with plenty of contrast are the only ones suitable for plaster relief work.

Dr. W. M. Daniels.

AT THE FOUNTAIN.

CHAPTER XXX

HAND CAMERAS

BEFORE us, as we write, is a dog-eared, time-stained little volume. It is a catalogue of photographic goods for 1885—just twenty-six years ago. We search in vain for particulars of hand cameras ; there are none. However, in an obscure corner, as if as anxious to escape observation as the holder of the instrument was supposed to be, there lurks an announcement of a "patent detective camera." You could buy it either as a leather-covered box, or even tied with string in brown paper to look like an ordinary parcel, and the description assures us that "photographs could be taken without rousing the slightest suspicion." The writer never dreamt that within ten years every bearer of a leather-covered box or brown paper parcel of oblong shape would be taken for a camera fiend.

There were other detective cameras in those days. We have one pattern still in our possession, an enormous watch-shaped article, about 6 in. in diameter, with a tiny lens attached near the circumference, which was supposed to peep out through a coat button-hole. It takes six pictures in succession on a circular revolving plate. And there were more excellent pieces of apparatus, such as Messrs. Marion's Academy Camera—a sort of twin-lens camera before its time.

The name of "Detective Camera" was not a happy one, and discouraged most of us from patronising it; when the epidemic of Frenas and Kodaks began a few years later the serious photographer was even more disgusted. It was not merely that he who had borne the burden and heat of the day with a 10 × 8in. instrument was being rivalled by the casual tourist with a feather-weight film Kodak; nor even jealousy that the latter should reap, as it were, the harvest that others had sown. What troubled him was the desecration of his calling by an ignorant, thoughtless race. Up to, say, twenty years ago, long after the days of wet collodion, only those who were prepared to take great pains, and to exercise thought, were attracted to photography. A heavy camera, an expensive plate, a limited number of slides; developing solutions which had to be made up as required; manuals on the mysteries of the art few and far between; all this entailed hard work and intelligence. Hence each plate exposed was likely to imply thought and purpose. The hand camera put a premium on ignorance. The standard of work was lowered to the very depths; and the man who pointed a fixed-focus box-camera at space and sent it to be developed, or who developed it himself with a few tabloids, passed current as an accomplished photographer. After twenty years' experience of the unintelligent kind of hand-camera owner, we are still not quite hardened enough to view their doings without a squirm of horror.

At a well-known seaside resort we observed a young lady, with whom we were slightly acquainted, go into a chemist's shop and emerge shortly afterwards with a packet of Ilford red label plates—some of the very fastest in general use. Then she sat down on the nearest seat and calmly proceeded to unpack the plates and slip them one by one into the sheaths of her camera. For a moment we stood paralysed with dismay, but recovered after a while sufficiently to approach the scene and offer a few words of protest.

"Pardon me, Miss Brown, but these plates are ruined. They will not bear the slightest white light."

Miss Brown turned upon us with a smile of kindly pity, and replied:

"Oh! But this is quite a *new* kind of camera."

We retired abashed. And we have no doubt that she informed her friends afterwards that the particular kind of plates were no good at all.

All this by way of prelude. The hand camera is not to be despised because of the misuse that it receives from the uninstructed. What we wish to insist on is that there is no royal road to photography in the true sense of the word. Most people nowadays begin with a cheap hand camera. It is either a toy for the moment which they will cast aside, like other toys, or it will whet their appetite for better things. Good work can only be done by those who are willing to serve their apprenticeship in focussing and composition, and all the other details explained in earlier chapters of this book.

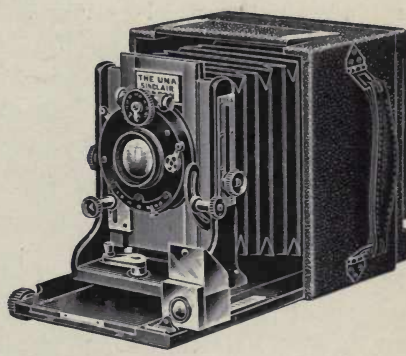


FIG. 54.—THE SINCLAIR "UNA" AT NORMAL EXTENSION.

The Hand and Stand Camera.—A few years ago the field camera and the hand camera were two distinct types, with clear demarcations. But the Sanderson on the one hand, and the better class of Kodaks on the other, have led the way towards a compromise between the two. We can buy compactly built, portable cameras with every movement, swing front, swing back, folding baseboard, triple extension, just as well equipped as a field-camera for the same size of plate. We illustrate a few of these; the price varies considerably, and each has advantages that make it worth the price. The beginner need not insist on all these features, if he does not contemplate an equipment necessary to face very difficult problems of architecture in narrow courtyards, or very long-focus lenses for taking animals in their native haunts, etc. Double extension is very desirable, and a rising front indispensable. Chiefest of all is the focussing screen, in order that practice in composition with the camera on the stand may be always available. And this is not the only use of the focussing screen. Without occasionally referring to it, no one can have real knowledge of the limitations of his lens; there is no other means of acquiring the power of seeing a picture as the camera sees it, which is the foundation of every real photograph.

The View-Finder.—But it is not reasonable to insist on every photograph being focussed on the stand before it is taken. We ourselves always carry a stand in the satchel, but often do not unpack it for whole days. When once we know our lens, and are in full sympathy with it, focussing on the stand is only required for elaborate landscape compositions, groups, or portraiture of a high order. For eight months of the year full exposures can be given with the camera held in the hand unless the weather is very dull, and for ordinary composition the view-finder will provide the experienced eye with all essential data. The ideal position for the view-finder is attached to the rising front just above the lens; unfortunately it is very liable to be knocked askew during those rough moments that attend the career of the most jealously guarded hand camera. The next best position is inset into the body close beside the level, so that the operator can keep the two simultaneously in view. Somehow we do not get on, as regards levelling, with "direct" view-finders, although we acknowledge their prime advantage of enabling the camera to be held at the height

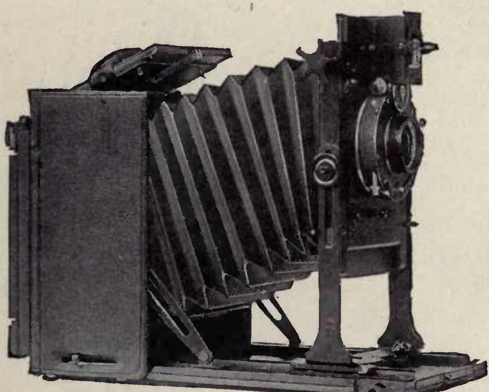


FIG. 55.—THE ADAMS "VAIDO."

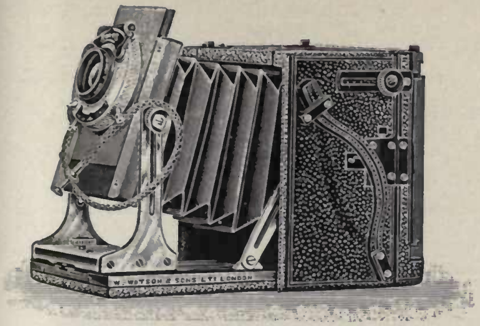


FIG. 56.—THE WATSON "ALPHA."

of the eye. View-finders on the body of the camera necessitate mental calculation when the subject is within 6 ft., and also when the rising front is in use—and the latter, so we find, is wanted for nearly every picture, or there will be a long stretch of ugly, useless foreground. The finder should be bright, and should give exactly the same amount of view as is seen on the plate.

The Focussing Scale.—On the baseboard of every focussing hand camera is a scale of distances from 5 to 30or 50 ft. indicating the point at sharpest focus. Some people seem quite unable to estimate distances quickly and accurately, and the only way seems to be practice with chalk marks on a pavement. Even a foot or two may prove a serious error when working at *f*/6·5 within 10 ft. of the lens, and, especially when enlarged, a picture is apt to betray its fault when the principal object is not in fuller focus than other subsidiary objects.

Depth of Field.—This is very important to bear in mind when focussing by scale, in order that objects in the foreground may not turn out to be glaringly out of focus. Short-focus lenses are not so likely to show this fault as those of longer focus. When in

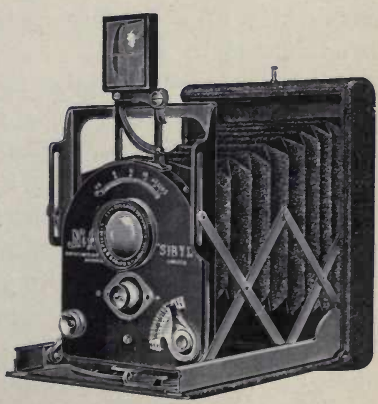


FIG. 57.—THE "SYBIL" CAMERA.

doubt, either avoid the foreground altogether or focus for it. Directions how to calculate depth of field are given in Chapter V, but a few rough calculations for the guidance of beginners are subjoined.

TABLE I (with a 6 in. lens)

Distances of focal centre	10 ft.	15 ft.	20 ft.	25 ft.
	Feet.	Feet.	Feet.	Feet.
f/6·5	9–13	11–22	14– 36	16– 55
f/8	8–14	10–25	13– 44	15– 77
f/11	7–16	9–34	12– 77	14–100
f/16	6–21	8–72	10–100	10 to infinity.

TABLE II (with a 5 in. lens)

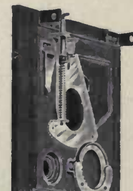
Distances of focal centre	10 ft.	15 ft.	20 ft.	25 ft.
	Feet.	Feet.	Feet.	Feet.
f/6·5	8–14	10– 28	12– 53	14–90
f/8	7–16	9– 35	11– 87	13 to inf.
f/11	6–21	8– 72	10–100	12 to inf.
f/16	5–43	7–100	8 to inf.	9 to inf.

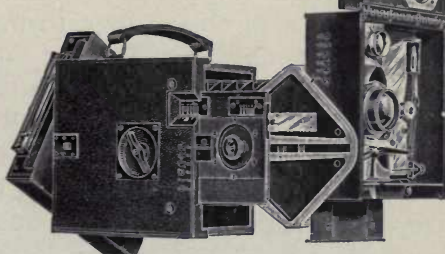
The above tables show amongst other things the great advantages of a short-focus lens when working with the hand camera by scale.

Infinity Mark.—On the focussing scale at 30 ft. or upwards we shall see a distance marked "Infinity," which indicates that when an object is focussed at this distance with the largest stop in the lens, everything beyond it will be in focus. The infinity mark is a distance dependent on the focal length of the lens, decreasing in proportion with the stop used. Thus at *f*/6·5 the infinity mark is reached at about 32 ft. with a 5 in. lens, but if we reduce the stop to *f*/8 it is reached to all intents and purposes at 25 ft., and with *f*/11 at 20 ft. All objects beyond half the distance from the camera to the infinity mark will also be in focus.

Fixed Focus.—Here we have the secret of the fixed-focus camera. If we set a camera with a 5 in. lens at 32 ft., all snapshots taken at objects beyond 16 ft. will be in fair focus at *f*/6·5. But if we are willing to work at *f*/11 there is the enormous advantage of being able to take anything at a distance beyond 10 ft., and get pictures sufficiently sharp for enlargement. Many cameras are now constructed to spring out automatically to infinity. But we gain very much in range for nearer objects, and incidentally in pictorial effect, if we calculate the mark of infinity for the particular stop we intend to use in the lens. And for all practical purposes, that is to say, when there is no very distant

Closed, as carried ready for ordinary work.





Open, to show fittings and movements.

FIG. 58.—THE NEWMAN AND GUARDIA UNIVERSAL CAMERA.

landscape to consider, the infinity mark for a 5 in. lens is reached when the depth of field approaches 100 ft. Even with a 6 in. lens the infinity mark *f*/11 may be taken at 30 ft. against a figure nearer 40 ft. at *f*/8. Of course, if we consider the higher capacities of lenses these figures are inaccurate and worthless. But then, no one expects of a fixed-focus camera good pictures of Alpine scenery, any more than we should employ them for portraits within a few feet of the lens.

Snapshots.—A snapshot we define as a plate exposed on the spur of the moment; one which we have no time to focus or compose either by means of the focussing screen or a scale of distance. We can go snap-hunting with the ordinary hand camera fixed at infinity, but it is hardly advisable to carry about a high-class instrument dangling down, with the bellows and delicate gear unprotected. Still worse to expect that we shall have space and opportunity to secure the quarry; many a time when wandering in the woods a squirrel has come within range; at the mere click of setting the shutter he has been off out of sight. With very little trouble and ingenuity a box of light wood can be adapted to serve as the body of a fixed-focus lens; we can screw the lens and iris shutter into the front, and provide clips for the movable back of our high-class camera. The length must be the fixed focus for *f*/11, which in that case must be the largest stop employed; and as already stated will provide us with an efficient instrument, ready set for all objects over 10 ft. distance from the lens.

Snapshot Cameras.—Do not despise the "Bullseye," "Scout," and cheaper magazine patterns, such as the "Klito," "Briton," "Empire," "Maxim," "Rover," etc., with which the market has been flooded in the past. Even if we do find them too often in the hands of inexperienced beginners, they are none the less capable of excellent work in their own proper scope. A box camera of the fewest possible movements is the only weapon available at an emergency. The other day we were shown an album of pictures secured with one of these humble instruments, and our soul was filled with envy at the sight. A few miniature cameras like the Ensignette may give like opportunities, because they are comparatively invisible; but if we want pictures of happy children by the seaside, or the casual mysteries of riverside and woodland, give us the box-pattern fixed-focus camera.

This sort of camera has one very serious defect—that it is much too cheap. People therefore treat it as an inferior article, good enough only for the beginner, who is just the person least qualified to use it. Although it is apparently the simplest form of camera, nevertheless it is the most difficult to obtain proficiency with, unless the owner has mastered the principles of focussing, and understands how to group his subjects in focus. For instance, when aiming at high-class pictorial results with a 5 in. fixed-focus lens, if all objects over 10 ft. are in focus, he will endeavour to secure that the centre of subject is at about 18–22 ft. distance, 20 ft. being about the distance of sharpest focus. Such knowledge and the ability to use it is not acquired without apprenticeship at a focussing screen.

Changing of Films and Plates.—The connoisseur in snap-shot work will be lavish in his expenditure on plates; he will be content with a small average of good pictures from a large number of exposures. He is obliged to decide quickly and must run many risks of failure. Hence he must take a large supply of plates with him. Roll films or film packs are, of course, easily exchanged, but are expensive in comparison with glass plates, the extra cost amounting to at least 150 per cent. Fortunately the new envelope system for flat films and plates has now attained a very high degree of perfection, and the slides can be reloaded almost as rapidly as the change of a double back, and with far less liability of error and double exposures.

During our own wanderings in the last twenty years we have almost exclusively made use of roll films, either with a proper roll-film camera, or with the very convenient cartridge roll-holders fitted on to an ordinary field camera. No other system is so safe, or gives so little bother and anxiety to the operator; and their is less risk of halation than even with backed plates. The films may be developed in the Kodak developing tank, or by the more interesting though, perhaps, more laborious method shown on p. 103.

CHAPTER XXXI

REFLEX CAMERAS

THE ordinary hand camera has this very serious disadvantage, that the actual image, which is about to be imprinted on the sensitive plate, cannot be seen by the operator. He is obliged to take it for granted, and estimate its actual qualities from the view-finder. Thus he has less facility for the composition of his picture, and loses the means of gauging the exposure by the comparative degree of illumination which the plate will receive. To meet these difficulties the twin-lens camera was invented, consisting of two lenses in two separate chambers superposed, the upper of which was used as a guide in focussing; and afterwards the reflex camera.

As its distinctive feature, a reflex camera is fitted with a hinged mirror crossing the body near the plate at an angle of about 45°, and reflecting the image in exactly the same focus as the plate on to a ground-glass screen at the top. Incidentally the image thus appears in its true direction, and not upside down, as on the ordinary focussing-screen. The screen is shaded from direct light by a more or less prominent hood. Early patterns of reflex camera were of exceedingly simple design, and one of these has survived to the present day—Messrs. Watson's Vanneck. In this instrument the mirror itself acts as the shutter. There are theoretic objections to a shutter working at such a distance from the plate, but for the moderate speeds (from $\frac{1}{10}$ to $\frac{1}{90}$ sec.) the Vanneck shutter does its duty very well. We used a Vanneck for some years, and had no fault to find with it except the plate-changing arrangement; and if it could only be fitted with dark slides we believe the Vanneck would still have a long and honourable career before it.

Estimating Distance.—We referred to this difficulty in the last chapter. It is often very troublesome to have to estimate the exact distance of the predominating feature in the view, and still more troublesome to remember the calculations with regard to the relative sharpness of other objects nearer or further from the lens, which form integral features in the composition. All this is obviated with a reflex camera. We see the actual view before us on the focussing screen, and can adjust the focus and the stop in the lens to produce the desired effect as accurately as if we were working with a stand camera.

Portraiture.—Here the above advantage is presented in more accentuated form. The figure within a few feet of the lens needs to be focussed to a nicety. The actual size of the features is seen, and not guessed at from the view-finder. But this is not all. Working with a large stop so near the lens, the background is necessarily thrown out of focus. A hand-camera portrait too often betrays its origin by the eccentric manner in which the circles of confusion, formed by the shadow of some distant object, enter into competition with the features or hair of the individual. When the portrait is focussed in a reflex there is some chance that the distracting elements will be observed and avoided.

Long- and Short-Focus Lenses.—Here again the reflex camera insures the operator against mistakes. We may fit the hand camera with separate scales for the wide-angle, rectilinear, and single combination. Only too well we know what a tax is put upon human frailty. *Aliquando nutat Homerus.* And the reflex lends itself to the occasional adoption of very long-focus lenses, which combine high rapidity with the greater pictorial possibilities inherent in views of this kind. To these we may add that the whole view is seen, no matter how much the front is raised or swung. When taking pictures in an ancient town the tourist often shrinks from setting up the stand. He knows too well that his act would be a signal for an admiring and inquisitive crowd to assemble, and even to pose themselves in the very midst of his view. Yet he is puzzled to decide whether his rising front will cut off too much foreground, or fail to reach the quaint gable-ends that he is bent on including.

Height from the Ground.—The chief objection urged against the reflex camera is that, owing to the length of hood, it must be manipulated at a very low level to enable the operator to follow the image on the screen, much lower than an ordinary hand camera, and therefore that most pictures will contain too much foreground. On the other hand, the rising front is available. At any athletic sports meeting press photographers may be seen holding their cameras upside down above their heads and following the image through the hood with perfect equanimity. The modern simplified pattern of shutter, which adjusts exposure with a single movement, provides for this method.

Animals and Wild Nature.—The reflex camera is the only one with which satisfactory pictures can be obtained of animals at play, birds in the garden or in the woods, and wild nature generally. In this special field the benefits of visible focus and power to employ long-focus lenses react on one another. By the aid of the latter fair-sized pictures are possible at a distance sufficient to escape the observation of these nervous and bashful subjects.

Instantaneous Pictures.—Moving objects up to a certain speed come within the province of the ordinary stand camera, that is, if they can be focussed for in advance, and are bound to pass over a fixed spot, as, for instance, an express train, a coach, or, to a certain extent, the competitors in a cycle or motor race. The hand camera may by good luck succeed, if fitted with a reliable shutter. But the reflex camera is now recognised as the instrument fulfilling the conditions involved in the most satisfactory manner.

The one great problem involved in taking instantaneous photographs—and it applies to a less extent to those taken by the previously set-up stand camera—is the capacity of ensuring that the shutter shall act at the psychological moment; for the best-devised shutter in the world takes a fraction of a second to respond to the press of the button. With an express train, a bird rising in flight, or a cricket bat, a very small error, say, $\frac{1}{50}$ sec., may rob the plate of all value as a record. The personal equation comes into value here. Constant training of eye and nerve will create the faculty of anticipating, by just the right interval of time, the instant when the moving object will reach the most favourable point. After some practice this faculty will become automatic. Owing to the double character of the mechanism of a high-class reflex camera, in which the mirror catch has to act simultaneously with the shutter-release, the interval is probably rather longer, but none the less may be anticipated quite accurately by the individual.

The Shutter.—Diaphragm shutters, which for every other purpose are preferable, scarcely enter into competition with the focal-plane shutter for instantaneous work at high speed. With no other "back" shutter can one be quite sure that the two movements which control the raising of the mirror and the rapid exposure of the plate have been successfully accomplished. No other shutter has been brought to so high a degree of efficiency during the last few years.

But beware of old-fashioned, second-hand, focal-plane shutters. Some are quite an inch away from the actual focal plane and create a sort of fog. And some operate with a jerk that may even affect the picture at low speeds, and will at any rate advertise the presence of the camera to every living thing within fifty yards. A cheap reflex with a cheap focal plane is worthless. To do good instantaneous work get one of the very latest patterns in which the multitude of cords, winders, hooks, and sliding knobs are done away with and, if possible, the tension springs as well. A single winding key should control all movements as in the old-fashioned Thornton Pickard shutter. Have the shutter tested for speeds at the earliest opportunity, to be sure that they are really attained by the instrument, or are purely arbitrary.

The intergearing of mirror and shutter should be such that when the mirror is shut up the shutter cannot be wound, and so expose the plate accidentally. Perhaps it is still better to demand a self-capping blind.

Our remarks about diaphragm shutters, however, require some modification. Since the time when this chapter was first written, two high-grade reflex cameras of great practical efficiency have been introduced, both equipped only with the diaphragm shutter, and one of them with the multi-speed shutter—probably the fastest in existence. But one great advantage of the focal plane remains still unchallenged, viz. that it permits of nearly double the amount of light reaching the plate in fast exposures with the lens at full aperture. There is a considerable loss of light with diaphragm shutters when working with a lens at any stop wider than *f*/8.

Size of Camera.—The worst of a well-equipped reflex camera is the size and weight. It is a cumbersome article on a tour, even now that an excellent folding reflex is on the market. A quarter-plate camera is as large as can be managed by the ordinary man; in fact we do not see why it will not serve for press purposes, seeing that an enlargement can be made as quickly as a contact print; 5 × 4 in. is certainly the most formidable reflex camera that we should care to be burdened with, and its weight is half as much again as the quarter plate.

The Higher Speeds.—A focal-plane shutter usually includes beyond the $\frac{1}{100}$, $\frac{1}{200}$, $\frac{1}{400}$, $\frac{1}{600}$, $\frac{1}{800}$, $\frac{1}{1000}$ sec. And a few calculations will show that in purely instantaneous work within a few feet of the plate these high speeds are frequently called into action. A man walking only three miles an hour moves $4\frac{1}{2}$ ft. per second. During that second his image will have travelled across the focussing screen if he is within, say, eight feet of the lens. A trotting horse is estimated to move through 39 ft., and a galloping horse about 50 ft. Express trains (not to mention birds, whose flight is at a speed treble that of the locomotive) soon exhaust the capabilities of a shutter at $\frac{1}{1000}$ sec.

In photographing rapid motion at athletic sports, races, and the like, the subject is, if possible, taken when approaching in the direction of the camera, and not crossing the field of view at right angles. The range of pictures at a comparatively low speed may be thus considerably increased—an important matter when the weather is dull and the light in consequence rather weak.

If the speed of a shutter to take an object moving at a given rate has to be estimated, the distance of the object must be divided by 100 times the focus of the lens, and then the rapidity of motion of object must be divided by the result. Or if R be rate of motion of the object, D the distance and F the focus of the lens, then, in order that the circle of confusion may not exceed $\frac{1}{100}$ inch,

$$S = \frac{D}{100F \times R}.$$

The subjoined table will give a few suggested speeds for the shutter, gathered from our own experience or from reliable sources. These speeds have no reference whatever to the light conditions prevailing at the time of exposure. In the A column is given the figure for objects in motion parallel to the direction of the camera; in B, objects crossing the field of view at right angles.

	A. sec.		B. sec.
Street scenes (no apid motion)	$\frac{1}{10}$		$\frac{1}{30}$
,, ,, cart traffic	$\frac{1}{20}$		$\frac{1}{60}$
Animals grazing, birds feeding	$\frac{1}{15}$	to	$\frac{1}{25}$
Man walking three miles an hour	$\frac{1}{30}$		$\frac{1}{90}$
Children building castles, paddling, etc.	$\frac{1}{30}$	to	$\frac{1}{60}$
Coaches, six miles an hour	$\frac{1}{60}$		$\frac{1}{180}$
,, ten ,, ,,	$\frac{1}{100}$		$\frac{1}{300}$
Cyclists (not scorching)	$\frac{1}{150}$		$\frac{1}{500}$
Galloping horses	$\frac{1}{300}$		$\frac{1}{900}$
Large birds flying, ducks, gulls, etc.	$\frac{1}{300}$		$\frac{1}{900}$
Athletic sports	$\frac{1}{300}$		$\frac{1}{1000}$
Small birds flying	$\frac{1}{600}$		

These speeds are calculated for a point about 50 times the focal length in distance from the lens. For nearer points the speed of shutter must be increased in proportion. For instance, a child skipping at, say, 25 ft. from the lens would probably give a sharp image at $\frac{1}{80}$ sec. ; at 8 ft. from the lens the highest speed of the shutter would perchance be vainly called into operation.

With many subjects there is a critical instant when a successful snapshot may be taken at a comparatively low speed and yet convey the most vivid impression. For instance during a high jump, and still better in skipping, motion is actually less just when the athlete is attaining the full height of his leap, and before he has commenced his descent. We have seen a capital picture of a batsman's middle stump falling, which was taken at $\frac{1}{100}$ sec.; the ball is not very sharp, but could easily be touched up, and is, after all, a minor consideration.

Arrested Motion.—In the hands of a master, like Mr. Adolphe Abrahams, and particularly in the portrayal of incidents occurring at athletic sports, rowing contests, and yacht races, the records of the instantaneous shutter sometimes rise to the dignity of true pictures. More often they are merely triumphs of a highly perfected instrument. We are shown snap-shots of an express train travelling at sixty or seventy miles an hour; the spokes of the wheels are all sharply defined; there is no sign of motion whatever. We might be gazing at a stationary locomotive engine discharging smoke in a high wind. Leaping horses look as if they were paralysed and hanging in the air by invisible wires; the winning eight have apparently posed themselves rather awkwardly after splashing the water somewhat. Portraits of ladies skipping are exceedingly uncomplimentary; their mouths are generally wide open and their whole aspect displays little of the grace of motion. We sigh for the old-fashioned sporting print. For this is a field in which the camera must fail in nine cases out of ten. The successive action of the muscles as each is called into play cannot be recorded on a single instantaneous plate; and we must be content to leave the artist to express motion conventionally, or resort to the continuous record on the cinematograph.

F. Low.

GUY'S MILL, WARWICK.

p. 283]

CHAPTER XXXII

STEREOGRAPHY (STEREOSCOPIC PHOTOGRAPHY)

WHEN we look at an object or scene in the ordinary way, with both eyes, we obtain what seems to be a single impression of it; this, however, is really a combination of two dissimilar images formed by the right and left eyes respectively, as a simple experiment will demonstrate. Hold a book vertically at arm's length, with its back towards the eyes; close the left eye, and adjust the book so that nothing but its back is seen. Now open the left eye and close the right. You now see, not only the back of the book, but its left-hand cover also. Then, look at the book, in the same position, with both eyes: the view thus obtained will be seen to be a combination of the two single-eye images. The difference between these latter is due to the fact that the eyes view the object from points about 2½ in. apart.

Our perception of the solidity of objects, and of their distances from us and from each other, is chiefly due to the fact that we see them at once from these two different view-points. If the reader will gaze at the objects around him with one eye and with both, he will perceive that when viewed with one eye only they lose much of their appearance of solidity, and that their relative positions and distances are by no means so readily estimated as when viewed with both eyes.

An ordinary photograph, taken as it is from a single view-point, is essentially a one-eye view, and cannot convey to the mind a perfectly true impression of the object or scene depicted. Stereoscopic photography, on the other hand, aims to reproduce the conditions of binocular vision, by means of two pictures taken from positions approximately the same distance apart as the human eyes. When these two pictures are combined in the stereoscope, the result is a representation of the scene in all its three dimensions — a representation so vivid in its realism that the beholder can scarcely believe he is looking at a mere photograph.

There is no extraordinary difficulty in stereoscopic photography. Any one who can take an ordinary photograph can take a stereograph, but to produce correct and pleasing results attention must be paid to certain important principles.

The Apparatus.—No special camera is necessary; any ordinary camera, of $\frac{1}{4}$-plate or smaller size, can be utilised for stereoscopic work. An exposure is made in the usual way; the camera is then shifted horizontally to a position from $2\frac{1}{2}$ to $3\frac{1}{4}$ in. to the right or left, and a second exposure made on another plate. The movement from left to right or *vice versa* must be perfectly horizontal, and the two positions of the axis of the lens must be parallel. This may be ensured by the use of a light wooden tray (Fig. 59), with open back and fitted with a screw bush, B, for firm attachment to an ordinary camera tripod. The internal width of the tray from E to E should be $3\frac{1}{4}$ in. in excess of the width of the camera, the front of which must be kept in close contact with the fillet, FF, during both exposures.

It is obvious that this method is only practicable in photographing perfectly still objects, and the photographer who wishes to do general stereoscopic work will provide himself with a stereoscopic camera. This has two lenses of equal focus, mounted side by side, and an interior vertical division extending from the front (between the lenses) to the focussing screen. In other respects it does not differ from an ordinary camera, and may now be obtained in almost as great a variety of forms, from the simple box pattern at twenty-five or thirty shillings, to the high-class "reflex" at as many pounds. A very convenient form for stand work is the combined half-plate and stereoscopic camera, obtainable of several makers. For a hand camera, one taking the standard size of stereoscopic plate ($6\frac{3}{4} \times 3\frac{1}{4}$ in.) is preferable, on account of the reduction of bulk and weight. Many smaller stereoscopic hand cameras are now on the market, but for serious work the size last mentioned is none too large.

In buying a stereoscopic camera, care should be taken that the lenses are accurately paired, and that the separation, or distance between the lenses, is not excessive. The separation is determined to a certain degree by the size of plate to be used. In a camera taking plates of standard stereoscopic size, the separation, if fixed, should be about $3\frac{1}{8}$ in. It is better to have the lenses mounted on two sliding panels, to allow of the separation being varied between limits of $2\frac{1}{2}$ and $3\frac{1}{4}$ in., to suit the subject.

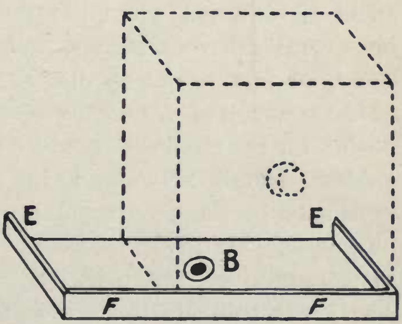


FIG. 59.

The considerations that govern the choice of lenses for ordinary photography apply equally to lenses for stereography. Excellent stereographs have been made with single achromatic lenses, but inasmuch as good definition over the whole picture is essential in stereoscopic work, and moving objects must be rendered with perfect sharpness, a pair of good anastigmats are worth their cost. Lenses of greater aperture than *f*/6 should not be chosen, however; the necessity for good depth of focus precludes the use of the wider apertures. The stops most used in stereography are *f*/11, *f*/16, and *f*/22, but when moving objects are being taken *f*/8 is useful, and for figure studies or *rapidly* moving objects *f*/6 is sometimes necessary. The most suitable length of focus for general work with plates of standard size is 5 in., but lenses of shorter focus are necessary in the case of the smaller cameras. On the other hand, lenses of 6 or $6\frac{1}{2}$ in. focus may often be used with advantage in a stand camera.

Selection of Subject.—With the exception of copying from a plane surface, practically all ordinary subjects for photography are within the scope of the stereographer. Landscape, seascape, architecture, interiors, still life, flowers, portraits, figure studies—all lend themselves to stereoscopic treatment. Landscape and seascape of the "open" variety, however, should be avoided : a strong foreground is essential to the making of a good stereograph, and the most pleasing effect is obtained when the points of interest are situated in several different planes, and form resting-places for the eye from foreground to distance.

Exposure and Development.—The good old rule of exposing for the shadows should be the stereographer's constant guide. Detail is wanted in every part of the picture, especially in the foreground; the exposure must therefore be ample. Under-exposure, always a bad fault, is trebly so in stereography, but a little over-exposure will not matter. The great thing is to ensure good detail everywhere. The lenses should be stopped down sufficiently to give full depth of focus and sharpness; no fuzziness or diffusion of focus is admissible. This rule should only be relaxed when circumstances demand an extremely rapid exposure, necessitating the use of a large aperture. In that case, special care must be taken that the actual subject of the photograph is in sharp focus.

Though exposure should be for the shadows, development should be for the high lights. Over-development must be avoided as carefully as under-exposure. Softness rather than pluckiness should characterise the stereoscopic negative, and the developer should be chosen with this in view. Whatever developer is used, it should contain only the minimum of bromide, and this should not be increased except in cases of known over-exposure.

Finishing the Negative.—If by accident or miscalculation a negative of "contrasty" character is produced, reduction by persulphate of ammonium will usually effect a great improvement, unless the error is that of great under-exposure in which case *destruction* is better. It is futile to attempt to obtain a pleasing stereoscopic print from a negative that lacks detail.

There is no branch of photography in which cleanliness and careful manipulation are more important than in the production of the stereoscopic negative. Every defect is intensified in the stereoscope; slight blemishes which would be unnoticed in an ordinary photograph are brought into startling prominence. The perfect negative should always be the aim of the stereoscopic worker; there is no place in stereography for careless and slapdash methods. Pinholes and slight defects of that nature will occur, however, in spite of the best care; and every negative should be minutely examined for them. Spotting must be done with extreme delicacy, or the remedy will prove worse than the disease. The density of the deposit in which the defect exists must be matched as exactly as possible, and the spotting medium must not be allowed to trespass beyond its limits. We find a No. 0 sable brush the best spotting instrument, and Indian ink, rubbed down in a few drops of water in which a little gum arabic has been dissolved, is a good spotting medium. To prevent the spreading of the medium, the tip of the brush only should be moistened with it.

Paper Prints. — For paper prints there is nothing so good as gelatino- or collodio-chloride P.O.P. All processes which increase contrast or diminish detail must be classed as unsuitable; thus we rule out bromide and gaslight papers. We have seen many stereographs on bromide paper, but not one that would not have been better on P.O.P. If gaslight printing must be resorted to, phosphate paper will be found to approximate most nearly to P.O.P. in gradation, tone, and rendering of detail. Whichever printing process is adopted, the paper should be of the glossy variety.

In making P.O.P. prints, continue the printing until the high lights have lost their whiteness. If, through undue contrast in the negative, this is not possible without clogging up the shadows, it is best to remove the print from the frame when the shadows are fully printed, and expose it boldly to the light until the white patches are slightly discoloured. The object of this "sunning down" is to prevent the snowy effect noticeable when slides of too contrasty a kind are viewed in the stereoscope.

A warm brown is, as a rule, the most suitable tone for stereographs, and care should be taken not to carry toning too far. After fixing and washing, hang the prints up to dry; the natural gloss thus retained is preferable to the mirror-like surface got by squeegeeing.

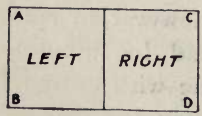


FIG. 60.

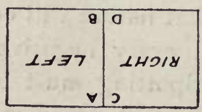


FIG. 61.

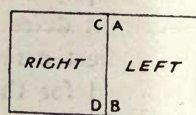
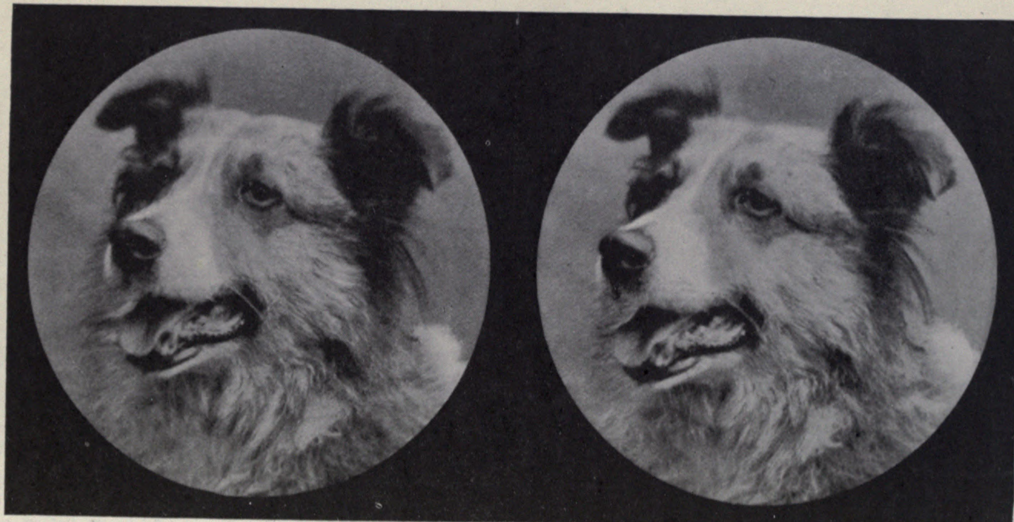


FIG. 62.

Trimming and Mounting.—In a contact print from a stereoscopic negative, the picture taken by the right-hand lens is on the left hand, and *vice versa.* Why this is so will be seen from the following diagrams (Figs. 60–62). Let us imagine the part of Fig. 60 marked "Left" to be an object as seen from the position of the left-hand lens, and the part marked "Right" to be the same object as seen from the position of the right-hand lens. The images thrown on the plate will be inverted independently of each other, and the negative, if looked at from the back, in the position it occupied in the camera, will be as Fig. 61, where, it will be noted, the outer edges, A, B, C, D, have become adjacent. On turning the negative right-way up, and making a contact print from it, we obtain the result shown in Fig. 62. Now, as it is necessary that the right-eye picture should be seen by the right eye, and the left by the left eye, the two sections of the print must be transposed before mounting. If this be



A. W. Lester.

"FLOSS."

neglected, the image obtained in the stereoscope will be *pseudoscopic*—turned inside out, as it were, the distance taking the place of the foreground, and the foreground receding into the distance. To guard against this error, every print, before trimming is commenced, should be lightly marked on the back with a pencil stroke as shown at A B in Fig. 63. When, later on, the print is cut into two, a portion of the pencil mark will be on each section, serving to show which edges must be *outermost* when the prints are mounted.

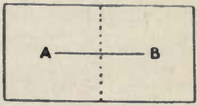


FIG. 63.

Trimming may be done by the aid of glass trimming gauges, but better by means of a 5 in. trimming board with pivoted shear-blade, or a small Merrett trimming-desk. Both prints must be trimmed to exactly the same size. The width of either should not exceed $2\frac{3}{4}$ in.; it may be as much less as the subject or the quality of the print demands. There is no need to include a defective edge or redundant marginal detail for the sake of full width. The height may be anything within the limits of the mount, and should be determined by the character of the subject. Many prints can be cut down to $2\frac{1}{2}$ in., or less, with advantage.

The two prints should coincide exactly as regards their upper and lower edges. In the case of the side edges a little variation may be introduced with good effect. If the inner edge of each print, as finally mounted, includes an eighth of an inch more of the photograph than the outer edge of the other print, the effect in the stereoscope will be that the entire view will appear to lie beyond the plane of the mount. (See illustration, "Guy's Mill.") This has been called the "window effect," because the sensation is that of looking at a view through an open window, of which the mount represents the frame. This method of trimming suits most subjects, but a contrary method is sometimes admissible in the case of flowers, still life, and small objects, the foremost parts of which may thus be made to appear nearer than the plane of the mount. Effective use has been made of this "dodge" in our second stereograph, "Floss." On viewing this stereoscopically, the dog appears to be standing with his head partly through the circular opening. It is a method which should only be used with great moderation, an exaggerated effect being anything but pleasing. The difference in the trimming, by either method, should be measured by the nearest foreground object.

The standard size of stereoscopic mounts is $7 \times 3\frac{1}{2}$ in. The most suitable colour is chocolate brown; light-tinted mounts should be avoided. Dry mounting with adhesive tissue is best; if a paste mountant is used it should be one

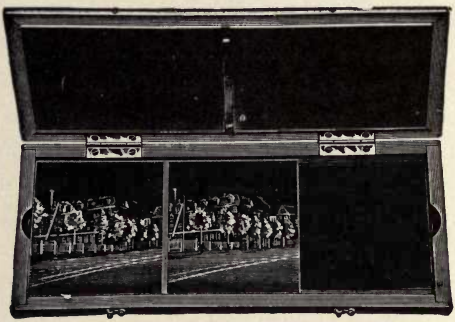


FIG. 64.—PRIMUS STEREOSCOPIC TRANSPARENCY PRINTING FRAME.

containing the minimum of moisture. Clean, smooth mounting is as important as good photographic technique. The prints should be so arranged on the mount that the distance from a point in the foreground of one to the corresponding point in the foreground of the other is not less than $2\frac{1}{2}$ in. or more than $2\frac{7}{8}$ in.

Glass Transparencies.—For vivid realism and pure photographic beauty, nothing can compare with a good stereoscopic transparency. Given a suitable negative, it is quite easily made, either by contact printing or by copying in the camera. There are three methods of contact printing:

(1) From the uncut negative in an ordinary printing frame, afterwards trimming the sides with a glazier's diamond,

transposing, and mounting on a plain glass. This is not a method to be recommended, as the transparency has to be cut into four pieces, making the binding up a matter of some difficulty.

(2) By first cutting, transposing, and trimming the negative, and exposing in an ordinary printing frame.

(3) By the use of a transposing frame, which obviates the necessity of cutting either negative or transparency. Such a frame is shown in Fig. 64. It is a little more than half as long again as the negative, which is first placed as shown in the figure. The transparency plate is then placed with its left-hand half (film downwards) in contact with the right-hand

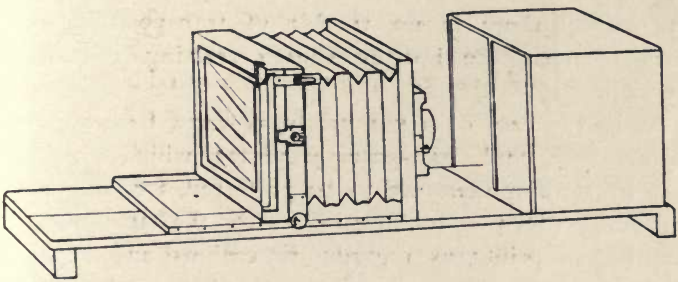


FIG. 65.

half of the negative (film upwards). The frame is closed and an exposure made, through an aperture $2\frac{3}{4}$ in. wide on the side of the frame not shown in the figure. The relative positions of negative and plate are then reversed, a second exposure made, and the plate developed and fixed.

Undoubtedly the best method of transparency-making is by copying in the camera. The taking camera may be used for the purpose, provided it has ample extension and adjustable lens separation. The other apparatus required is simply a flat board fitted at one end with an open box having a central vertical partition as shown in Fig. 65. In the outer end of this box (not seen in the figure) is an aperture, to accommodate the negative in such a position that its central division coincides with the partition of the box. The camera should slide between guides fixed to the baseboard, to ensure parallelism between negative and focussing screen.

The negative having been placed in its aperture, upside down and film-side out, the image on the focussing screen may be examined like an actual stereoscopic slide, with a hand stereoscope, and the separation of the lenses of the camera adjusted so that the right amount of subject is shown on each side. The exposure is made on a transparency plate, in the same way as when enlarging in a daylight enlarging camera. The space between camera and negative-box should be covered with an opaque cloth to shut off extraneous light. In making transparencies by this method there is no trouble of transposition, as the lenses re-invert the images, thus correcting the original inversion.

As in the case of paper prints, a warm tone suits most subjects best, and transparency plates which give warm tones by development are to be preferred, for this reason. The rules given in connection with the trimming and mounting of prints, as regards dimensions and separation between corresponding points, should be closely observed in transparency-making. The transparency is finished by masking and binding up with a cover-glass, similarly to a lantern slide, except that the mask is a double one. Ready-made stereoscopic masks can be obtained, but it is better to cut the mask to suit the subject, or build it up of binding-strips. With a transparency made by contact, the cover-glass forms the front; with one made in the camera as above described, it forms the back. Some stereographers back their transparencies with ground glass, but this is neither necessary nor desirable, as all stereoscopes designed for the viewing of transparencies are fitted with ground glass diffusers, and the grain of the ground surface is less obtrusive to the eye, if transparency and diffuser are separated a little, than if bound up in contact.

CHAPTER XXXIII

ENLARGING

OF late years, the fashion in cameras for outdoor work has been in the direction of a smaller and smaller plate each season. Once upon a time, whole plate at least was *de rigueur*, if a man wished to preserve his reputation. Later on, a half-plate became excusable; now we meet Fellows of the Royal Photographic Society unblushingly wielding a little instrument which takes exposures on plates each about two square inches in area. Manufacturers are competing with each other to produce lenses and fittings for these small sizes, just as accurate and highly finished as their larger rivals.

This movement is, of course, partly due to the economy of the small plate, and its portability. A dozen whole plates are a serious burden, as well as an expense not worth incurring when we can enlarge quarter-plate negatives at our leisure. But there is an æsthetic side as well in the matter. Size is an artistic quality of a picture. The man who is content to print every one of his negatives on one particular scale is destitute of the sense of proportion. For some subjects whole plate is ridiculously small; for others it is much too large. Therefore, it is politic to commence with a size which is conveniently manipulated in the enlarging camera, wherein the final dimensions of our exhibition print will be decided.

The process of enlarging negatives is attended with very little difficulty provided the means adopted is an efficient one; makeshift methods are an entire waste of time. The old practice of cutting a hole in the dark-room shutter the size of the plate, and sticking the camera up against it, will not secure the even illumination of the plate which is the first necessity for a successful result. But there are many devices available, by which the ordinary camera may be effectually adapted for use in enlargements without straining the purse strings very heavily.

The Negative.—But before we decide to enlarge a particular negative we must examine its capacity. Unless the focus is fairly sharp we had better leave it alone. When a quarter-plate negative reappears printed as 15×12 in., or nearly four times the size, the circles of confusion, instead of being about $\frac{1}{100}$ in. in diameter, will be about $\frac{1}{25}$ in. Not that the roughened effect will matter greatly with most subjects, considering the greater distance at which they will be viewed when framed on the wall. However, any faults of definition in the original will be horribly exaggerated. The worst cases are those of films which were buckled during exposure in the camera; such are hopeless. No method of enlarging possesses any power to correct erratic focus, although converging lines in architecture may be partially straightened by the use of a swing negative slide, or by inclining the easel upon which the bromide paper is pinned.

Very dense negatives, veiled or stained, are not likely to give satisfactory results; nor will those containing excessive contrast. But in a new negative, made either by direct contact or by transparency, these defects can be mitigated considerably. The best negatives for the purpose are those full of soft gradations and detail, and without any of the harsh contrasts which yield "soot and whitewash" effects.

Daylight Enlarging.—No great difficulty will be found in devising an arrangement whereby the small quarter-plate or 5×4 in. field camera can be attached temporarily to a large camera, the lens of the former entering the front of the latter in such a way that the junction is light-tight. But one of the standard Lancaster or Middlemiss patterns is greatly to be preferred. Enlarging is not worth doing unless under conditions that will ensure accuracy, and an instrument specially constructed for the purpose by a reliable maker is obviously better than the contrivance of the novice; and in the long run not any more expensive. If only an occasional enlargement is wanted, and one particular size will do, *e.g.* from quarter plate to 10 × 8 in., a fixed-focus enlarging chamber may be constructed, of wood frame and cardboard, to work with the ordinary quarter-plate camera. For dimensions see table of enlarging distances.

In practice, daylight enlarging is fairly simple. The negative is fixed in position at A and focussed to the

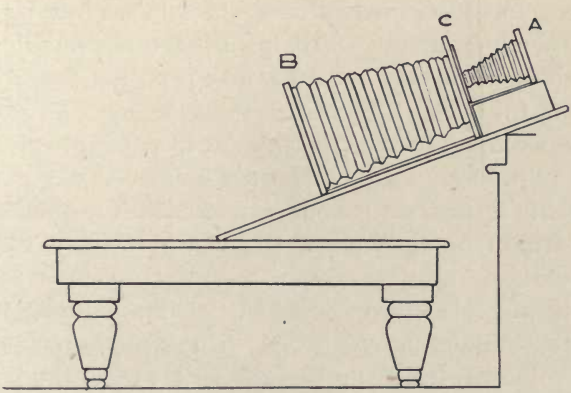


FIG. 66.

required size on the ground glass at B. The ground glass will afterwards give place to a dark slide containing the bromide paper. We need hardly remind the operator that the larger the size of picture required, the longer the distance must be between B and C, and the *shorter* the distance between C and A; in fact, from B to C will equal A to C multiplied by the number of times the enlargement is to exceed the original. A negative is not a handy thing to focus, as it provides no clear standard of comparison; and in getting accurate focus it is usual to substitute a glass plate ruled in parallel lines and squares. Focus with a full aperture and then stop down, remembering that enlarging work is a very severe test of the virtues of a lens, and that the smaller the stops the better for the outlines, but, on the other hand, the longer the exposure.

When using films or plates of smaller size than the full capacity of the negative holder, take care that the margins are well masked, either by the suitable plate-carriers or black paper. Marginal light is as fatal almost to good enlarging as pinholes in the bellows.

Exposure.—Choose a window having a north aspect or, at any rate, such that the direct rays of the sun are not within the field of view; tilt the camera as shown in the figure in order to secure even illumination, which is not interfered with by the shadow of the earth, intrusive trees, buildings, etc. If the situation is very confined, take it on the roof or out-of-doors and tilt nearly upright.

Now we come to the crucial point in daylight enlarging—time of exposure. Fixed tables are useless as a guide. We must create a standard for our own lens with the actinometer. A test strip of bromide paper is given a series of exposures in the dark slide, by moving the shutter upwards or downwards at intervals of 20 seconds. On development the best result is obtained at 60 secs., when we will suppose the actinic value of the light is such that the full tint of the actinometer is reached at 30 secs. This may be taken as the normal exposure, from which all others can be calculated. If on the next occasion we require a similar enlargement, the full tint takes 40 secs. to print, the exposure necessary is found by simple rule-of-three:

30 : 40 : : 60 : 80 secs.

According to the numbers of times the original is to be enlarged, exposure is increased in proportion to the square of the distance that the camera is racked out. If for our normal exposure the distance between lens and bromide paper was 12 in., and in order to get greater enlargement this distance is increased to 20 in., the exposure must be also increased in the ratio of 12^2 and 20^2 or as 144 is to 400. In altering the stops we must remind the reader that, for enlarging purposes, the equivalent focus varies with the degree of enlargement, and that the diaphragms are of proportionately diminished value. We can no longer rely safely on the rule of doubling exposure with each diminution of stops as marked on the lens, although, in view of the latitude which bromide paper permits of in development, the error would not be a very serious one in a single change, *e.g.* from (nominal) *f*/22 to *f*/32.

Enlarging by Artificial Light.—Daylight enlarging has its advantages, amongst others that of giving greater softness and better gradation. But the majority of workers prefer artificial light, with its constant exposures independent of weather, and its many opportunities for variation of effect.

For negatives not exceeding 3 in. in length the ordinary magic lantern will serve as a basis for the enlarging lantern. If it emits stray beams of light, as some patterns do, a box must be made to enclose the body. The projection lens is probably not of chemically correct focus, and a rectilinear lens, or that in the camera, must be used instead. Most of the hundred different varieties of enlarging lanterns are on the principle of the magic lantern, with improved methods for holding the negative. The most recent are provided with a swing, both for front and back, and sufficient extension to allow of a great variety of lenses, as well as for the use of the same instrument in lantern-slide making. The condenser should in all cases exceed in diameter the diagonal length of the plate to be enlarged. Thus, even illumination will be obtained over a quarter plate by a 5½ in. condenser, while half plate will need about 8¼ in. Oblong-shaped condensers should be about 1 in. longer than the plate with which they are to be employed. Of illuminants, the most desirable are acetylene and incandescent gas, the latter being the most convenient, and giving exposures short enough for all ordinary purposes, particularly the latest inverted mantles. Oil lamps should be relegated to the backwoods, though no doubt, were there a sufficient demand, an incandescent oil lamp could be manufactured for lantern use nearly as serviceable as the gas lamp has proved itself. For commercial work, the arc light, Nernst, or mercury vapour lamp are adopted.

Ordinary focussing cameras may be converted into fairly efficient enlarging lanterns with the expenditure of a few shillings. There is the ellipsoid reflecting lantern, or a lantern with condenser attached, either of which can be readily clamped on to the back of a camera of corresponding size of plate, and both systems are constantly undergoing improvements.

Enlarging Easel.—A good easel consists of a board provided with a detachable hinged frame holding a sheet of plate-glass, behind which the bromide paper is kept perfectly flat. For convenience it should swing, in cases where, for the correction of lines, a vertical position is unsuitable. In practice we use a large printing-frame containing the bromide paper, and clamp it to the board with two adjustable slips, which slide up and down as required. This easel should be fixed at one end of the table devoted to enlarging purposes.

Focussing.—Preliminary focussing is performed with the ruled screen, as in daylight enlarging, and the stop adjusted to produce even definition. A yellow glass cap is then placed on the lens, the negative is inserted, and the final focussing carried out with the bromide paper actually in position on the easel. For exposure simply remove the yellow cap. The rules governing exposure are in general very similar to those laid down for the daylight camera. Do not let the source of light approach too near the condenser until it has been thoroughly warmed, and see that a sharp image of the mantle does not appear focussed as part of the picture on the easel. Shift the burner backwards and forwards until it is quite out of focus. Another caution refers to the yellow glass cap. Sometimes it alters the focus of the lens, and this must be allowed for in the final adjustments. The ideal place for the yellow mask would be behind the negative.

Vignetting.—Suspend a piece of cardboard in which a suitably shaped hole has been cut about midway between lantern and easel; the nearer the lantern the larger will be the vignette, and the softening of the edges is secured by keeping it constantly in motion. Masks for borders must be pinned immediately in front of the sensitive surface.

Clouds.—These it is preferable to print in before the main picture, giving a very short exposure, probably less than a quarter the usual time, and protecting the site of the landscape with a piece of blotting paper or serrated card. Hold the mask in the hand, shading the sensitive paper at some distance, and move it up and down gently. A very little practice will make perfect in details of this sort. Landscape enlargements look very poor and bare without clouds of some sort, and in river pictures a suggestion of these clouds ought to be reflected in the water below.

Development.—For the general methods of developing, *see* the chapter on Bromide Paper. Wet the paper thoroughly before pouring on the developing solution, and, if there is any doubt about exposure, start with a weak developer, such as rodinal 1 in 80, which may be strengthened if the image does not come up within a few seconds. Do not be afraid to give full development, and do not remove from developer till a satisfactory amount of vigour and contrast is apparent. Over-development, if not too serious, can be cured by subsequent toning. An under-developed print is of very little value, and quite useless for bromoil, ozobrome, or similar processes.

Enlarged Negatives.—A positive transparency is first made from the original negative by contact, either on a process or lantern plate or by the carbon method. Development must be carried much further than is the rule for lantern slides; fair density and plenty of detail is the object to be aimed at, provided that at the same time the shadows are not allowed to get so black that their detail is clogged.

On the whole we think that the best transparencies are made on gaslight emulsions, if only care is taken to give them adequate and even exposure. Even development is also much more important than with the ordinary lantern slide.

The enlarged negative is then made from this transparency, and whether by daylight or artificial light matters very little. Negatives to answer many purposes are made in bromide paper of thin, vigorous quality. More often a process plate is adopted, with a backing of black stuff to prevent halation. The edges of the transparency should be masked with black paper, so that the light may have no excuse for lateral spreading. Development should be proceeded with very cautiously, for, owing to the larger dimensions of the plate, the shadows are proportionately greater, and convey the impression to the beginner of under-exposure.

Personally we prefer the bromide-paper negative for the making of carbon or platinum enlargements. The exposure is not much longer, and the grain of the paper does not show unpleasantly, even if no waxing preparation is applied to increase transparency. Moreover, such negatives are most easily made by contact in a printing-frame with the first bromide enlargement, saving the whole bother of the transparency.

For the further study of the subject we cannot recommend a better work than Mr. C. Welborne Piper's *Photographic Enlarging*.

CHAPTER XXXIV

LANTERN SLIDES

How old the magic lantern is, no one knows! The Egyptians had something corresponding to it, although the illuminant was sunlight introduced into the darkness of the temples for projection purposes through small circular diaphragms, perhaps fitted with lenses. Roger Bacon is credited with the magic lantern amongst his other ingenious inventions. At any rate, for exhibition purposes the projection lantern is at least two hundred and fifty years old.

Just at present the lantern slide is threatened with two serious rivals. Public entertainers are now expected to use the more agile and exciting cinematograph film. In the smaller lecture-hall the mirroscope will show on the screen, with good illumination and definition, images from ordinary prints and postcards, thus obviating the necessity of making any transparency. But those who take the trouble to make lantern slides of their work, will be well repaid by the greater clearness, brilliancy, and delicate light effects which they are certain to render from good negatives.

Lantern Slides by Reduction.—Unless only a very small portion of a plate is required, the additional work involved in making slides by reduction is very slight, and is likely to give the best and most artistic results. Special cameras are made for the purpose; but they are usually mere fixed-focus boxes, made to reduce a particular size of plate to lantern size. The negative may be put in a frame against the window and photographed through the camera on to the lantern plate. But the apparatus which we employ ourselves is so easily constructed, and will adapt itself so well to give exact reduction of different-sized plates, that most readers will probably prefer a method of the kind.

Take a long, planed deal board about 1 in. thick and of the same width as the camera. Screw a bevel on each side, so that the camera may slide evenly up and down the plank as required for focussing. The length of the board will depend on the focal length of the lens. For the ordinary 5 to 6 in. lens 3 ft. will be ample. At the opposite end to the camera an upright square of wood is fixed as an easel, in which there is an aperture cut, of centre corresponding to height of lens, and of size to take the largest negative that will be required to be reduced, say half-plate, with carriers for 5 × 4 and quarter-plate negatives.

On the focussing screen of the camera draw in pencil, exactly corresponding with the lantern-plate carrier which will go in the dark slide, a square $3\frac{1}{4} \times 3\frac{1}{4}$ in. Place the negative in position on the easel, upside down, with film facing the camera, and focus. Allowance must be made for the black mask and border; so that the actual size of image should not exceed $2\frac{3}{4}$ in. A small stop is advisable for exposure, in order to secure great sharpness. Remember that your little pictures, less than 3 in. in size, may have to appear on the screen enlarged up to twenty feet.

When using daylight for the exposure, care must be taken that features in the landscape do not intrude their shadow and cause uneven illumination. We always incline the board at an angle towards the sky. Choose a north light for preference; at all events avoid the neighbourhood of strong sunlight.

If daylight is not available, magnesium wire, or any artificial light behind a condenser, may be tried. We know of many workers who make their lantern slides in the ordinary gaslight enlarger. Traces of uneven illumination will possibly make themselves apparent unless the slide is much over-exposed or under-developed. Ground glass between the light and the condenser ought to remove this difficulty.

Lantern Plates.—The lantern plates for reduction purposes are coated with an emulsion similar to that on bromide papers; for contact slides, gaslight plates (coated with the same emulsion as gaslight papers) are most satisfactory. Each may be developed in just the same way as the corresponding papers; and the gaslight slides will give a variety of tints according to the time of exposure and strength of developer.

Developing.—Pyro, metol-quinol, glycin, amidol, or rodinal are all most suitable for lantern plates, but with the first of these care must be taken not to over-develop. The plate may generally remain until the shadows are visible on the glass side; the exact density will be learnt by practice. Beginners usually make their slides too thin, when they must be intensified by the bichromate method, which will also tone them a rich brown colour. If they are too dense, reduce them in the following:

Iron Perchloride	15 gr.
Citric Acid	20 „
Water	10 oz.

The best test of the density of a lantern slide after fixing is to hold it about a foot from the wall of an ordinary room fairly lighted. The pattern of the wall paper ought to be discernible through the darkest shadows. The high lights must not be veiled, and yet very little of the plate ought to be clear glass.

Toning.—The toning baths for bromide papers may, as a rule, be used also for lantern slides. A good platinum formula, which will not necessarily be suitable for gaslight slides, is:

Platinum Chloride	1 gr.
Hydrochloric Acid	1 min.
Water	10 oz.

Clouds.—Nothing is more trying to spectators than a series of landscapes in which the sky is represented by clear glass, without clouds or indication of atmosphere—that is, nothing except *bad* clouds. The sky must receive from the lanternist even more care than it demands in the ordinary print. The lighting of the sky must come from the right quarter, and a sunlit landscape must not be rendered ridiculous by heavy storm-clouds which throw no shadow whatever on the background. Sometimes, especially in winter pictures, sophistication is profitable; that is, a suggestion of clouds in the contact-printed slide by means of judiciously applied green paint on the glass side of the negative. The reflections of such clouds should not be forgotten, if there are stretches of water in the scene.

The best way of introducing clouds is to print them by contact on a second plate, which will perform the function of a cover glass; one incidental advantage is that, if the clouds, either by over-printing or lack of tone, prove incongruous, they can be transferred to another slide. Light printing is nearly always the best for such clouds.

Transfer Slides.—We have already given some directions for slides by the carbon process under that section. An ordinary P.O.P. print may, without very great difficulty, be mounted as a lantern slide. Bleach and clear an old lantern plate until the gelatine is as clean as the glass. Harden with formaline and allow to dry. Then take any P.O.P. print, freshly toned and fixed, if possible, and one that has not been treated with either alum or formaline. Squeegee it while wet into contact with the lantern plate (film side, of course), and paint the back with glycerine. After a little warmth applied at the fire the paper will peel off, and leave the toned print ready for mounting as a lantern slide.

The ordinary collodion, or gelatine P.O.P., emulsions have occasionally been coated on lantern plates, but somehow or other have not proved commercially successful. Exquisite effects may, however, be obtained by treating ordinary gaslight plates for one minute in a 1 per cent. solution of sodium salicylate. These plates will print out by daylight, when dry, and will tone in any gold bath.

Masking and Mounting.—All slides should be masked; and some thought should be given to the shape and size of mask to be used for each particular picture. The rectangular shape is much better than all others; except for portraiture, we should use it in all cases. Binding on the cover glasses will not be found very difficult after a little practice, and various devices have been invented to assist the inexpert. Before binding, two white spots must be placed on the front top corners of the slide for the guidance of the lanternist, though sometimes these spots are provided for on the binding strips.

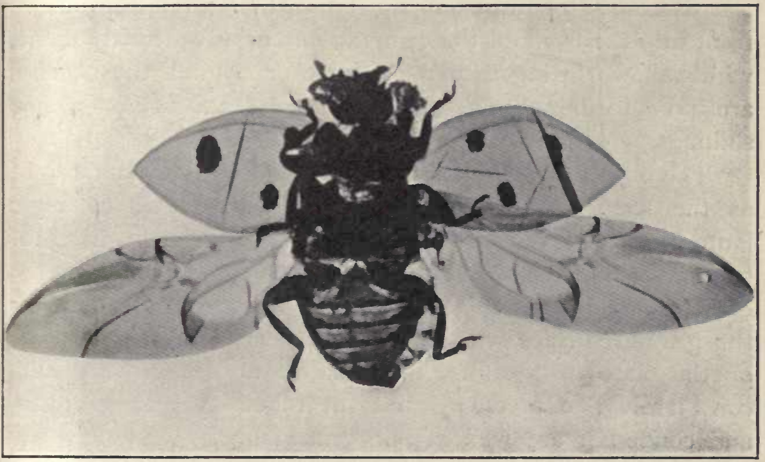
Before binding up, the cover glasses ought to be scrupulously clean, and the film of the plate clear from dust, holes, or scratches, which would all be immensely exaggerated when projected upon the screen. A coat of crystal celluloid varnish will help to preserve the life of the slide and render it less liable to injury from an over-heated lantern. Lantern slides, by the way, should always be unpacked and exposed to warmth and air for about half an hour before the commencement of a lecture. We know of one architectural authority who prefers his slides shown cold, on the ground that the slight condensation of moisture on the film improves the gradation in sculpture and suchlike subjects. But we have registered a solemn resolution not to lend him any of our cherished plates.

CHAPTER XXXV

PHOTO-MICROGRAPHY

A VERY awkward word is this, and one which somehow sticks in the throat of its user in a most disagreeable manner. Why not Micro-photography? Sad to say, the latter term has already been annexed by the authorities, to describe the tiny photographs of scenery or country life which we used to find in ivory pencils or paper knives bought at the seaside. The field of photo-micrography is a very wide one indeed, embracing the vast insect population of the world, not to speak of the cellular growth of the whole vegetable and animal creation, great and small, or that unknown world of protozoa and bacteria, with which we are acquainted only through the medium of the high-power microscope. It stands alone as the only method of recording observations made in the regions visible through the microscope, the work of the hand craftsman being quite worthless. We may divide this field into three sections: (1) Low-power photo-micrography, which is concerned with the photography of subjects needing only a magnification ranging from two to sixteen diameters; (2) medium-power work, in which the magnification rises from eighteen to about 500 diameters; (3) high-power or critical photo-micrography embracing magnifications from 500 diameters onwards, and of course demanding most accurate instruments, combined with the highest skill and experience.

Low Power Micrographs.—Although these include by no means the least interesting class of subjects, the apparatus required is very simple, in fact any kind of enlarging lantern can be adapted. A thin wood slide, the size of the ordinary dark slide or enlarging lantern slide, may have a circular hole cut in its centre, about $\frac{3}{4}$ in. in diameter, and a beading glued above and below, of the proper size to take the usual glass microscope object slides. Focussing must be done with the usual ruled glass plate. This method will serve very well for the enlargement on to a quarter plate of any fairly transparent object, such as an ant, spider, caterpillar, or other winged insect.



Harold S. Cheavin, F.R.M.S.

LADY BIRD (SEVEN SPOT) × 36.

A daylight enlarging camera is to be preferred to the enlarging lantern, in which the condenser is so near the object. And if the operator possesses a camera of the old-fashioned type, focussing backwards, i.e. in which the front is fixed, and the focussing screen travels towards the operator, a still more serviceable contrivance may be erected, and one which will serve for opaque objects to be photographed by reflected light, as well as those which, being transparent, are photographed by transmitted light.

Having a piece of wood of the same width as the camera and about four feet long, the camera must be clamped at one end. Remove the sliding front carrying the lens, and fit it to the front of a large oblong box of cardboard, of the same diameter as the camera front, and carefully blacked inside with Brunswick black. This cardboard box is open at the back, and has a cloth hood glued on it, which covers an inch or two of the bellows and is held in position by a rubber band in one of the folds. A piece of wood, glued to the front part of the cardboard box at the bottom, will make it correspond in height with the baseboard of the camera. This will form an extension to fit into the front of the camera; extensions properly made, with bellows fitting either in front or behind the camera, are now to be obtained from camera makers for a few shillings.

The object must be raised on a stand to the same height as the lens, and behind it is introduced either a magic lantern with its front lenses removed, or some kind of condenser and lamp. A piece of ground glass between the condenser and the object (provided it is out of focus, or the ground surface will enlarge and show a grained image on the plate) will diffuse illumination and improve results considerably. Great care must be taken that lens, object, and condenser are well in one central line.

For all microscopic work backed plates should be used, preferably isochromatic, but when the illuminant is either oil or incandescent gaslight we need not always employ the yellow screen. Development should be very fully carried out, glycin or pyro-caustic soda being very suitable developers. An under-developed photo-micrographic plate is utterly useless.

For the printing of photo-micrographs, smooth gaslight paper seems preferable to all other methods; the least satisfactory is P. O. P. gelatine, owing to the great loss of detail in toning and fixing. A glossy surface paper must be chosen. For lantern slides, gaslight plates are far the best, and, as few operators would attempt photo-micrographs of larger size than quarter plate, they can generally be made by contact.

Medium- and High-power Work.—The essential outfit consists of a long extension camera, a microscope with object glasses, etc., a good lamp, and last, but not least, a solid platform. Makeshift arrangements, in which the various instruments are brought into contact with piles of books on an ordinary table, only end in disappointment and loss of time. The foundation of all things should be a piece of well-planed board, about 4 ft. long, 12 in. wide, and 1 in. thick, at one end of which the camera will rest screwed to a box or block of wood, which will raise the centre of the focussing screen to the level of the tube of the microscope when in a horizontal position. During the last twenty years the evolution of the field camera has proceeded on lines which render it most unsuitable for use in connection with the microscope, while the older patterns lack the necessary extension. Unless the operator possesses unusual mechanical and inventive powers, he will find it the cheapest way in the long run to invest in a proper camera, constructed for the purposes of photo-micrography. Daylight enlarging cameras can generally be adapted, but are somewhat cumbrous, considering the small size of plate in use and the great additional length of baseboard entailed.

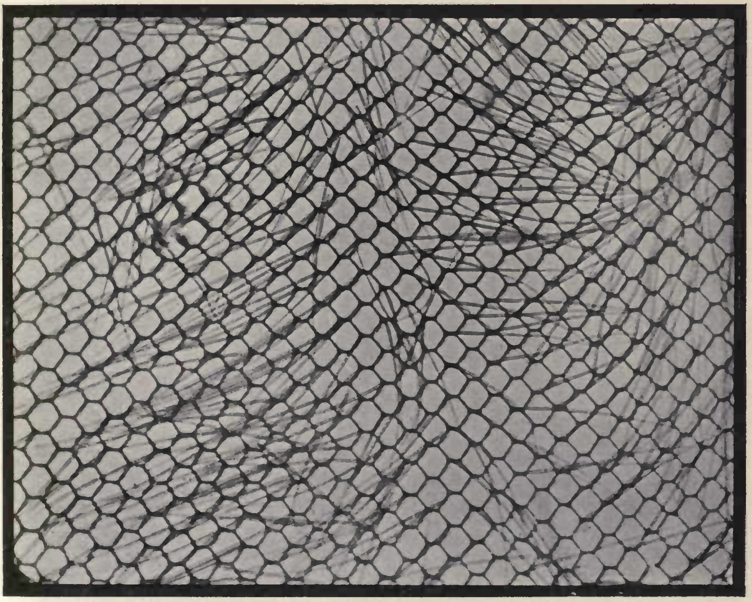
The Microscope.—Any good microscope, with a joint to the body enabling it to be inclined to a horizontal position, may be employed, but for a home-made arrangement a solid stand is essential, perfectly firm in all positions, no matter to what angle the body tube may be inclined. Tube and substage should be fitted with standard thread and gauge of the Royal Microscopic Society, all good modern lenses being made with this standard thread. Cheap and old-fashioned instruments are not always corrected for chemical as well as visual focus. Perfect correction of chromatic and spherical aberration, as well as close definition, are indispensable. The tube must be lined with black velvet internally, or at least blacked throughout; otherwise, when photographing without the eyepiece, there will be reflections from the metal surface, causing bright spots in the centre of the focussing screen.

Source of Light.—Oil lamps are rather to be discouraged, except for low magnifications; the intensity of light is often variable, exposure is very long, and another objection is the danger of greasy fingers. The arc light has its little erratic ways; but the Nernst burner will be found more satisfactory where electricity is available. Acetylene is perhaps the best of all, especially if the burners are enclosed with a small round hole for the emission of the light after the manner of an army-signalling apparatus. Incandescent gas is also convenient, and conducive to cleanliness and absence of anxiety with regard to the lighting department. For higher powers it is insufficient, owing to the fact that ground glass has to be interposed between burner and condenser, in order to keep the image of the mantle from producing uneven illumination.

A bull's-eye condenser must be introduced between the source of light and the object glass, in such a way as to evenly illuminate the field. For all powers higher than one inch we must employ a substage condenser, consisting of a series of lenses to concentrate upon the object a wide-angle cone of light. When opaque objects have to be illuminated the source of light must be moved to one side, ten inches being usually a convenient distance, and the light focussed upon the object by means of the condenser; the smaller the image of light, the better for the result.

Focussing with the Microscope.—We will suppose that the object on the stage of the microscope is of transparent character, and that lamp, condenser, and camera have been placed in position. The object is, say, a simple botanical section, and the 1 in. power will suffice. It is first focussed by means of the eyepiece. The latter is then removed and a piece of white cardboard is held in front of the entrance of the microscope tube, and from 8 to 10 in. away. An image of the illuminant will be thrown upon the card, and a distance at which this is sharp must be chosen. If the lighting is not uniform over the whole circle, either lamp or condenser is not truly central, and must be readjusted until all is clear and sharp, with the image well defined.

The camera is now brought into connection with the microscope, by means of the velvet hood, and racked out into focus at the desired magnification. A hand focussing glass



Harold S. Cheavin, F.R.M.S.

EYE OF WATER BEETLE (DYTISCUS MARGINALIS) × 260.

will be a great help in getting exact focus. Of course the ordinary ground-glass focussing screen will not be fine enough to show detail ; a thin cover glass is usually cemented on to the centre with Canada balsam. If the lighting is too brilliant the Davis shutter, a kind of iris diaphragm, may be introduced into the body tube, and indeed is indispensable for many varieties of objects.

Possibly, when the required magnification is reached on the focussing screen the image will be found lacking in sharpness. At the same time, the distance from the back of the camera to the microscope is too great, when the bellows are racked out, for the operator to manipulate the fine adjustment. A silk cord, rubbed on a piece of resin to make it "bite," is sometimes passed round the milled head of the fine adjustment and carried by screw eyes to the back of baseboard. But the focussing rod attached to Messrs. Watson's student's camera, as illustrated, is a much more efficient means for this delicate adjustment.

Exposure.—At length we are ready to expose. Place the card in front of the condenser, to cut off the light and act as a shutter. Insert the dark slide, and expose the plate by

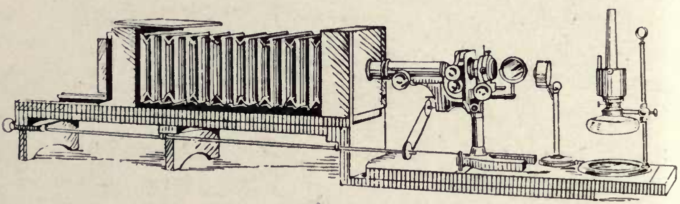


FIG. 67.—THE STUDENT'S CAMERA.

withdrawing the card. The length of exposure must depend upon the illuminant, the amount of magnification, and the colour of the object. An orthochromatic plate is essential, and it must be backed ; fifteen seconds may be taken as the normal exposure, without the yellow screen, using the one-inch power.

Orthochromatism.—One of the most serious problems in photo-micrography, especially at high powers, is that of colour values, with a view to securing contrast and, at the same time, sufficient detail. Readers who have studied the subject of orthochromatics will readily understand that neither are likely to be satisfactory in the result, unless the object is photographed by light of the wave lengths comprised within its absorption band. The two rules to be observed are: (1) To increase the photographic intensity, or render it as black as possible, use a screen of complementary colour ; (2) to decrease the photographic intensity, that is to say, in order to render detail within the subject itself, use a screen of the same tint as the light it transmits. The application of these two rules will depend upon circumstances, the nature of the background, and the variation of colour in the substance itself. As a preliminary method of determining by what light the maximum contrast is obtainable, Messrs. Wratten and Wainwright recommend visual examination under the microscope, first by means of screens transmitting light absorbed as completely as possible, and then by other screens in which the light is less completely absorbed. Such filter screens are usually fitted either to the stop holder of the condenser, or introduced into a special holder between the microscope mirror and the light, according to the system in use.

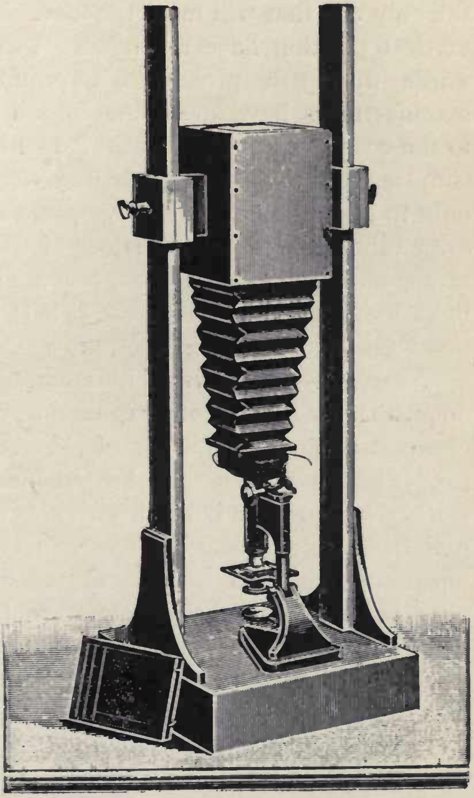


FIG. 68.—THE "BECK" VERTICAL PATTERN OF CAMERA.

Vertical Cameras.—There are advantages in the vertical pattern of camera, one of which, from Messrs. R. and J.

Beck's numerous varieties of apparatus for the purpose of micrography, is illustrated here. It is very easily attached to the microscope, without previous preparation, and for objects of a fluid nature as, for instance, when photographing the inhabitants of a drop of ditchwater, the vertical form is the only one that will meet the case. Microscopes used in a vertical position have a tendency to gradually drop downwards during a prolonged exposure; this difficulty the manufacturers have overcome by an adjustable stop-block to the coarse adjustment of the "London" microscope. For simpler souls there is a little fixed-focus camera, which has only to be pushed on to the eye-piece end of the microscope draw tube, after careful focussing of the object, and the whole arrangement is ready for exposure. It is quite efficient, of light weight, and takes plates $2\frac{1}{8} \times 1\frac{5}{8}$ in.—not too small for making lantern slides.

Sunlight.—In our list of illuminants we omitted to mention one which for most photographic purposes is regarded as the cheapest and most efficient of all. And no doubt the best results in this branch may be obtained from sunlight if the worker will provide himself with a heliostat—an inexpensive pattern will often meet the case—in order to keep the sun's image concentrated on the object during exposure. For even in the short space of time required our earth goes on travelling steadily on its axis, and without this piece of clockwork, the beam of light which we focussed with such nicety would creep away and expend its radiance elsewhere.

The Amœbæ.—Instantaneous work with the microscope is not impossible with a good instrument, and a large diaphragm shutter that will fit on to the barrel. The nimble proteus, and suchlike forms of life, have been successfully taken at $\frac{1}{45}$ sec. with a very rapid plate. For accurate results, the liquid should be placed in a Holman life slide some hours before the amœbæ undergo the ordeal of portraiture, in order to accustom them to their surroundings. Needless to add, the exposure must be by limelight, or a very reliable arc burner.

Degree of Magnification.—A micrograph is of very little value unless the magnification has been ascertained. This is not a difficult task. Remove the slide just photographed from stage of microscope, and, without altering the focus, substitute a stage micrometer. With the aid of a divider, the comparative size of the image on the focussing screen and of the original is an elementary matter of calculation.

The best English works on the subject are *Photo-Micrography*, by E. J. Spitta; *Practical Photo-Micrography*, by J. Edwin Barnard; and *The ABC of Photo-Micrography*, by W. H. Walmsley.

CHAPTER XXXVI

THE PINHOLE CAMERA

JUST as nature sometimes indulges in a reversion to the primitive type, so art finds renewed vitality by a return to first principles. And so photography, which is neither nature nor art, but a hybridised pursuit, may revert back to the original camera of some three centuries ago, when men first observed with wonder the images thrown on a screen by a hole in the shutter of a darkened room. The pinhole camera is simply the oldest form of camera in miniature. To begin again with primitive implements is educative in itself. It teaches us that our highly specialised cameras, our costly sets of lenses and multitude of accessories are merely matters by the way, enabling us to work with convenience and great saving of time. So far as the pictures themselves are concerned, leaving moving objects out of consideration, just as good results are obtainable with an ordinary cardboard box and a tiny needle-prick instead of a lens.

We say "just as good," but in some respects the pinhole will give us better results than the best lens is capable of. First, because there is no distortion. The lines in a pinhole negative will be geometrically true from corner to corner, not betraying any curvature of field or achromatism, or any other of the faults of the ordinary lens. And this with a width of angle which may be as much as 125°, against the 75° of a wide-angle lens. The picture also will be found to possess a roundness and expression of distance values, as compared with the flatness of the usual photograph. Many pinhole views may almost be compared for quality with those seen through a stereoscope. For copying, the method is unrivalled, if only time can be spared for the long exposure. To all these advantages it must be added that focussing can be almost ignored. Whether the distance from pinhole to plate be three inches or ten, only the size of picture and angle of view are changed; definition is practically the same.

The Pinhole.—And now we must explain that the pinhole usually adopted is not a pinhole at all. Photographs *may* be taken by means of an actual pinhole, but they will be more or less "fuzzy." The hole made by a pin in any substance is irregular in shape, with numerous jagged edges, reflecting the rays of light in all sorts of directions, and prolonging the exposure before sufficient of the correctly inclined rays can reach the plate. What we want is not an irregular tunnel, but a perfectly round hole, with edges so thin that scarcely any rays are intercepted by the sides of the opening. The best apertures are made with thin copper or brass drilled through by needles (7, 8, 10, 12 are the most useful sizes), the surface cleaned with a fine file, and then drilled again. Fine stencil brass is as good as anything, and the needle pricks may be made through pieces about ¾ in. square, while the metal lies flat on a boxwood block or cardboard. The surroundings of the hole must then be blacked, not with varnish, which would add considerably to the thickness, but by fuming with sulphur or dipping, while heated, into some blackening solution such as nitrate of silver.

Shutter.—If three or more "pinholes" of different sizes have been made, a very simple combined diaphragm holder and shutter may be contrived as follows. Take a strip of thick cardboard, or thin cigar-box wood, about 1 in. wide and 6 in. long. Punch in at intervals of 1¼ in. four round holes each ½ in. in diameter. Over each of these holes secure with stamp-paper one of the prepared punched metal slips, and make tidy and safe with a further layer of paper. This long strip may slide backwards and forwards over an aperture in the camera front $\frac{3}{4}$ in. wide, with a mark showing when each "pinhole" is centred over the aperture. Still better, the set of holes may be punched in a kind of diaphragm wheel. Such a wheel has been designed by Mr. Alfred Watkins of exposure-meter fame, and may be obtained at very low price from the dealers.

Working Distance.—We have stated that focussing is a matter of no practical importance with the pinhole, definition being good whatever the distance between plate and camera front. The circle of illumination is another matter. Rays of light which impinge on the plate at an angle have a much greater distance to travel than those which fall on it almost perpendicularly. In other words, the nearer the pinhole approaches to the plate the smaller the circle of effective, even, chemical action. A good rule in practice is that the distance between plate to be covered and aperture should never be less than the length of the plate; and for really good work that distance should be about the diagonal of the plate; for a quarter plate say 5 in., for a half plate 8 in., and so on.

Exposure.—The pinhole does not allow sufficient illumination to use the focussing-screen, and for ascertaining time of exposure we are dependent entirely upon calculation.

Now, the pinhole may actually be taken as the diaphragm of an imaginary lens, or rather infinite series of lenses, because at whatever distance the pinhole happens to be from the plate, this becomes the focal length. The diaphragm value is therefore the ratio between the diameter of the pinhole and the distance from the plate. If we take the size of the aperture made by a No. 10 needle as ·02 in., and are working at 5 in., this value $= \frac{\cdot 02}{5}$, or $f/250$. Mr. J. H. Noble some years ago worked out a system on these lines, making an allowance for the additional margin of time necessary beyond the rigidly calculated exposure in practice.

The time usually allowed for a lens working at *f*/8 must be multiplied by the figures opposite the distance given.

No. of Needle.	Distance of Plate from Pinhole.						
	3 in.	4 in.	5 in.	6 in.	7 in.	8 in.	9 in.
8	265	471	725	1060	1442	1884	2385
10	486	864	1250	1944	2646	3456	4374

The Watkins System.—Mr. Watkins has come to the rescue with a simplified method of calculating these exposures. To each pinhole he attaches a Watkins number which multiplied by the distance from plate gives a diaphragm value. The value is intended for use with Mr. Watkins' Bee meter, but the time given for this *f* value must be taken in minutes or fractions of a minute instead of the seconds, or fractions of a second, on the meter tables. The Watkins numbers

Watkins No.	Diameter.		Nearest Needle Size.	Good Working Distance.
	Inch.	Inch.		Inches.
1	0·160	$\frac{1}{7}$	—	—
2	0·080	$\frac{1}{13}$	—	—
3	0·053	$\frac{1}{19}$	1	40
4	0·040	$\frac{1}{25}$	4	20
5	0·032	$\frac{1}{31}$	5	14
6	0·027	$\frac{1}{38}$	7	10
7	0·023	$\frac{1}{44}$	8	8
8	0·020	$\frac{1}{52}$	10	5

are arrived at by taking $\frac{1}{40}$ as the standard instead of $\frac{1}{60}$. This simplifies calculation of the additional exposure in excess of the theoretical *f* value always necessary in dealing with pinhole apertures.

The accompanying photograph was taken through a No. 7 needle hole, 5 in. from plate, with an exposure of 5 minutes, at midday on the shortest day of the year—weather somewhat overcast. It was rather too large an aperture to use at short distance and so the definition is diffuse, but not unpleasantly so. The 8 and 10 needle holes are the best to employ when the distance is 6 in. or under.

Architecture.—It is in architecture that the pinhole lens is most useful, not only because it ensures geometrical truth

PINHOLE PICTURE (TAKEN WITH A NO. 7 NEEDLE HOLE ON A 5 × 4 PLATE).

of line and proportion, but also because it conveys a better idea of dimensions. For wide-angle work it is excellent. Even with the best glass lenses, true perspective can only be got at certain distances. By varying the distance between pinhole and plate, we can get true perspective almost irrespective of distance. The failure of any focussing screen is a slight disadvantage in obtaining a particular view; in the absence of the image on the screen we must resort to calculation. Supposing H be the height of the building, D its distance from the camera, h the height of the plate, and d distance between plate and pinhole. Then

$$\frac{h}{2d} = \frac{H}{D}.$$

For instance. We wish to photograph the spire of Notre Dame, at Bruges, on a 5 × 4 in. plate 5 in. from the lens. Reputed height of spire 410 ft. How far from the base of the spire must we place the camera?

Naturally, we shall use the camera with the longest side of plate perpendicular; therefore our equation will be

$$\frac{5}{10} = \frac{410}{D} \therefore D = 820 \text{ ft.}$$

or, leaving a few feet for headroom, since we do not wish the spire to look as if it was just tightly wedged into the picture, say 825 ft. On the other hand when we have stepped back 630 ft. we come to an obstruction, from behind which it would not be possible to get a satisfactory view. We are not beaten yet. We only have to increase the angle by decreasing distance between plate and pinhole.

$$\frac{5}{2d} = \frac{410}{630} \therefore d = 3\tfrac{3}{4} \text{ in. (roughly).}$$

This is an extreme case, and it would be better to use a camera having a rising front when for $\frac{h}{2}$ we can substitute height of pinhole after the front has been raised above base of plate. We will suppose the rise of front to have been one inch. The equation becomes

$$\frac{3\frac{1}{2}}{d} = \frac{410}{630} \text{ when } d = 5\tfrac{1}{4},$$

so that we can leave distance between pinhole and plate at 5 in. and get a good half-inch of sky above the vane of the spire.

By similar methods we can calculate the breadth of a view in confined spaces.

Some splendid interior pictures have been obtained with the pinhole camera, the only difficulty being the enormous length of exposure. When working with a lens at *f*/22, very few church interiors can be photographed in less than five minutes. So that, on the Watkins scale, a comparatively light interior could not be photographed on a 5 × 4 in. plate at 4 in., through a No. 8 needle hole, in less than five hours!

The pinhole lens has also been adapted for stereoscopic work, the best arrangement being two No. 10 needle holes at a distance of 3 in. from the plate.

ST. ALBANS ABBEY BEFORE RESTORATION.

Print from wet-plate negative.

CHAPTER XXXVII

THE WET-PLATE PROCESS

HAD this book been produced ten or twelve years ago, we might have omitted all detailed description of the wet-plate process as almost obsolete; the introduction of the excellent Mawson process plate seemed destined to prove the signal for its final doom, even for the purposes of photo-engraving. But the prophets have been wrong in their calculations. Although the process dry plate will give first-class results, and is no doubt the best to employ where orders for process negatives are only occasional, the wet plate is in practice the cheapest by far, and is preferred by all the leading photo-lithographers and photo-engravers.

The Glass Plate.—The first essential for the glass support is that it must be flat, or it will not sustain the heavy pressure of the printing frame, possibly in contact with a metal engraving plate. Sheet glass is often slightly curved, and therefore only suitable for very small plates; plate glass has been ground and polished, generally to the injury of its outer skin. Flatted crown, although expensive, is the best and most economical in the long run, especially as the negatives for engraving purposes are not stored, and after once printing may be cleaned off, and the glass used again. The smooth side of the glass must be very carefully cleaned, by soaking in a weak solution of spirits of salt, say 5 per cent., and then washed and rubbed, after drying with a clean wash-leather. To prevent splitting of the collodion on the glass, the latter is sometimes flooded with the following solution, and then allowed to dry:

Albumen	1 oz.
Ammonia (·880)	10 min.
Water	50 oz.

or sometimes the margin is run round with rubber solution.

Collodion.—It is a question whether collodion is worth manufacturing at home, the time and skill involved being considerable. Pyroxyline or gun-cotton is made by dissolving cotton wool in a mixture of sulphuric and nitric acids, or, alternatively, in a mixture of sulphuric acid and pure potassium nitrate, which latter is rather the easier process. In either case the operation should not be undertaken by those who are not experienced in the handling of sulphuric acid.

Hardwich Formula.

Sulphuric Acid (1·845 at 60°)	18 oz.
Nitric Acid (1·457)	6 "
Water	5 "
Cotton Wool	300 gr.

Alternative Formula.

Sulphuric Acid	18 oz. (fl)
Potassium Nitrate (dried)	10½ "
Water	1 "
Cotton Wool	180 gr.

The sulphuric acid must be mixed very cautiously with the other chemicals, when the temperature will rise to somewhere near boiling point. Stir the mixture with a glass rod, and commence to add the cotton wool in small quantities with the aid of the glass rod, when cooled to 150°, which temperature must be maintained to ensure success. The cotton wool must have been previously purified from resinous and greasy matter by boiling in an alkaline carbonate and then drying. When the cotton wool has been immersed about ten minutes it may be removed with the glass rod, the acid drained away, and then washed for twenty-four hours in running water. For use as collodion it is dissolved as follows:

Pyroxyline	10 gr.
Alcohol (·820)	1 oz.
Ether (·720)	1 "

In winter rather less alcohol is used, and a proportionately greater quantity of ether, in order to promote more rapid setting.

In practice, the worker will either purchase celloidin, or some other form of collodion, ready-made, and will be able to proceed direct to the iodising.

Iodising.—Dissolve the celloidin in a solution which will differ slightly according to whether for use in summer or winter. For winter:

Alcohol (·805)	6 oz.
Ether (·720)	8 ,,
Celloidin	130 gr.

In summer the amounts of ether and alcohol may be equalised. Then add the iodising mixture:

Zinc Bromide	30 gr.
Zinc Iodide	70 ,,
Alcohol	2 oz.

or:

Cadmium Bromide	10 gr.
Cadmium Iodide	30 ,,
Sodium Iodide	10 ,,
Ammonium Iodide	15 ,,
Alcohol	2 oz.

The mixture must then be set aside to ripen for about a week, after which it may be bottled off for use. It will improve with age, and keep good for about six months.

Coating the Plate.—This must be done immediately before it is required for use, and is not a very easy task for the beginner, even with the proper collodion pourer. Dust the plate with a badger-hair brush, and then, holding it in a horizontal position, pour upon it on the right-hand side a good quantity of the iodised collodion; incline the plate so that it runs to the right-hand further corner, then to the left corner, then towards the operator, and finally, via the last corner, back into an extra bottle provided with a funnel. Rock sideways so as to prevent the formation of stringy ridges while draining. Some considerable practice will be required with a steady hand before the operator can get a perfectly smooth homogeneous film, such as is necessary for fine half-tone work.

Sensitising.—Carry the coated plate directly into the dark room, and (under yellow light) immerse the plate in the silver bath. Lay the opposite end on the bottom of bath first, and then lower the end held by the fingers, so that the sensitising solution will flow evenly over the surface, film side upwards. Here it must be left for fully three minutes. Then lift out without touching the film side, allow to drain, and wipe sides and back dry with a wisp of blotting-paper, when it is ready for placing in the dark slide.

The Silver Bath.—A silver bath is usually made up with 30 gr. of nitrate of silver to each ounce of water, and a grain of potassium iodide to each 8 oz. Some workers add a few drops of the iodised collodion instead of the potassium iodide. The silver and the iodide are first dissolved separately in a small quantity of the water. When all is mixed it is filtered, and after standing some hours tested with blue litmus paper, when, if there is no acid reaction, a drop or two of nitric acid is added. The bath must always be kept at this strength of 30 gr. to the ounce; hence fresh silver nitrate is necessary from time to time Impurities will be acquired of organic and other nature, which must be removed by filtration. If very dirty, render the bath alkaline by the addition of strong ammonia and leave in the sun for a short time, when the organic matter will be precipitated and may be filtered off. For half-tone work the bath must only be just acid; that is, must only very slowly turn the blue litmus paper a reddish colour. Remove any scum by drawing pure filter paper across the surface.

To test the amount of silver nitrate in solution take, say, half an ounce, and precipitate by adding excess of hydrochloric acid. Filter off, dry the filter paper, and weigh the amount of chloride. Multiply this weight by 1·18 and it will give the amount of silver nitrate.

Exposure.—Ordinary dark slides are not suitable for wet-plate work; the most useful pattern is a single slide opening at the back. After draining the plate a piece of blotting should be put in the lower edge of the dark slide to receive any further drippings; otherwise these drainings may in hot weather creep up the film by capillary attraction, and produce odd markings. With regard to exposure, it is difficult to lay down any precise rules; with experience, the operator will learn to guess the time required fairly accurately.

Development.—The usual developer is the ordinary copperas or sulphate of iron.

Ferrous Sulphate (saturated solution)	5 oz.
Acetic Acid (glacial)	2 ,,
Alcohol	1½ ,,
Water	35 ,,

The exact amount of alcohol is not important, but more must be added if the developer does not flow evenly over the plate, which is not immersed as in dry-plate development, but held over a sink in a pneumatic holder, and a quantity of solution poured evenly over the surface. As little as possible of the liquid must be allowed to escape into the sink, as it will carry away much of the free silver, which should be redeposited on the image; and the developer should cover the whole film at once, or markings will result. Rock very gently until the fine detail is visible, when it is rinsed carefully and fixed, not in the usual hypo bath, but in a ten per cent. solution of potassium cyanide.

Other developers are

Ferrous Ammonio-sulphate	150 gr.
Acetic Acid Glacial	150 min.
Copper Sulphate	15 gr.
Alcohol	1 oz.
Water	9 ,,

An acid pyro developer is sometimes employed, but requires longer exposure than ferrous sulphate, and bromides must be omitted from the iodiser. However, it gives a very dense black image which is most excellent for copying purposes.

Pyrogallic Acid	10 gr.
Acetic Acid	150 min.
Alcohol	½ oz.
Water	10 ,,

Intensification.—Before fixing, the plate may be examined and, if too thin, redeveloped with

A.	Ferrous Sulphate	10 gr.
	Acetic Acid	10 min.
	Water	2 oz.
B.	Silver Nitrate	15 oz.
	Water	1 „

Mix A and B immediately before using. If the weakness of the negative is not discovered until after fixing, either of the mercury or copper intensifiers used for dry plates may be applied.

Collodion Emulsion.—This may be procured sensitised ready for use, and it is especially coming into favour for colour work, as the colour sensitisers can be added to the emulsion before coating. With the ordinary wet plate, collodion emulsion has little in common, except that it has to be coated on the glass plate before using. The chief difficulty in its manufacture, as compared with gelatine emulsion, is in the washing out of the soluble salts.

Care of the Collodion.—Always keep the collodion bottle in a cool place, and use ordinary care in decanting it, or when coating plates, with regard to any gas jets or artificial light near adjacent. It is inadvisable to perform these operations near the fire, in view of the fact that ether vapour is heavier than air. In the days of the wet plate disastrous explosions were not uncommon, owing to such accidents as a cat upsetting a bottle of collodion, the contents of which leaked into other apartments. For this reason we would suggest that it should be stood in some safe cupboard and not on an open shelf; above all, not in the dark room.

For fuller particulars regarding collodion the following works may be consulted: *Wet Collodion Photography*, C. W. Gamble; *The Wet Collodion Process*, Arthur Payne; *Collodion Emulsion*, H. O. Klein.

CHAPTER XXXVIII

EMULSIONS FOR DRY PLATES AND FILMS

WHETHER it is feasible for the photographer, amateur or professional, to prepare his own dry plates is a question hardly worth discussing. The processes are attended with precariousness and intricacy at every stage. Each batch of that very uncertain substance, gelatine, must first undergo special testing. The apparatus is expensive. Provision has to be made against changes of temperature; space set apart in workshops where scrupulous cleanliness can be observed, and, above all, freedom secured from that ubiquitous enemy, dust. Moreover, the greater part of the work has to be performed in non-actinic light. Even under the best conditions, it is not unusual to see in any great commercial establishment whole tubs full of emulsion, which has had to be condemned for one reason or another. Still it is expedient that the photographer should have some insight into the manner in which the emulsions are prepared, if only to assist him to unravel any problem arising during exposure and development.

Boiling Process.—There are several different methods of preparing the emulsion; but we shall here only describe two typical ones—the boiling process with hydrochloric acid, and the Monckhoven, or ammonia process. In the first of these, to take a typical formula, 60 parts Nelson's No. 1 photographic gelatine is dissolved at moderate heat in 900 parts of water, and removed into non-actinic light, when 350 parts nitrate of silver dissolved in 480 parts of water, at about 120°, is stirred in, and the mixture well shaken up; after which the solution

Potassium Bromide	280 parts
Potassium Iodide	10 ,,
Hydrochloric Acid	1 minim to every 2 oz.
Water	1,200 parts

is slowly poured in, with much shaking of the vessel to ensure perfect incorporation. All is then digested in a water bath raised to boiling point, the emulsion being occasionally shaken, for 30 to 45 minutes.

Meanwhile 300 parts of hard gelatine have been soaked and then dissolved at 110°, or less, in 1,960 parts of water; this is added to the emulsion when it has been allowed to cool down to 80° or 90°, together with ammonia in 10 per cent. solution, 10 minims to each ounce of emulsion.

Ammonia Process.—As this is the more attractive process for experimental purposes, we give alternative formulæ. Both of these are for slow plates, such as the amateur might possibly succeed in carrying to successful conclusion.

(1)	Ammonium Bromide	15 gr.
	Solution of Potassium Iodide (10 per cent.)	3 min.
	Hard Gelatine	30 gr.
	Nitrate of Silver	25 ,,
	Distilled Water	1 oz.
(2) A.	Potassium Bromide (Dr. Eder)	120 gr.
	Solution of Potassium Iodide	20 min.
	Hard Gelatine	100 gr.
	Water	2 oz. 5 dr.
B.	Nitrate of Silver	150 gr.
	Water	2 oz. 5 dr.

The gelatine is first dissolved in the water, by application of moderate heat; after soaking for about half an hour the bromide and iodide may be added, at a temperature not exceeding 110°. The nitrate of silver solution (to which sufficient ammonia has been added, drop by drop, to cause the precipitate at first formed to redissolve) is usually poured into the emulsion warm and by degrees, with vigorous shaking. According to the speed required the emulsion may then be poured out into a flat dish to set, or digested over a water bath at 100° for 45 minutes. The proportion of iodide is variable. For landscape work the iodide is recommended as decreasing the liability of halation, and, according to Dr. Eder, plates are rendered thereby somewhat more sensitive.

Ripening the Emulsion.—If an emulsion after mixing is digested in the water-bath at 100° to 140°, according to circumstances, for a time varying from 30 minutes to 2 hours, and then cooled rapidly in running water and allowed to stand for 48 hours, the sensitiveness is enormously increased. The time must not exceed 48 hours, or fog will probably occur in the plates. No doubt the gelatine itself plays an important part in the formation and development of the latent image; but, although some theories exist, none are capable of proof, in view of the difficulties involved in the chemistry of gelatine. The ripening process may also be set going by the addition of ammonia to the emulsion. One alteration brought about by emulsion is an increase in the size of the halide particles.

Slow and Rapid Emulsions.—The difference between a slow and rapid emulsion is, therefore, not merely in the proportions of the amount of bromide and iodide salts to the nitrate of silver; although in the latter it is usual to employ a larger quantity of iodide, and also much more bromide than would be required according to Ackland's Tables. A slow emulsion is usually set at once, immediately after mixing. Digestion in the water bath for half an hour at 110° may increase the speed from 4 to 5 times on the Hurter & Driffield Scale.

An excess of bromides and iodides with prolonged digestion at higher temperatures may raise it to 30 times. For instance, in formula (1), by increasing the bromide to 32 gr. and the iodide solution to 12 minims, stewing for an hour after addition of silver nitrate at 120°, then cooling rapidly and allowing to stand for 32 hours, the emulsion would possibly show a speed of 200 H. & D.

Chloride Emulsions.—Most silver chloride emulsions are slow and suitable only for contact lantern places, gaslight papers, etc., etc. Lüppo-Cramer's formula represents an endeavour to produce a sensitivity in the chloride comparable in some degree with that of bromide :

Gelatine	10 grams
Common Salt	7 "
Hydrochloric Acid (sp. gr. 1.9)	10 c.c.
Water	100 c.c.

Heat to 176° Fahr. and add:

Silver Nitrate	10 grams
Water	100 c.c.

at same temperature. Digest in water bath for a quarter of an hour, and then treat as usual. The ammonia method tends to produce fogged emulsion.

Washing the Emulsion.—The hard, stiff jelly must now be forced, either by machinery through a sieve, or squeezed through canvas netting in cold water, and then collected once more into the canvas bag for from half an hour under running water to a soaking of several hours in still water ; the squeezing process is then repeated, exposing fresh surfaces of gelatine to the action of the water. By this time the excess of nitrates and bromides will have been removed, and the emulsion is very carefully drained over a hair sieve, then collected and melted once more at a temperature of about 120°, when it is filtered, and is finally ready for coating the glass plates. If the gelatine shows signs of degeneration small quantities of formaline or chrome alum are introduced ; but the latter will tend to lessen the sensitiveness of the plate. Special machinery is of course employed in coating plates for commerce. For our trial plates we may take the glass from which old negatives have been stripped, and immerse them, first in some acid bath, and then in caustic potash, after which they are rinsed in warm water and rubbed thoroughly dry with a clean dishcloth. Beware of dust at all stages, but at this moment every speck of dust is a source of destruction and ruin.

Coating the Plates.—Pour a pool of emulsion in the centre of the plate, and smooth over with a glass rod. Or, if the glass is laid on a scrupulously level surface, a smooth film will distribute itself with a little coaxing on the part of the operator. A thin substratum of albumen or gelatine with chrome alum forms a good sizing for the plate, and will prevent frilling. The plate may be warmed, but must not be too hot, and the emulsion must be kept at a high temperature—not less than 120°. It is not easy to decide how thick an emulsion should be. Very thin coatings tend to pinholes; thick coatings will often contain uneven knobs. 1½ drams ought to be the average for a quarter plate, and 2½ drams for a half plate. Some will consider this too liberal.[1]

Testing Plates.—Nearly all plate makers have adopted the Hurter and Driffield system of speed-marking. It is a method of sound and accurate character, designed with the utmost thought and care, including a standard light and standard developer. Unfortunately this excellent apparatus is sadly misused by some manufacturers, and the measurements on plate-boxes are often seriously inaccurate. Another ingenious little instrument is the Chapman Jones plate-tester, consisting of a screen-plate with several divisions, which is placed in front of the film to be tested at a certain distance from the standard light. The various divisions provide an index to: (1) The speed of the plate. (2) Its range of gradation. (3) Range of exposure. (4) Colour sensitiveness. (5) Grain. (6) Liability to halation. (7) Safest light for dark room. Every photographic club ought to place this inexpensive and most serviceable aid to correct exposure at the disposal of its members.

Drying.—A proper drying cupboard, in which the air is kept at a constant moderate temperature, is most important. It should be light-tight and air-tight, with a box underneath the shelves containing lumps of calcium chloride—a moisture absorbent which can always be restored to efficiency after

[1] W. K. Burton advises 1 dram for a quarter plate, 1½ dram for a half plate.

saturation by merely baking in a hot oven. Sudden changes of temperature, or rapid drying under heat, spoil the fibre of the gelatine and cause frilling. The plates should take about 12 hours to dry. If wanted in a hurry, they should be dried by the application of alcohol. When dry they should be packed in the usual boxes, and wrapped up to preserve them from damp and changes of temperature. The best and simplest way of packing is to place each two film to film, with the usual paper spill at each end, and wrap the pair in soft brown paper. A good emulsion, if kept dry and away from light, should be capable of giving a satisfactory negative for at least two years. In practice, dry plates of more than a year old should be rejected. On the other hand we have tested plates five years after the date marked on the box by the maker, and found them all that could be desired.

Emulsions on celluloid films are not in essence different from those used on plates ; some makers coat the same emulsion on their plates and films of corresponding rapidity. Roll-films first receive a layer of hard gelatine on the reverse side to that which is to take the emulsion. This obviates much of the curling during development, and, still worse, after drying, which was formerly characteristic of these films. Emulsions for bromide or chloro-bromide papers are also prepared in a very similar way, except that these do not undergo any prolonged boiling, digesting, or ripening process.

CHAPTER XXXIX

PHOTOGRAPHY IN NATURAL COLOURS

The Beginnings.—It is an interesting fact that some of the first recorded experiments in photography were directed to obtaining results in natural colours. More than fifty years before photography, as we know it, was invented, such experiments were being made; and when the researches of Daguerre and Fox-Talbot culminated in the production of permanent light-pictures in monochrome, the scientists of the day, while giving them due credit for their epoch-making discoveries, declined to regard photographs without colour as the realisation of their dreams; and the search for a means of photographically reproducing the colours as well as the forms of objects was pushed forward with redoubled vigour. For, after all, nature and art alike appeal to us as much by beauty of colour as by beauty of form, and no method of pictorial representation can be considered as perfect, which, while reproducing the one, fails to convey any adequate impression of the other.

The aim of the early experimenters was to discover how to prepare a photographic surface that would not merely darken in varying degrees under the influence of light, but would directly reproduce the colours of the image thrown upon it. The substance they were seeking proved as elusive as the philosopher's stone of the ancients. Some faint resemblances to the colours of the spectrum were obtained on a surface prepared with chloride of silver; but these results were very imperfect, and no means could be found of fixing the tints.

Other investigators, quite apart from photography, had in the meantime been studying the nature and properties of colour; and in 1860 Prof. James Clerk Maxwell demonstrated conclusively that all colours could be produced from three simple or primary colours — red, green and blue-violet. This discovery suggested a solution of the problem of photography in natural colours. The search for a substance that would permanently reproduce the colours of the light rays thrown upon it had failed, but perhaps it would be possible to photograph separately the three primary colours, and by combining them produce a complete colour photograph. Prof. Clerk Maxwell himself experimented on these lines, and in 1861 displayed on the lantern screen at the Royal Institution, in the course of a lecture, a crude colour-photograph obtained by the method indicated. He did not follow the matter up, however, and it was left for an exceedingly able French experimenter and inventor, Louis Ducos du Hauron, to elaborate a practical system of three-colour photography, which he published in 1869. Ducos du Hauron, in his work, anticipated all the really successful methods of tricolour photography of the present day, including the easy and popular screen-plate processes, and may justly be called the father of practical colour photography.

The Principle.—It may be well, at this point, to state briefly the scientific facts underlying these methods of producing colour photographs.

Colour is purely a sensation produced upon the eye by rays of light. Without light there can be no colour, nor can we be conscious of any colour that is not contained in the rays of light falling upon the object we term coloured. It follows that, as our natural source of light is the sun, all the colours of nature are contained in sunlight. These infinitely varied colours, as Clerk Maxwell showed, are equivalent to mixtures of the three primaries—red, green and blue-violet —so it is convenient for our purpose to consider sunlight as being composed of red, green and blue-violet rays in equal proportions. These three, so combined, produced the sensation of white light, and a sheet of white paper, or a whitewashed wall, appears white because it reflects all the rays equally. Some surfaces, however, do not reflect all the rays, but absorb some of them. For instance, a red rose absorbs the green and blue rays, reflecting only the red ones; consequently it produces on the nerve fibrils of our eyes the sensation of red. The grass absorbs the red and blue rays, leaving only the green to be reflected, so it appears green to us; while the blue corn-flower absorbs the red and green, and we therefore say it is blue. The same may be said of transparent objects; for instance, one piece of glass is blue, because it absorbs the red and green rays and only allows the blue ones to pass through it; another is red, because it absorbs the blue and green rays; a third is green, because it absorbs the red and blue rays.

The Application.—It is this property of transparent substances to absorb some rays and pass others that is utilised to produce colour photographs. If before exposing our photographic plate we place before the lens, or between the lens and the plate, a transparent medium which absorbs the blue-violet and the green rays, we shall get a photograph of only those objects or parts of objects before the camera that are reflecting red rays. If we take another photograph through a transparent medium absorbing the red and blue-violet rays, it will represent only those objects or portions of objects which are reflecting green rays; and if we make a third exposure through a medium which absorbs the red and green rays, the result will be a photograph of those objects or portions reflecting blue-violet rays.

The Achievement.—But although the theory of three-colour photography was practically complete before the year 1870, many difficulties had to be overcome before practical success could be achieved. Endless experiments had to be made before the exact colours necessary for the light-filters could be arrived at, but the chief obstacle was that all the photographic plates of those days were far too sensitive to blue-violet rays, very little sensitive to green, and quite insensitive to red.

Thus, although Du Hauron actively continued his experiments, he failed to produce any satisfactory results, and for nearly twenty years from the publication of his treatise the practicability of his methods remained unproved. The credit of first practical success belongs to Mr. Frederic Eugene Ives, of Philadelphia, who, after many years of patient research and experiment, not only produced light-filters of the necessary degree of accuracy, but devised a most ingenious camera, by means of which he simultaneously exposed three specially prepared colour-sensitive plates, thus obtaining triple colour-sensation negatives by what was practically one exposure. These negatives, of course, were entirely destitute of colour in themselves, as also were the positives made from them ; but when the latter were viewed by light passed through suitably coloured light-filters in Ives's cleverly devised "Kromskop," or projected on the lantern screen by his equally ingenious triple-projection lantern, the effect was a startlingly lifelike representation of the objects photographed, in all their natural colours. In the stereoscopic Kromskop the illusion of reality is particularly striking. The writer recollects inviting a lady to look into such an instrument at a photograph of a vase of flowers. While she did so, he endeavoured to explain how the colour effect was produced. "But," said she, looking up from the instrument when the explanation was concluded, "that's not a photograph ; it's a real vase of flowers."

Transparencies in Colour.—But beautiful as were the effects produced by Ives's apparatus, it was too complicated and too expensive to become popular. What was wanted was such a colour-photograph as could be viewed in the hand, without apparatus, or used as an ordinary lantern slide in any single projection lantern. The Ives process having proved the practicability of the triple-negative method, other experimenters attacked the problem assiduously, and before the end of the nineteenth century Mr. Sanger Shepherd in

England, and Messrs. Lumière in France, had brought out, on commercial lines, processes of transparency-making in colours based on the Ives method. These processes are still in active operation, and for many purposes remain superior to any of the more recent methods.

In the Sanger Shepherd process, three negatives of the subject are obtained on colour-sensitive plates by exposure in the camera through red, green and blue-violet light-filters respectively. A positive, on an ordinary lantern-slide or transparency plate, is then made from the negative taken through the red filter, and toned to a greenish-blue. Transparencies from the negatives taken through the green and blue-violet light-filters are then made on thin celluloid films coated with bichromated gelatine, the picture being reversed by printing through the celluloid film. These are developed by dissolving out the unhardened gelatine with warm water, after the manner of carbon prints. The gelatine image obtained from the green-filter negative is then stained magenta-pink, and that obtained from the blue-filter negative, yellow. The two stained film positives are carefully superimposed upon the blue-toned glass positive, and the whole bound up with a cover glass in the ordinary way.

It will be noted that the positives are not stained in the colours of the light-filters through which the negatives were taken, but in colours complementary to them. The necessity for this will be made clear if we consider the effect of photographing a single colour—a disc of green, for instance—on a white ground. In the negatives taken through the red and blue-violet filters, it will appear as a transparent patch on an opaque ground; but the negative obtained through the green filter will be opaque throughout, because the green rays from the disc and those from the white ground have alike been passed by the filter. A bichromated gelatine film exposed under such a negative would, of course, be entirely protected from light-action, with the result that the gelatine, on development, would be entirely dissolved away, leaving nothing to take up the dye. In the positives from the red-filter and blue-filter negatives, however, the green disc would be represented by undissolved gelatine. Supposing these were dyed with the colours of the filters through which the respective negatives were taken, and then superimposed, we should have a red disc upon a blue one. The effect would be this—the red would cut off the blue and green rays, and the blue would cut off the red rays; so, instead of the disc appearing green, it would appear black, all the light being cut off by the two superimposed colours. If, on the other hand, we dye the red-filter positive greenish-blue, and the blue-filter positive yellow, the correct result is obtained, thus—the greenish-blue cuts off the red rays, and the yellow cuts off the blue rays; the green rays are therefore the only ones to reach the eye, and the true colour-sensation is produced.

The production of colour photographs by the superposition of dyed positives is known as the *subtractive method*, because the final colours are obtained by the action of the dyes in each subtracting, from the white light falling upon the photograph, the rays that are not required. The Sanger Shepherd process may be taken as typical of the many processes for the production of transparencies by the subtractive method, differing from each other only in detail.

Colour Photographs on Paper.—The subtractive method is also applicable to the production of colour photographs on paper, and many processes have been devised by which this can be successfully accomplished. Ducos du Hauron suggested in 1869 the use of three carbon tissues, pigmented respectively in red, yellow and blue. This suggestion has been successfully put into practice within the last few years, and very beautiful results have been obtained. To facilitate exact superimposition of the prints, the carbon tissues are supplied on temporary supports of transparent celluloid film. The process has been introduced commercially in England by the Rotary Photographic Co. and the Autotype Co., and all the necessary materials are readily obtainable.

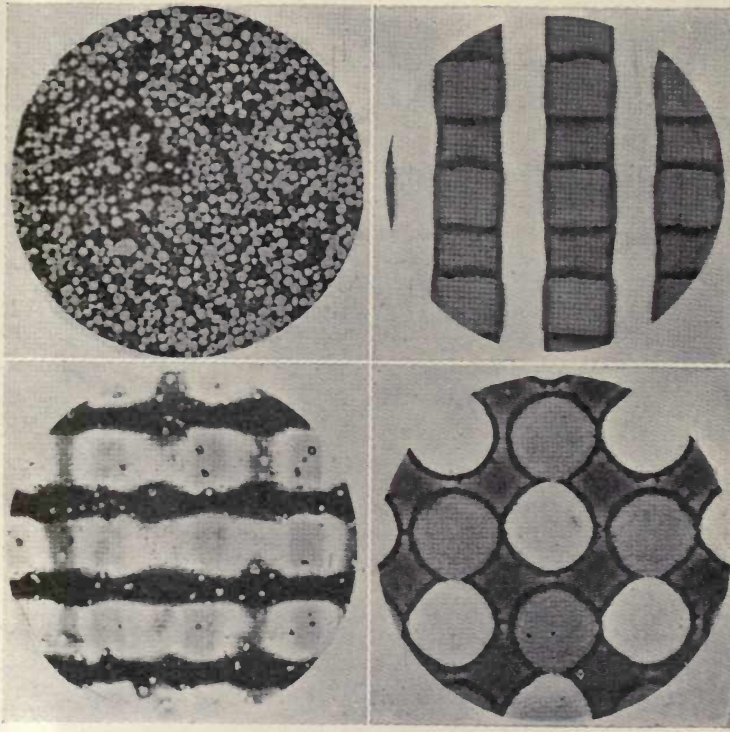
In the Lumière process, introduced by Messrs. Lumière, of Lyons, a print on glossy bromide paper is made from the red-filter negative, and toned blue. Prints from the other two negatives are then made in bichromated gelatine on a transparent celluloid support, and thes, after being stained yellow and pink respectively as described above, are superimposed on the blue print, each being stripped from its celluloid support after being brought into exact register with the blue print.

Messrs. Sanger Shepherd & Co.'s very successful Imbibition Process is based on the discovery that a thin film of soft gelatine on damped paper, placed in contact with a dyed gelatine relief, will quickly absorb all the dye from the latter. The process consists in printing from the triple negative in bichromated gelatine on a transparent celluloid support. The developed prints are stained in the usual colours, and successively brought into close contact with a sheet of damped gelatine-coated paper, by which the stains are absorbed, the gradations of each positive being exactly represented by the depth of the staining. A complete colour print is thus produced on the paper, and the celluloid positives, entirely cleared of their dyes, are ready for use in making another paper print, and may be used again and again, there being no necessity, as in the processes before described, to make a fresh set of positives for every print. Another advantage of this process is that the three dyed positives may be viewed in superposition over a sheet of white paper, as a test of the colours, before bringing any of them into contact with the printing paper, and any errors in depth of staining may thus be detected and rectified in time to prevent spoiling a print.

"Pinatype," introduced by Dr. König in 1905, is another process in which colour prints are produced by transference of dyes to gelatine-coated paper from bichromated gelatine "printing plates." The peculiarity of this process is in the dyeing of the printing plates. In the Sanger Shepherd process it is the hardened gelatine image that is dyed; the Pinatype dyes, on the contrary, are taken up only by the unhardened gelatine. The printing plates are therefore made by exposure under positives, instead of direct from the negatives, and do not require development, as the unhardened gelatine must not be removed. As in the Sanger Shepherd process, the printing plates may be used over and over again.

The Screen-Plate Processes.—Excellent as are the results obtainable by the indirect or triple-negative processes already described, no method which involves so many operations can be regarded as ideal in its simplicity ; and although the invention of these processes made three-colour photography and three-colour printing a commercial possibility, they were too lengthy and troublesome to be adopted by more than a very small minority of amateurs. The long-felt want was a photographic plate by means of which a direct colour photograph could be obtained, with approximately the same ease and certainty as an ordinary photograph in monochrome. This desideratum has been realised in the screen-plate.

The fundamental principle of the screen-plate processes is the same as that of the triple-negative method already described—the separation of the colour rays by means of light-filters of red, green and blue-violet. It is in the application of the principle that they differ from the earlier method. The screen-plate avoids the necessity of making three separate negatives, by combining the three light-filters in the form of an infinite number of microscopic lines, dots, patches, or grains of the essential colours, evenly distributed over the entire area of the plate. Superimposed upon this composite colour-screen is a film of photographic emulsion, made sensitive to all colours. The plate is exposed with the glass side towards the lens, so that all the rays of light which go to form the picture must first pass through the microscopic light-filters. Naturally, when the plate is developed, silver is only deposited under the red particles of the screen in those places where red rays fell upon them, and those portions of the emulsion covered by the green and blue-violet particles of the screen are only affected in the areas where green and blue rays respectively fell. The result is a composite negative image—the three colour-records split up into countless thousands of separate but



MICROGRAPHS OF THE COLOUR SCREENS (× 100).

Autochrome. Dufay.
Omnicolore. Thames.

closely adjacent particles or lines. The colour-screen, being protected by a special varnish, remains unaffected by the development of the sensitive film above it, and if the plate is fixed after development and examined by transmitted light, a negative image is seen in complementary colours, the positive colours being blocked out by the silver deposit. Instead of fixing at this stage, however, the negative image is usually converted into a positive, by dissolving out the reduced silver bromide and redeveloping the plate after exposing it to daylight—two very simple operations, occupying only a few minutes. The effect of the redevelopment is to deposit silver over all those portions of the colour-screen through which the light rays did *not* pass during the original exposure: thus all particles of colour not required for the finished picture are blocked out; and as the original silver deposit has been dissolved away, the colours blocked out by the first development are disclosed, the result being a transparency in the natural colours of the objects photographed.

The screen-plate idea was originated by Louis Ducos du Hauron as long ago as 1868, but no practicable screen was made until 1895, when Prof. John Joly, of Dublin, produced screens formed of fine lines of colour in juxtaposition. These screens were, however, so costly to manufacture that the Joly process was commercially a failure; and it was not until 1907 that the first really successful screen-plate was placed on sale, by Messrs. A. & L. Lumière, under the name of the Autochrome Plate. The introduction of this plate marks a new era in colour photography. From being a costly and lengthy process, involving many delicate operations with proportionately numerous risks of failure, photography in natural colours became at once so simple and inexpensive as to be within the reach of almost every amateur.

The Autochrome Plate.—The Autochrome screen is composed of millions of grains of potato-starch, of an average diameter of about $\frac{1}{1800}$ in. The method of manufacture is, briefly, as follows. The starch grains, separated into three lots, and dyed respectively red, green, and blue-violet, are intimately commingled until the mixture appears of a uniform grey tint. The glass plate having been coated with a transparent tacky varnish, the coloured grains are "dusted on," until the whole surface is uniformly covered.

Reproduced by Tri-Colour process, and engraved and printed by The Half Tone Engraving Company, Ltd., from a colour transparency by the Thames Colour Plate, Ltd.

A PORTRAIT STUDY.

The grains are then rolled into close contact, no interstices being left, and a protective varnish is applied. The screen is then coated with a panchromatic emulsion, and the plate is complete.

The mode of using the plate is as outlined above, but it should be noted that, in this and all other screen-plate processes, a yellow "compensating screen" is used before or behind the lens, to cut off the excess of blue and violet rays.

Since the arrival of the autochrome plate, a bewildering number of methods of screen-plate manufacture have been patented by different inventors, and many varieties of screen-plates are now on the market. Space will only allow of our referring in detail to those which are most generally in use.

The Omnicolore Plate.—The Omnicolore plate, though not yet actively marketed in this country, possesses a special interest as the actual invention of the veteran pioneer of colour photography, Louis Ducos du Hauron, in conjunction with his nephew, R. de Bercegol. Its introduction immediately followed that of the Autochrome plate, in 1907. In differs from the latter in the formation of the screen, which consists of a film of gelatine, dyed in a regular pattern of red and green rectangles crossed by blue-violet lines. The red rectangles have an area of about $\frac{1}{420} \times \frac{1}{600}$ in.; the green ones are somewhat larger, and the width of the blue lines is about $\frac{1}{500}$ in. The dyed gelatine being more translucent than starch grains, the time of exposure is proportionately shorter than in the case of the autochrome plate.

The Thames Plate.—The Thames plate is a British production, the inventor being Mr. C. L. Finlay, of London. In this plate also the screen consists of dyed gelatine, the colour units being a regular series of dots of red and green, each about $\frac{1}{220}$ in. in diameter, the interstices being coloured blue-violet. This screen is particularly translucent, and as the emulsion is also a rapid one and its colour sensitiveness so adjusted that the compensating screen need only be of moderate depth of colour, comparatively short exposures may be given with successful results. A feature of the Thames plate is that the screen may be had either with or without the sensitive coating. In the latter case it is used in conjunction with a pan-chromatic plate, the two being placed together in the dark slide, film to film. They are separated again before development, and the plate may be fixed as a negative and any number of positives printed from it, each of which, when bound up in register with any Thames screen, becomes a complete colour photograph. This method of reproduction is, of course, only possible with a perfectly regular screen, such as the Thames.

The Dioptichrome Plate.—The Dioptichrome plate, another French product, is the invention of Monsieur Louis Dufay, and was first issued in 1909. It is now readily procurable in this country, and the results shown are so excellent that a wide popularity may be predicted for it. In structure the screen is somewhat similar to the Omnicolore (described above), the pattern consisting of continuous green lines, interspersed with rows of red and blue rectangles. The colour-rendering of this plate appears to be exceptionally good; flesh tints and white (the latter a very severe test for a screen-plate) being reproduced with remarkable fidelity.

It will have been noticed, from our general description of the screen-plate method, that there is no superimposition of colours. The colour sensation is not produced by the subtraction, from the light falling upon the photograph, of one set of colour rays after another. The rays which pass through the photograph to the eye are of the exact colours of the light-filter elements—red, green, and blue-violet—and it is by the addition of colour ray to colour ray in the eye itself that the correct colour sensations are produced. This is known as the additive principle, in contradistinction to the subtractive principle of the superimposition processes before described.

No satisfactory way of obtaining colour prints on paper from screen-plate photographs has yet been invented. For this purpose, the triple-negative method is still the only practicable one.

The Lippmann Process.—Though we cannot here attempt to describe every process of colour photography hitherto invented, mention must be made of the Lippmann process, which, though one of the least practical for everyday purposes, is undoubtedly the most interesting of all from a scientific point of view. Invented by Dr. Lippmann, of Paris, in 1891, it is independent of the three-colour theory, and dispenses with all light-filters except the usual yellow "compensator," used before or behind the lens to cut off the excess of violet rays.

The process is based upon the undulatory theory of light, and is itself one of the most interesting proofs of the truth

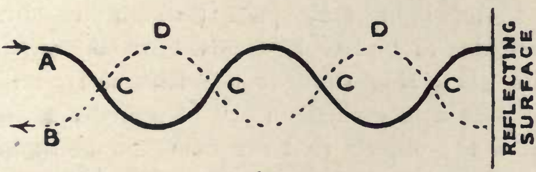


FIG. 69.

of that theory. Briefly, the undulatory theory regards light as being the effect of wave-like movements of the all-pervading ether, in the same way as sound is the effect of undulatory movements of the air. As in a scale of music the different notes are due to differences in the length of the sound-waves, so in the spectrum the various colours are the result of differences in the length of the light-waves. The longest light-waves by which our eyes are affected produce the sensation of deep red; the shortest produce the sensation of violet. Between these are yellow, orange, green, and blue, all produced by waves of different lengths. In actual measurement these waves are inconceivably minute, ranging in length from about $\frac{1}{35000}$ in. in the red to about $\frac{1}{65000}$ in. in the violet, a wave-length being the measurement from wave-crest to wave-crest (D to D, Fig. 69).

If a ray of light is reflected back upon itself, in such a way that the crests of the reflected waves are in opposition to the depressions of the advancing waves, as shown in the diagram (Fig. 69), where A is the advancing and B the reflected wave, the waves will neutralise each other at the points where they cross (C C C in the figure), producing points of darkness, while the light action will be increased at the points where the crest of one wave is opposite the depression of the other (D D in the figure). In other words, the light will be split up into layers, with layers of darkness between.

The Lippmann photograph is taken in such a way as to fulfil the conditions necessary to produce this effect. A specially prepared photographic plate is used, the sensitive coating being practically grainless and perfectly transparent, so that the light may pass through it without being "scattered." The plate is exposed in an ordinary camera, with its glass side towards the lens and its film side in contact with a reflecting surface of mercury. The coloured rays from the objects that are being photographed, passing through the plate to the mercury, are reflected back upon themselves, producing the effect above described. The result, on development of the plate, is that the silver is deposited in microscopic layers, whose distance apart varies according to the colour of the rays which fell upon that particular part of the plate. This is diagrammatically illustrated in Fig. 70, where red, green, and violet rays respectively are represented as entering the film and being reflected back upon themselves, the shaded portions showing the points of maximum light action, where the layers of deposit are produced on development. No attempt is made in the diagram to represent the actual number of layers produced. They are even more inconceivably minute than the light-waves themselves, as they occur at every half wave-length. Thus, in a film only $\frac{1}{500}$ in. in thickness, a red ray may be represented by as many as 140 layers and a violet ray by as many as 260.

Such a photograph, viewed by transmitted light, is perfectly devoid of colour. But when a black backing is applied to it, and it is viewed at a certain angle, a wonderful change takes place. The light falling upon and reflected from it is decomposed by the microscopic layers of silver deposit, each set of layers obstructing and suppressing all

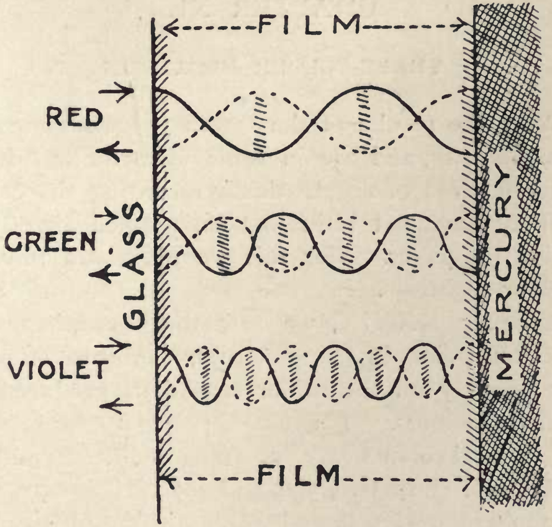


FIG. 70.

the light-waves, except those whose length fits its own structure. Consequently, the light rays reflected to the eye from each point of the photograph are of the same wave-length, or colour, as those which fell upon that point when the plate was exposed in the camera, the result being a complete colour picture of remarkable brilliance.

23

CHAPTER XL

THREE-COLOUR NEGATIVES

ALTHOUGH the results of the screen processes are often of exceeding beauty, and are in some ways far in advance of any other method of automatically recording the colours of nature, they have not hitherto been applied directly to reproduction on paper. For this we must still rely on the three-colour negatives.

In Chapter XXXIX, we saw that by selecting three special colour points in the spectrum, a mixture of these will suffice to convey all the colour sensations produced by the intermediate colours. The exact points to be selected for the fundamental colours vary according to different authorities: Clerk Maxwell chose 630, 530, and 457; König 675, 508, and 475; Grünberg 665, 506, and 482. Sir W. Abney, working with more accurate instruments than were at Clerk Maxwell's disposal, does not differ very widely from the latter, but selects a red near the red lithium line, a green near the E line, and a violet near the blue lithium line. The nerve fibrils stimulated by the particular coloured rays have also considerable sensitiveness towards the rays of adjoining parts of the spectrum. Thus the nerves most sensitive to the green are also to a considerable extent sensitive through the orange to the red on one side, and to the blue on the other, the blue sensitiveness also applying to the green. This sensitiveness is expressed by Clerk Maxwell and others by curves, which indicate at highest point the greatest degree of stimulation and taper off according as the sensitivity of the particular set of nerves decreases.

If we wish to obtain three negatives, which are to be used for the expression of natural colour, they must correspond with these three curves. Such a combination will then be more or less interpreters of the three sets of colour nerves in the human eye. The greatest densities of each when used for transparencies and superposed over each other must give a white light.

Chromatic Plates. — Except for some photo-mechanical work, it is no longer the custom to sensitise three different sets of plates for the three selected colours red, green, and blue-violet, but to employ for all alike a plate sensitive to the whole spectrum. Such plates are usually stained with cyanine, pinachrome, or still better in a solution of pinachrome and pinacyanol, in the proportions of 3 to 2. Prof. Namias,

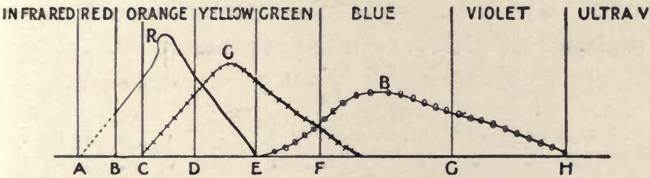


FIG. 71.—THE COLOUR CURVES ACCORDING TO CLERK MAXWELL.

while recommending ethyl-violet and erythrosine in the proportions of 3 to 2, remarks that pinachrome gives a band which runs from ultra violet to nearly all the red with two inconsiderable minima, one between G and F (blue-green) and the other between D and E (yellow-green). Plates treated with ethyl-violet and erythrosine must be exposed through the red filter for at least double the time of plates treated with pinachrome. A pinachrome solution (1 gram to 500 c.c. pure alcohol 95° and 500 c.c. distilled water) is diluted for use with fifty times its bulk of pure water, and the plates immersed in the dark for fifteen minutes. After this they are rinsed, plunged for a moment in an alcohol bath, and dried in the calcium-chloride box. With the arc light, pinachrome is almost perfect as a sensitiser. The amateur will be well advised, in view of the considerations involved, if he contents himself with the ready-prepared panchromatic plates and the filters recommended by the makers concerned.

Colour Filters.—The exact tints of the three filters, orange, green, and blue, will differ slightly according to the light employed, and the dyes with which the plates are sensitised. Earlier workers were satisfied with glass filters tinted orange red, chromium green, and cobalt blue. Glass filters reliable enough for many purposes may still be obtained, and they have the advantage over the aniline dyes of being less liable to lose colour under the action of light. A good selection of filters may be obtained from firms such as Wratten & Wainwright, or Sanger Shepherd & Co. The advanced worker will do well to consult the *Atlas of Absorption Spectra*, lately completed by Dr. Mees and S. H. Wratten. Merely for the sake of example we will give filter dyes suitable for plates sensitised in pinachrome.

Blue

Methylene ($\frac{1}{2}$ per cent. solution)	50 min.
Water	50 ,,

Green

Methylene ($\frac{1}{2}$ per cent. solution)	30 min.
Auramine G. ,, ,, ,, ...	180 ,,

Orange

Erythrosine ($\frac{1}{2}$ per cent. solution)	35 min.
Metanile Yellow (sat. solution) at 60° Fahr. . .	40 ,,

and these solutions may be adapted for liquid filters, dry filters, or for staining the plates themselves.

But the question of filters is scarcely one on which it is wise to dogmatise. Three different classes of filters are in common use for colour work, and all seem, in the hands of skilful operators, to produce excellent work:

(1) Filters that divide the spectrum into three bands, from some point in the red to D, from D to F, and from F to H, forming three zones without overlap or gaps.

(2) Filters forming three zones, which considerably overlap each other.

(3) Filters whose zones contain gaps or lacunæ.

The first system is the older one and might almost be called the orthodox method, but the second has very strong support and is rapidly gaining favour.

Exposures for Landscape.—The ordinary landscape dark slides are unsuitable for three-colour work, owing to the impossibility of securing exact registration of the three negatives. No two dark slides can be depended upon to hold the plates in precisely the same relative position. During the withdrawal and replacement of a slide the camera is certain to shift, and, however slight this movement, it will destroy any hope of getting the negatives to correspond. A "repeating back" must be employed comprising three screens of the proper colours, which fit on to a dark slide containing one long, narrow plate, on which the three exposures are successively taken, a spring catch denoting when each third of a plate is in position. There are difficulties in gauging the relative exposures for the three screens, which may vary from 4 : 2 : 1 to 3 : 2 : 1½ according to the type of plate and the intensity of light. One great difficulty about these three exposures in the open air is that, owing to atmospheric changes, the light may vary in quality. If one plate is taken in clouded weather and the next in sunshine, the results will be inharmonious. The exposures must also be such that plates of corresponding density are obtained; and they must be accurate within 2 per cent.

By the way, the student may be interested in knowing that Herr Stenger has worked out the relative exposures with ordinary non-colour-sensitised plates, using, of course, the proper filters. They are, blue 1, green 750, red 9,000. The ultimate results are, he contends, exactly similar to those obtainable on panchromatic plates.

One-Exposure Cameras.—Obviously, a system which will give all these exposures simultaneously is to be preferred. But the triple-lens system, as hitherto applied, is unsuitable for the photography of near objects. The images from the three lenses side by side will each represent an image, varying only slightly, perhaps, yet sufficiently to make coincidence impossible with regard to any object nearer than one hundred times the focal length. Herein comes the advantage of the Sanger Shepherd one-lens, one-exposure camera, in which, by means of prisms, the three exposures are given at one time, and relatively through each screen. Only two sizes are at present to be obtained to give negatives $2\frac{3}{8} \times 2$in., and about lantern size; but, of course, it is easy to make enlarged negatives from these on ordinary slow plates. The method relieves the operator from all anxiety, as there is not the slightest danger of varying exposure, or of the register being lost by any movement of the camera before the three negatives have been secured.

Development is not a very serious matter, if care be taken not to work too near the source of light, and to use a movable cover (a cardboard-box lid will do) for the developing dish. The plate becomes less sensitive as development proceeds; great density should be avoided, and evenness of development is important.

Lantern Slides.—According to the older fashion, three transparencies in black and white were made from the three negatives, and projected by a triple lantern through red, green and violet glasses. This system is now replaced by the printing of three coloured positives on thin celluloid; and when these are bound together, and projected through the ordinary lantern, they should reproduce with fair accuracy all the colours of the original. Lantern slides projected by either method, when carefully executed, far surpass in brilliancy anything hitherto effected by means of the screen plates.

Printing on Paper.—One important difference must be noted, however, between illuminating transparencies through coloured glasses and colouring the actual positives. A photograph is a record, not of lights, but of shadows. We must therefore employ in printing, not the colours through which the original negatives were taken, but those which are as nearly as possible complementary to them. The complementary colour to the blue-violet is yellow, to green pink, and to red a blue with a very slight tinge of green in it. And it is these colours which we must have recourse to, whether for the Sanger Shepherd slides, or for prints in carbon or gum-bichromate from three-colour negatives.

Reproduction of Screen Colour Plates.—In the studio, where the light sources are under control, and the studio or process cameras provide for exact registrations, most of the difficulties of the landscape artist in producing three-colour negatives are non-existent. A new field has been opened by the advent of the Autochrome, Thames, and similar plates, which require translation into three-colour negatives for reproduction on paper. In practice there is a certain amount of difficulty, owing to the nature of the image, wherein the three synthetic colours lie side by side, instead of being blended into homogeneous masses of colour as in nature, each colour occupying a comparatively small portion of the total area of the plate. A photographic negative, therefore, from either colour, also only occupies a portion of the plate, the intermingled portions, which theoretically should be quite transparent, representing the areas occupied by the other colours.

Mr. Howard Farmer, the well-known Principal of the Polytechnic School of Photography, has explained how this trouble is overcome in his very successful reproductions. The secret consists in imparting to the image just sufficient an amount of diffusion to cause a spreading of the silver deposits on the negatives so that they fill these intermingled spaces. The screen plate is in itself a composition of grained and mottled texture, and will therefore bear without loss of visual definition such devices as the diffusing glass, vibratory motion, irradiation or intentional diffusion of focus. Success will depend upon practice, as the diffusion of the image must be sufficient to fill in the spaces, or the mottled effect will be rather worse than when the film is sharply focussed.

CHAPTER XLI

THE LIPPMANN PROCESS IN PRACTICE

In the present state of the screen colour process, it is hardly advisable for us to give practical directions. Improvements are introduced almost daily, and the directions issued by the manufacturers of the various plates are so complete, that any supplementary advice on our part would be unnecessary. The method of interference colour photography has more than a passing interest to the student, and it has very recently been brought within the reach of the ordinary worker, who would otherwise have been barred by the difficulties of making grainless plates.

The following emulsion is suggested by Mr. Edgar Senior:

A.	Gelatine	75 gr.
	Potassium Bromide	32 "
	Distilled Water	8 oz.
B.	Gelatine	75 gr.
	Silver Nitrate	45 "
	Distilled Water	8 oz.

Soak the gelatine and dissolve in water, raise the whole, when the salts are added, to a temperature of 95° Fahr., mix the two at this temperature, filter through finest silk or muslin, and coat the plates immediately; after cooling they must be washed for about half an hour. Clean plate glass of good quality must be used, and the emulsion must not be left after filtration, or it will ripen and acquire a grain. The plates must then be panchromatised with the usual dyes. Such plates require a somewhat long exposure, unless they are flooded with an alcoholic solution of aceto-nitrate of silver just before use. However, Messrs. Carl Zeiss, who have been mainly instrumental in reviving the Lippmann process, have arranged for a ready-prepared plate to be placed on the market.

Exposure.—The plate may be handled quite safely in red light. It is transparent, and some difficulty may be experienced in discovering which is the coated side, especially as it must not be touched by the hand, finger marks, and even the minute scratches of a cloth or brush, showing on the finished positive. A special dark slide is employed, into which the plate is introduced, with its coated side away from the lens, screwed into position with a rubber marginal fitting, and the mercury backing is then poured in through a patent filler. After exposure, the mercury is extracted and poured back into the bottle, by the aid of the same apparatus which served to fill the space at the back of the slide. Exposure is necessarily long—at least, one to two minutes in bright sunshine at $f/4{\cdot}5$; especially as the yellow correction filter is essential.

Development.—Before developing, brush the plate well with a soft-camel hair brush, to remove any minute globules of mercury. Any good standard developer, diluted, will serve the purpose, but amidol is generally preferred.

Amidol	2 gr.
Sodium Sulphite	20 ,,
Water	1 oz.

Messrs. Zeiss recommend a very much weaker solution—about $\frac{1}{4}$ grain amidol to the ounce of water—above all if intense contrasts are present. It is very important to guard against any pronounced density, and development ought to be complete for the purpose within two or three minutes, when the plate may be rinsed and fixed for $1\frac{1}{2}$ minutes in a 15 per cent. solution of hypo. If left long in this the delicate silver deposit would be attacked. Wash well in running water to remove all traces of hypo, and bleach the image in

Mercury Chloride	6 gr.
Water	7 oz.

after which, redevelop in the amidol developer as before. This completes the preparation of the plate, which may now be washed for five minutes and set up to dry.

Pyro is not an unsuitable developer, provided that a sufficiently intense illumination has been given for the mixed colours, and is specially recommended for photographic spectra.

Viewing the Colours.—When the plate is dry, its appearance will be somewhat disappointing to those who expect to get vivid colouring. As a transparency the pictures show merely a uniform dark-brown colour, but a certain amount of colour is visible by reflected light, albeit far from being correct. Prof. C. Wiener has explained this defect as due to the light, reflected from the outer surface of the film, coming into conflict with the coloured rays from the internal strata. These effects may be minimised by placing the film in intimate contact with a wedge-shaped layer of some substance possessing approximately the same refractive properties. Prof. Wiener found the simplest means to be a narrow glass trough filled with benzole. The picture to be viewed is placed in this trough in a slanting position, the bottom of the trough being sloped to one side so that each plate set in it will automatically take up the proper angle. Such an apparatus is, no doubt, most suitable for testing the colour qualities of a plate, but rather troublesome for the amateur. A method long in favour is to cement a prism of low angle, or wedge-shaped glass, upon the film by means of thick Canada balsam, and then blacking the whole rim and back of the plate with dead black varnish, afterwards protected with paper. The prisms need not be optically worked, and therefore are not expensive.

The pictures are most easily seen in a room lighted by one window rather high above the ground, and the particular angle most suitable for observing the colours must be found by practice. Several instruments, after the nature of the closed stereoscope, have been recently devised, as well as a contrivance for fitting on the ordinary magic lantern for the optical projection of Lippmann slides.

No doubt, many of the earlier so-called solutions of the colour problem, particularly the exhibits of Poitevin and Vidal, were really due to interference phenomena. About twenty years ago, Messrs. Townson & Mercer introduced an albumen paper with a blue ground, which gave most suggestive and pleasing tints under orthochromatic negatives. Unfortunately, before we had time to submit it to any exhaustive tests, the paper was withdrawn from sale. A few days ago, a friend showed us a delightful print of an apple tree in bloom. The tints were not very pronounced, but were soft and delicate, as became the subject. We were informed that it was printed from an ordinary negative on an emulsion coated on silvered paper. Apparently, a little white matter, either starch or barium sulphate, had been added to give the required degree of opacity in the high lights.

CHAPTER XLII

THE COLOUR SALT

If we trace back the origin of almost any great discovery or invention, we find that it was heralded by a whole series of "dreamers of dreams." With the dream came the irresistible impulse to set to work and make it a reality. Each would-be discoverer is like to a man groping across a trackless desert, guided only by the bones of those who have fallen by the way. His dream may prove but a will-o'-the-wisp, a "Belle dame sans merci," leading only to failure and disappointment. Or he may eventually stumble on to a great success, and then the world will call his vision "foresight and enterprise."

The story of photography itself begins with its generations of dreamers, who convinced themselves that there must be some means of recording permanently the pictures shown in the camera obscura. Thirty years after Thomas Wedgwood had commenced his vain experiments, Daguerre was threatened with imprisonment in an asylum for the ridiculous conceit; then came the lucky accident of an upset mercury bottle, and the escaping vapours developed the first Daguerrotype. It would be rash to prophesy that any such happy chance is destined to reward the seekers after the colour salt, or method of sensitising plates that will chemically reproduce the colours of nature. It is irrational to regard the goal as being hopeless of attainment, as was the Philosopher's Stone or the Elixir of Life, elusive though it has hitherto shown itself. The arguments in its favour are, at least, plausible, and the facts already known point to something more than mere coincidences.

Analogies in Nature.—Certain animals and insects have the property of assuming, very rapidly, the colours reflected by their immediate surroundings. The case of the chameleon is well known; also the caterpillars of sensitive skin, that are bright green when feeding on cabbage leaves, but become bright yellow when transferred to a sunflower in bloom, or dull brown on a dead leaf. All the fauna of the Arctic regions take on a pure white coat during the months when the ground is covered with snow. The flatfish, white in colour below, has an upper surface exactly imitating the hues of the sea bottom which he frequents. Some of these phenomena will admit of ordinary physical explanations; others seem to point to the existence of a colour-sensitive secretion.

Allotropic Forms of Silver.—Just a century ago Seebeck discovered that chloride of silver, when exposed to the action of light, partook of slight variations of colour, according to the particular rays of light to which it was exposed. Thus violet rays produced a brown substance, and blue rays a species of blue, while, during its transformation under white light, it frequently passed through the stages of yellow and red. Later on, after the advent of the photographic process, M. Bequerel succeeded in securing definite but fleeting bands of colour on a plate of silver, prepared by immersion in dilute hydrochloric acid in connection with an electric current.

Niepce de St. Victor.—Between 1851 and 1867 this famous experimenter—a nephew of the great Niepce, the colleague of Daguerre—devoted considerable attention to the phenomena of colour photography, and finally came to the conclusion that chloride of silver was actually the colour salt. At the Paris Exhibition he showed numerous specimens of photographs in colour. According to eye-witnesses the colours were exact and life-like. Flowers, stained-glass windows, and brightly dressed dolls were portrayed in a manner to satisfy the most exacting critics. Unfortunately the colours disappeared as soon as any ordinary fixing agent was applied; and even as shown in a dark box, somewhat similar to the old-fashioned stereoscope, they faded away within a week. Niepce prepared them by treating silver plates with a solution of ferrous and cupric chlorides, afterwards coating them with dextrine containing lead chloride. It is not possible for us, from the data given, to decide how far the colour was produced by chemical means, or whether these plates were a foretaste of the interference process, since perfected by Prof. Lippmann. A quasi-colour process was afterwards devised by Niepce & Kopp, developing the colours one by one with the aid of various chemicals; the finished portion being protected by varnish, while the remaining colours were subjected to fresh treatment in order to develop them.

In 1866 Wharton Simpson treated collodio-chloride of silver on an opal plate with excess of nitric acid, and then dried it before a fire till it became lavender grey. He succeeded in getting black, orange, ruby, and magenta correctly.

The Red Photo-Chloride.—With the investigations of Carey Lea a much more hopeful stage seemed to have been reached. His instructions for the preparation of photo-chloride run somewhat as follows: In a 4 oz. bottle, dissolve 40 gr. silver nitrate in an ounce of distilled water, and add sufficient hydrochloric acid to precipitate silver. Shake up well, to agglomerate the particles of the precipitate, and then pour off water, not worrying about losing a grain or two of the precipitate in the process. The precipitate is then washed three times in succession with distilled water. The next step is to fill the bottle one-third full of water and add strong ammonia till precipitate redissolves, when 60 gr. of proto-sulphate of iron, in just sufficient water to dissolve it, must be added. A black precipitate will be produced, which must be allowed to settle, and is then washed in succession with dilute sulphuric acid, dilute nitric acid, and lastly with water. If these operations have been correctly performed the result will be pink or red chloride of silver, producing with fair accuracy many of the colours of the spectrum. That is to say, that when exposed to red light it remains red, under blue light it turns blue, and violet light changes it to violet. But alas! it is useless for practical photographic purposes because, when exposed to high lights, instead of bleaching it becomes black! Carey Lea was convinced that there was a great future for his red photo-chloride; by the addition of lead and zinc chlorides a certain amount of bleaching took place in the high lights, while sodium salicylate increased its sensitivity threefold. But ill-health prematurely put an end to his experiments.

Gelatino-chloride Emulsions.—We have not advanced very far on the road since the death of Mr. Carey Lea, but a renewed interest in the matter has arisen with the introduction of chloride of silver developing emulsions for plates and papers. The range of colours obtainable simply by varying the exposure, seems to constitute a new link in the chain of evidence pointing to the photo salt. By employing a dilute developer, such as rodinal 1 in 80, or glycin, especially with Gravura, Rotox, and Gevaert gaslight papers, we can obtain a succession of colours embracing a great part of the spectrum. Thus, if a short exposure give us a dark blue, the following are all possible :

Relative Exposure	Colour
2	Olive green
3	Sepia
5	Red
6	Reddish-brown
10	Orange
15	Yellow

By varying the constituents and strength of the developer as well as length of exposure, a very much richer range of intense colours may be secured. But this would not help us very much. The object should be rather to decide what developer, and at what strength, has most considerable range.

Acetone sulphite is said to have useful properties when added to such developers as hydrokinone and edinol. It will be observed that the last colour reached by prolonged exposure is yellow, and that yellow rays predominate in the source of light employed for gaslight exposures. The result of exposures under slips of different-coloured glasses is encouraging, in view of the slowness of the emulsion, and the fact that it is not chemically affected to any great extent, except by the violet and blue-violet rays. Lüppo-Cramer has proved that, by the acid-boiling process and ripening, a fine-grain chloride emulsion may be manufactured, which will compare for sensitivity with usual bromide emulsions. We have also the enormous advantage over the chemists of the last generation, that with the aid of suitable dyes we may render silver chloride much more responsive to the longer vibrations of light at the red end of the spectrum.

But, is it necessary to employ the colour salt in making the negative? In an ortho-chromatic negative, and still more in a negative made by the Thames Plate separate method, the wave-lengths of the spectrum are correctly represented by gradations which the colour salt should once more translate into their proper colours on the positive. This our experiments have shown to be within the limits of possibility.

It recently occurred to us to expose a sheet of glossy Gravura paper to daylight under a landscape negative having strong gradations. Printing out was necessarily a work of time, and in the long run nothing was gained by nitrating the paper. Gradually, a very beautiful and very vivid series of colours unfolded themselves to the eye. True, they were not the exact colours of nature, but at certain stages of printing the combinations of tints were far from unpleasing. The following shows the results obtained by repeated experiments:

Short Exposure: Soft tones, yellow; hard tones, pink; shadows, blue.

Prolonged Exposure: Soft tones, pink; hard tones, blue; shadows, green.

Very long Exposure: High lights, pink; soft tones, blue; hard tones, green; shadows, brown.

To ensure deep printing the paper was dipped in the following solution, and dried on a ferrotype plate, before printing:

Sodium Salicylate	10 gr.
Potassium Bichromate (10 per cent. solution) . .	5 min
Water	4 oz.

Fixed for 30 sec. in the ordinary hypo bath, the colours completely changed; but returned on exposure to light after washing as: soft tones, pink; hard tones, blue; and shadows, green. Rapid fixing in ammonium sulphocyanide 10 per cent. solution gave slight variations of colour. The general result seemed to prove that the colour was dependent upon the thickness of the deposit of allotropic silver. Only occasional batches of the paper (Gravura No. 1) possess this property of printing out in brilliant colour. But, possibly it is shared by some other gaslight papers with which we are less well acquainted. We imagine it to depend on a slight ripening of the emulsion grain. These experiments are worth comparing with the exhaustive researches made by Mr. Chapman Jones into the effect of grain on the colour of the silver image. Toning improves the colour.

We have arrived then at one important principle, viz. that the colour of the silver image will, under certain given conditions, follow a definite rule. According to the fineness of the metal deposited in this particular allotropic state, the colours will be in order, yellow, pink, blue, green, brown; and some experiments with denitrated P.O.P. lead us to believe that with much thicker deposits of silver there is another ascending series also giving the same order—yellow, red, blue. Needless to say that, except for very brilliant autumn foliage, these tints do not correspond at all with the gradations of the ordinary negative. Whether they can be corrected by an admixture of the various sensitive silver salts is a question which only the experiments of a number of skilled chemists can determine.

Rough and steep is the path of progress; slow the march towards the perfection of an ideal. This brief summary of what has been accomplished during a hundred years warns us not to be optimistic. Much circumstantial evidence has been gathered together, but the real solution of our difficulties may yet be afar off. We can only endorse as still true words written nearly forty years ago, by a contemporary of Niepce de St. Victor: "Though but a very short portion of the road towards the great end has been opened up, still it would be wrong to despise what has been done, or to regard the final solution as an altogether Utopian or chimerical problem." Somehow or other, it is a law of nature that, wherever a strong enough demand exists, a means of supply will ultimately be found; and, with so many minds engaged on the search, we may look forward hopefully, with the faith which is the evidence of things yet to be seen.

CHAPTER XLIII

ANIMATED PHOTOGRAPHY

WE have already commented upon the difficulties of the instantaneous shutter as a means of representing rapidly moving objects, in that the results do not usually convey more than the idea of suddenly arrested motion. A snapshot of a stage in the Derby contest fails utterly in comparison with the old racing print. The former can include only one particular set of muscular contractions, while the latter conventionally represents the successive series of movements involved when horse and rider are straining their utmost to be first at the winning post. And the very perfection of the modern multispeed or focal plane shutter, by its sharp delineation of detail, is an element in destroying the artistic effect.

In short, the great fault of the snapshot instantaneous photograph is that it gives us a faithful record of say $\frac{1}{500}$ sec., whereas the event, witnessed by the observers as one continuous whole, occupied several seconds before it was completed. A single snapshot is but a small fraction of the story. But if we can take a sufficient number of these snapshots at short intervals, and then present them one by one to the spectators, a fair impression can be conveyed of what actually took place. The cinematograph does more than this. It causes the series of records to blend into what is apparently one photograph, in which the characters move and perform their parts at approximately the same rate, and in the same manner, as in real life.

The Optical System.—We need not dwell at great length on the mechanism of the cinematograph machine, which serves to project the pictures on the screen. The strip of film containing these pictures is drawn past the lens system of the projection lantern by a series of jerks, moving exactly one picture's length with each jerk. In the old Zoetrope, or "wheel of life," of our childhood, the pictures were viewed through a black cylinder pierced with slits at intervals: in the cinematograph a revolving shutter cuts off the light during the change of pictures, and so performs the same office as the perforated cylinder.

Persistence of Vision.—It is this well-known phenomenon that renders the "living pictures" possible. An image once formed on the retina of the eye is, so to speak, photographed there for the time being. Years ago this was demonstrated in the advertisements of a famous soap; we were invited to gaze for a few seconds at the huge red letters on the hoarding, and then to turn our eyes upwards to the sky, when it seemed as if the letters were printed there. The image remains on the retina for a length of time, ranging from $\frac{1}{8}$ to $\frac{1}{30}$ sec. So that if the pictures succeed each other at the rate of fifteen or twenty to the second, and the changing process occupies only a small fraction of the time, say $\frac{1}{8}$ of the space of time during which each picture is visible, the successive pictures will be seen blended into one. Were they to be drawn at a continuous rate without the intervention of a shutter, the effect would be a mere blurring.

The Camera.—A similar piece of mechanism must be included in the instrument used for producing the pictures, so that each photograph may be taken, and the film jerked on for the next exposure in exactly the same way as it will afterwards be projected upon the screen. Otherwise, the camera might be described as of box form, fixed focus, magazine pattern, containing two or more film slides, which may each hold from 180 to 600 feet of film, and may be changed in daylight for others as required. A great stimulus has been given to the manufacture of lenses of very large aperture for the purposes of the cinematograph, working at from $f/3{\cdot}5$ to $f/5{\cdot}4$, and with a very short focus, so that pictures are often taken successfully when the atmospheric conditions are far from happy. The shutter is usually of the fan focal plane variety, adjustable to different widths of slit, and some makers claim for their shutters that they will give, when necessary, exposures as short as $\frac{1}{5000}$ sec. Most instruments are sighted by means of the view-finder. However, a recently introduced camera is fitted with the reflex system for focussing the image.

The camera is generally sent out to meet the needs of professional operators, with a lens of the shortest possible focus. Whenever the light is good, and other circumstances will allow of it, we always prefer a long-focus lens, say 5 or 6 in., and whenever a film taken under such conditions is shown on the screen, the greatly improved perspective and truthful representation of real life is very noticeable. Set pictures can nearly always be arranged so that the actors shall keep within the narrower angle included by the long-focus lens. In choosing a cinematograph camera, a pattern should be preferred which will readily permit of interchanging lenses of varying foci ; also one in which the film boxes are conveniently placed. Another good point is a method of automatically marking off on the film any change of subject, or a place where the film can be divided if too long for development at full length. Most good instruments allow of the film being drawn backwards as well as forwards in the production of "Trick films."

Anybody with experience in hand-camera work can soon become familiar with the requirements of the cinematograph picture-producer. The only serious difficulty he will encounter is in turning the handle which actuates the changing mechanism at a uniform speed, and without any jerks or abrupt stoppages. Much practice at home with an empty camera is advisable, keeping an eye on the indicator dial, and timing it with a watch, till one unconsciously acquires a rhythmical motion of 15 to 25 pictures a second. The so-called "Trick films" are produced at a much slower rate, enabling the actors to perform feats which, when the film is run rapidly through the projection lantern, appear absolutely magical or ridiculous, as the case may be.

The Film.—The length of film may be anything from 80 to 500 ft. In width it is about $1\frac{3}{8}$ in., taking pictures each $1 \times \frac{5}{8}$ in., and about 16 pictures on each foot of film. At the usual rate of exposure 50 ft. of film pass through the camera in a minute, producing about 800 pictures. It is generally possible to break up events into separate episodes of about 125 to 150 ft. each, but nearly all cameras will run for 500 ft. without a break; and one or two have a capacity for over 1,000, or in other words, a twenty-minute story!

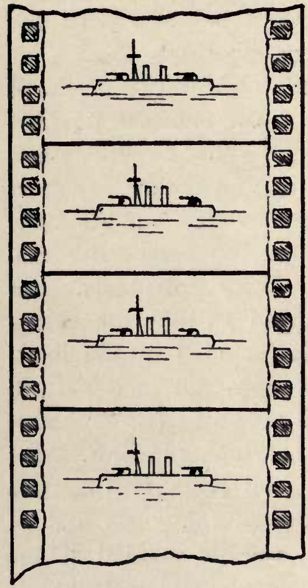


FIG. 72.—CINEMATOGRAPH FILM.

Development.—We are often asked by a kodak-user, conscious of how unmanageable a quarter-plate film of twelve exposures can become in the dark room when wet: "How on earth can you develop a hundred and fifty feet of film? You tell us *you* have done it in an extemporised dark room in a guard's van, on the journey between Liverpool and Euston." And yet, given the proper appliances, the task is very simple. Once upon a time we used to wind the film round a large wooden drum which revolved above the developing dish. The bother of this was that the developer was exposed so much to the air that its oxidisation produced stains, unless one was very careful. Development was somewhat uneven, and it was necessary to work by a rather dim light. Then came the pin frame, which can be best understood by the diagram. It consists of a kind of cross frame or wheel, of wood or metal, the spokes of which are studded with a large number of pegs. The one we use is

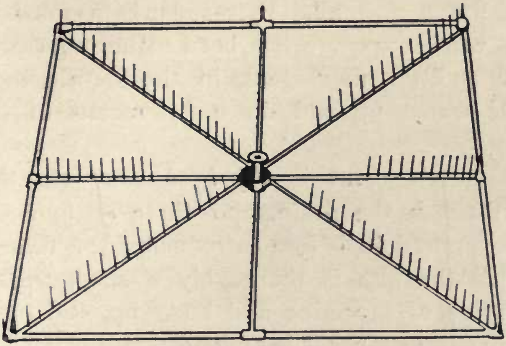


FIG. 73.—THE PIN FRAME.

two feet square and takes with ease 160 feet of film, wound carefully round the pegs sensitive side outwards, beginning at the centre. Our actual procedure is as follows: First

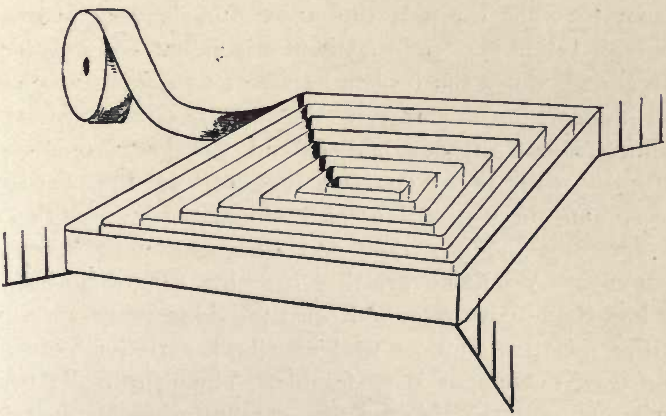


FIG. 74.—A FILM WOUND ON THE PIN FRAME.

we cut off two or three inches at one end, as a test with the developer, to see if the exposure is under or over the normal. According to the result of this preliminary test the constituents of the developer must be modified. We then make up a time developer (usually pyro or glycin) in quantity sufficient to fill a stoneware sink twenty-six inches square inside to a depth of about three inches, and immerse the film, frame and all. Pyro-soda is a good developer, especially when exposure has been rather short. It is well to create a little movement in the developing solution, lifting the frame up and down by means of the central handle.

When development is adjudged complete the sink is emptied through the drain, and three or four changes of water are poured in before introducing the fixing solution, after which the film is thoroughly washed, treated with a weak solution of glycerine and hung up, still on its frame, to dry. In hot weather it is of course necessary to commence operations with a moment or two immersion in formaline, one ounce to the pint.

Printing.—Many cameras are claimed by their makers to be available for printing the positive film by contact, but the danger of one film creeping upon the other, as they are drawn together through the apparatus, is very great. If the registration is once lost, the film is valueless for projection purposes, because the broken halves of two adjacent pictures will appear on the screen, the upper one showing legs walking about without bodies, and the lower one ending abruptly with the characters cut off at the waistband. Everything in connection with cinematograph work must be carefully thought out, and executed with scrupulous accuracy. A reliable printing machine cannot be obtained for less than about £35, and must provide against shrinkages in the negative film as well as slight variations of width. The claw movement is preferable. The printing is usually performed with the aid of a fifty-candle-power filament lamp printing from five to ten pictures a second. Development of the positive film follows the same rules as those described for the preparation of the negative. Only, it must be remembered that the positive film is a kind of continuous lantern slide, and therefore a brilliant, plucky effect must be the aim in development—plenty of detail without great density or fog. Each of these little inch pictures may have to cover a screen of twenty or thirty feet, and therefore must allow of an enormous amount of light passing through them.

Perforating.—In the projection lantern the films are kept in due registration by passing over cylinders studded with little cogs or pegs which fit into perforations in the margin of the film and secure regular and even motion without slipping. Films are nearly always perforated by a special machine to the Edison gauge of four perforations to each picture. They may be bought ready perforated before exposure, but for commercial purposes are perforated by the photographer, in order to make sure that his system corresponds throughout with the machines in use. Variations in gauge are a great trouble to the cinematograph lanternist and are frequently due to slight shrinkage of film which has been perforated before development.

Perforation is also of great assistance in securing exact registration when two lengths of films have to be joined together—which is easily done by means of thin strips of celluloid moistened with acetone—or when introducing the black bands during which ordinary title slides are being projected on the screen. But titles are nearly always printed as part of the film itself.

Cinematography in Colours.—Most of the coloured films hitherto shown have been tinted by hand—and not badly when it is considered that the artist has such a tiny picture to work upon, and the laborious task of dealing with some thousands of pictures, in which the same tints have to be repeated *ad infinitum*. Some are machine-coloured by a clever contrivance. But the real colour film has arrived. A special shutter is provided with two ray filters, orange-red and blue-green, one for each alternate exposure; and a similar shutter is used for the projecting lantern. The eye seems capable of imagining for itself the complementary colour. The film has to be very highly sensitised, as well as panchromatic, because the pictures must generally be produced, considering the two filters, much faster than the ordinary ones—at least twenty-five to the second. However, one of the most exquisite achievements in colour effects is a film showing a bed of tulips just ready to bloom. The exposures were taken at intervals of a quarter of an hour. Those who have had the pleasure of seeing this film at the cinematograph entertainment when, as if at the bidding of some fairy, the trembling leaves draw further apart, the stalks waver and the buds burst open one by one, to display their richly hued wealth of petals, must agree with us that it is most delightful and beautiful.

The Opening for the Amateur.—In this country alone there are no less than 5,000 cinematograph theatres, besides travelling entertainers and educational establishments where the moving film has been adopted. New films are always in request, and for a really popular one the Continental and American rights fetch a considerable sum. Here is a chance for any one of artistic talent. The commercial films are far from good. In many places, especially in the country, it is easy to get together a number of characters and construct little amusing comedies which will be worthy of reproduction. Episodes of this kind and pastoral plays are the best field, leaving pageants and public events to the professional photographer, with whom it is unwise to attempt competition. A good camera and developing outfit is the only necessary outlay. When a good negative film is secured, the best plan is to send it to one of the leading firms, who will undertake the printing, and probably make an offer for the copyright.

The Founders of Cinematography.—In 1877, Muybridge of California took a large number of photographs of a trotting horse by employing a series of separate cameras arranged side by side, and illustrated his lectures on the subject by projection through a lantern. Anschutz, in Prussia, invented a camera wherein successive images were impressed on a rapidly moving plate, and revived the Zoetrope in an improved form, for the display of these movements. At about the same time, Mr. W. Friese-Greene took out the first patent for a machine, using a continuous celluloid film as the support for the series of moving negatives, and he must therefore be regarded as the father of Animated Photography in the modern sense. The Edison Kinetoscope appeared in 1891. In April 1895 Messrs. Lumière, in Paris, and Mr. Birt Acres, in London, almost simultaneously arrived at a practical machine. Mr. Acres photographed the University Boat Race in that year. Other names to be remembered are Varley, Paul, and Maskelyne. The progress of the cinematograph, like that of all notable developments, is strewn with the wreckage of many ingenious but unhappy inventors. For the last ten years the records of the Patent Office show an average of two or three applications in each week, most of which have found oblivion at an early stage in their career.

Many of the commercial machines are capable of producing pictures at a very high speed, subject only to the adjustment of the shutter slit, and the provision of a driving power capable of imparting a uniform rate of motion. Machines for special scientific purposes have been devised, of extraordinary capacity, such as that by Dr. Cranz, of Berlin, which will photograph the path of a bullet fired at a bladder of water hung on a string. The effect of this film when drawn through the optical lantern at the ordinary rate is very curious, as well as instructive. More significant still are the photo-micrographic films, showing the domestic proceedings of the animalculæ; and those illustrative of X-ray work, which latter we have not yet had an opportunity of seeing. Stereoscopic films are more a matter of expense than of any other difficulty, and altogether the applications of the cinematograph are each season becoming so various, that they are almost coterminous with photography itself. For one type of work alone we can say definitely the cinematograph film is ineligible—the hand camera. And the reason of this would be appreciated by the reader, if he had once witnessed the projection of a film prepared with the instrument held in the hand, and had experienced the hopeless giddy sensation while figures and buildings rock up and down, with an occasional desperate leap skyward followed by a plunge into the depths of the earth. One thing we must postulate for the animated-picture maker—a good, rigid, and reliable stand for the apparatus to rest upon.

The only modern handbook on the subject is by F. P. Liesegang, and at present there is no English translation.

CHAPTER XLIV

PHOTO-ENGRAVING, COLLOTYPE, ETC.

ALTHOUGH some of the methods of preparing photo transfers for lithography and zincography were known sixty years ago, it is only within the last quarter of a century that photography has gained acceptance as a means of reproducing illustrations for the printing press. Once recognised, it speedily conquered the whole field, to the exclusion of all rivals. In no other industry has the hand-craftsman been so completely displaced, and this from the sheer merit of the new processes rather than for economic reasons. Wood engravers of genius were few in number; artists as well as photographers got tired of seeing their productions travestied under the graving tool. More exact and conscientious expedients were bound to win their way.

Line Work.—Etchings, steel engravings, diagrams, and, in fact, any kind of black-and-white drawings, comprised entirely of lines, are very easy either to translate into a printing block, or to transfer on to the lithographic stone, by photographic means. Such drawings reproduce most clearly if executed in some perfectly black medium, such as process ink or ebony water stain. It facilitates matters if the paper is of pure white colour, and not too rough in grain, though pencil drawings on various patterns of hard stamped or grained paper reproduce as line work very effectively. The drawing is copied to the size required in the camera, with the reversing mirror if to be printed straight on to the zinc plate, exposure and development being so carried out as to produce a negative of great contrast. The wet-plate process or photo-mechanical plates are essential. All the lines of the original have to be represented in the negative by clear white glass on a dense black ground.

Printing on Zinc.—For the direct method, a zinc plate is carefully cleaned and polished with fine emery powder, finishing off with rouge and a bath of weak nitric acid, when it is ready for coating with the sensitive surface, which is to form the foundation of the acid resist. A machine called a whirler is usually employed for this purpose. The plate receives a pool of the liquid and is then whirled round at a great speed; meanwhile the material is spread homogeneously over it. Bichromated albumen is most commonly employed, though for the finest work sulphurised bitumen, dissolved in benzole, is still occasionally in use. After exposure under the negative, the unchanged albumen is washed off in water, leaving the image on the zinc for etching, a process outside the scope of this book. The bitumen image is developed either by turpentine or chloroform.

Transfers.—There are many ways of making phototransfers, analogous in character to the oil printing process. Sometimes a paper, coated with gelatine and sensitised in a bichromate bath, is exposed under the negative, subjected to a prolonged soaking, and then an image in oily transfer ink printed upon it with the aid of a gelatine ink roller. Other transfer papers consist of a gelatine substratum covered over with a layer of albumen. The transfer ink is thinned with turpentine, and distributed as smoothly as possible over the surface of the print. A quarter of an hour in a warm temperature allows the turpentine to evaporate, when the paper is floated on cold water for a time, and sponged with a soft sponge, or pledget of cotton wool dipped in water. This removes the superfluous ink with the albumen, leaving the lines of the image clear for transference to the lithographic stone or zinc, as the case may be. With this paper the sensitiser is also a bichromate salt.

Half-Tones.—When translating an ordinary photograph into a form suitable to meet the exigencies of the ordinary printing press, some mechanical device is required, corresponding to the various hatchings and cross-lines of the old-fashioned wood block. The metal surface must be so grained that the various gradations between the deep shadows and the high lights will be rendered in approximately their true value. For the lithographic stone we can use transfers, wherein, by introducing such chemicals as sodium chloride and potassium ferricyanide, a graining is imparted to the gelatine closely resembling the effect of lithographic chalk. Many attempts have been made to apply this principle to the typographic block, but without avail. The result invariably has been attended with smears and blurs; a grain of this nature is too rounded for the composition roller, and experimenters have therefore resorted to a screen of cross-lines through which the photograph or wash-drawing is copied in the camera. For the earliest screens fine netting was employed, after the manner of Fox Talbot's original method of photogravure; later on, indeed up to about ten years ago, the screens consisted of negatives obtained by photographing huge white cards engraved with a series of diagonal lines in one direction only. When the exposure was half completed the plates were reversed, so as to produce a crossline effect. Such screens were placed in contact with, and in front of, the plate used in photographing the original. In the blocks prepared in this manner, especially in ordinary commercial work, the pattern of the screen was generally very obtrusive, and the whole effect obviously mechanical.

The Crossline Screen.—The Levy screen, now almost universally used, consists of two sheets of crystal glass, ruled diagonally with black lines by a patent process and cemented together with Canada balsam. The ruling in different screens may vary in fineness, from 50 to 300 lines per inch, according to requirements, and the relation of black to white may be either as 1 : 1 or 5 : 4. Instead of being placed in contact with the sensitive plate, the screen is advanced a certain calculated distance in front of it, so that in place of the conspicuous pattern of the old-fashioned half-tone block, a series of dots appears of various sizes according to the gradations of the original. In practice, each aperture in the ruled screen acts as a pinhole lens, photographing a little picture, varying in shape and size according to the shape of the diaphragm aperture of the lens. A round aperture gives a round dot, a square aperture a square one, and so on. The object being to get several distinct kinds of dots, and especially to prevent vacant areas of transparency —above all in the high lights—the ordinary round lens-diaphragm is of little service, as compared with the square shape. Various shaped diaphragms are employed in practice, such as lozenge shape, with extended corners; or the Ray multiple diaphragms, pierced with three or more openings instead of one large opening, triangular, square, or round.

We have stated that the screens are ruled with varying degrees of fineness. Fifty lines to the inch is not too coarse for the daily newspaper tossed through the press at lightning speed, though some of the illustrated dailies print with 85, and even 100 line blocks in a very creditable manner. Fine blocks on art paper vary from 175 to 250, the former degree being sufficient for nearly all subjects. However, Mr. W. Gamble, the leading authority on photo-engraving, has produced blocks of still more delicate character, and is of opinion that, with the present high quality of letterpress printing, the 500 line block ought not to be regarded as an impossibility. In such blocks, the screen effect will have entirely disappeared, and the result be equivalent to the continuous tones of the silver print.

Half-tone Etching.—What has rendered this fine degree of tone possible on metal has been the substitution of the fish-glue film for bitumen or albumen as the acid resist. Sixteen parts of fish glue and six parts of pure albumen are dissolved in the equivalent of their bulk of water, and sensitised with ammonium bichromate. The exposure of the metal plate does not usually exceed two minutes in sunlight, after which the superfluous glue is washed away, and the film is heated almost to charring point, when it forms an excellent resist. Copper is now employed in place of zinc, and the biting-in process is either performed with perchloride of iron, or Dutch mordant—the latter a very weak solution of hydrochloric acid, with a little chlorate of potash.

Paynetype.—Constant improvements and variations are inevitable in the photo-engraving processes; one that is worthy of record is the direct process of Mr. Arthur Payne, which is known as Paynetype, and does away with the necessity of a negative. The metal plates are to be purchased ready for use, coated with a thin gelatino-bromide emulsion like ordinary dry plates, and are placed in the dark slide (behind the ruled screen if for half-tone work). After exposure the plate is developed in the dark room for $2\frac{1}{2}$ minutes with a glycin developer, rinsed under the tap, and then immersed in a 5 per cent. solution of potassium bichromate, which has the well-known effect of hardening the gelatine in the presence of the silver image. On the application of hot water the soluble gelatine is washed away, as with a carbon print, leaving the negative image on the plate. Reversal is either obtained by rolling up the plate with litho ink mixed with varnish, or by the electro-deposition of a thin copper film on those portions of the zinc plate that are not protected by the image, after which the etching process may proceed in the usual manner, and the whole manipulations, as described, need not occupy more than about 15 minutes, a consideration, especially in newspaper work, apart from the saving of expense. For line work, and for all half-tone work up to the 85 or 120 screen, Paynetype possesses many salient advantages, and will greatly simplify the reproduction of up-to-date photographs in the daily press. When a negative is available the block can be made even more rapidly, because, as a positive is obtained from the negative, there is no need for reversal, and the original image on the zinc will form the basis of the resist.

Photogravure.—The Talbot-Klic process, a modification of that originally devised by Fox-Talbot, is not a very intricate one for the amateur with leisure and a little mechanical skill. A very carefully cleaned copper plate, so finely polished that not even the minutest scratch is discernible, and cleaned from grease by immersion, first in a solution of caustic soda, and then in very dilute nitric acid, is, when dry, prepared to receive an etching grain. For this purpose a dusting box is required, such as engravers use. Any closely made box will do, provided it is more than twice as large in area as the copper plates to be etched, and has a narrow, hinged door, or flap, extending along the bottom of one side. About a pound of very finely ground bitumen and colophony is put into the box, and the door closed, when it is shaken vigorously and turned upside-down several times, until the atmosphere within is heavily charged with dust. Then the copper plate is inserted through the hinged flap, and the dust allowed to settle upon it for about five minutes.

The nature of the grain depends upon the subject to be etched. If a fine grain is wanted the box must be left for a minute or so before the plate is inserted; if this is done immediately the box comes to rest, coarser grains are obtained. Exact degrees of grain will be ascertained after a little experience; it can be examined, on removal from the box, under a reading glass. Next the plate is laid on a copper heater or hot plate, in order to cause the grain to adhere firmly on the plate; when a sort of bloom appears it will be a sign that a sufficient amount of heat has been applied, and the plate should be removed and allowed to dry. If left too long, the resin and bitumen will have melted and formed a solid coating on the plate; when this happens the whole must be cleaned off with benzole, and we must begin again.

The next proceeding is to secure a negative carbon of the subject, which is generally made from a positive transparency. Some workers can make the carbon negative direct by sensitising the tissue in a solution of ferric chloride rendered acid by the addition of citric acid; but this is far from easy, and the positive transparency is the quickest method in the end. If a light-coloured tissue is adopted, printing is visible. The usual "safe edge" will give us a black border, and if this is not desired, a resisting border may be secured by masking the tissue after printing with a card or piece of orange paper rather smaller than the transparency, and exposing once more to light for a short time.

Now, the carbon is transferred direct on to the copper plate and developed in the usual manner. All the soluble gelatine is thoroughly removed by a final washing in warm water, and the plate, with the clean negative image upon it, is allowed to dry, but not under heat sufficient to alter the character of the graining. Sometimes the plate is flooded with methylated spirit to facilitate drying, but it is better to allow it to dry by natural means. When dry, the back and edges are carefully protected with engraver's varnish, made by dissolving orange shellac in methylated spirit, and all is ready for etching.

The usual etching fluid is a solution of perchloride of iron in five varying strengths, prepared by boiling with distilled water, and then adding distilled water in five portions till they respectively register 45°, 40°, 37°, 33°, and 27° on a Beaumé hydrometer. In the first solution, which attacks only the deep shadows, the plate may remain one minute. Then this is poured away, and No. 2 solution substituted for two or three minutes; then No. 3 for three minutes, and so on. Meanwhile the progress of the etching may be watched by the decoloration of the metal, as it turns black under the action of the mordant. It is important that each bath should be poured away when it ceases to spread, and the higher lights will probably not be affected until the fifth bath has remained on for a minute or two. Within a minute of the darkening in the higher lights the last bath must be poured off and the plate dipped in a 5 per cent. solution of caustic potash or soda. Lastly, the carbon, varnish, and grain are cleared away with the aid of paraffin or turpentine, followed by hot water and soda; and then a final rinse in warm water before rubbing dry with a soft rag. Photogravure plates are, of course, of "intaglio" character, with the ink in the hollows, and therefore can only be printed in a copperplate press. A fuller account of various methods of photogravure will be found in the works on the subject, by Herbert Denison and Thomas Huson.

Woodburytype.—A very beautiful method of intaglio printing, invented by the late Mr. W. B. Woodbury, but now seldom adopted. Well-executed prints were often mistaken for silver prints, so soft and delicate were the gradations; but it was better suited for the old-fashioned wet-plate negatives, or for landscape negatives taken with a very small stop in the lens. A film of bichromated gelatine, on some homogeneous support, was exposed in the printing frame in the usual way, after which the superfluous gelatine was dissolved off in hot water, leaving the picture in relief. This relief was laid on a perfectly true steel plate, a sheet of lead placed upon it, and subjected to a pressure of at least four tons to the square inch of surface. An intaglio plate was left, forming a faithful copy of the relief, while, strange to say, the delicate gelatine was left uninjured and was capable of serving as the matrix for several more lead plates. A special liquid gelatine solution containing pigment was employed for the ink, and copies were obtained in a copperplate press with fair rapidity.

Collotype.—This is the most economical process for obtaining reproductions of photographs in printing inks, with the tones represented in the same gradations as in an ordinary silver print. So far as the process itself is concerned there are no great complications, but, in practice, better results are likely to be secured by a commercial firm, than by the ordinary photographer. Collotype is by far the best method for multiplication of postcards when the numbers required do not exceed a thousand or two, and the cost is not much greater than the ordinary "half-tone" block.

Negatives for Collotype must be reversed, unless they are on celluloid film. These films also are far preferable for the purpose, than those made on ordinary dry plates, the latter being far from flat, and therefore liable either to break under pressure or to give an imperfect image, from insufficiently close contact with the collotype plate.

Sheets of best plate glass, at least $\frac{3}{8}$ in. thick, are first ground truly level, and then coated with a sizing consisting of—

Stale Beer	10 parts
Syrupy Silicate of Soda	1 part

and dried in an oven at 120° Fahr., after which they are allowed to cool, rinsed under the tap, and left in a rack to drain. The sensitive film is composed as follows :

Hard Gelatine	3 oz.
Potassium Bichromate	300 gr.
Ammonia (strong)	10 min.
Water	15 oz.

The gelatine is soaked for an hour in the water, and then dissolved gradually under heat, after which the other ingredients are stirred in. Immediately before coating, about an ounce of methylated spirit is added for every ounce of gelatine solution about to be used, and the whole is strained through fine muslin. The glass plates must be scrupulously level and warm to the touch. Thirty to fifty minims may be allowed for every square inch of glass. After coating, the plate will dry in about a quarter of an hour in a drying oven, in which the temperature must not exceed 115°. The films will keep for about ten days if protected from moisture and light.

Previous to exposure in a pressure-frame it is usual to mask off the edges, either with tinfoil or black paper. Progress of exposure may be judged, either by means of an actinometer or by examination of the image through the glass at the back of the printing-frame. When complete, most workers advise that the plate should be laid face downwards on a piece of black paper, with the back exposed to the light, for a minute or two. This will harden the back of the film, and so insure its adherence to the glass during the subsequent operations.

Development takes place in several changes of water, until all the bichromate salt has been removed, when the film may be dried and put away in store for months, if necessary. When copies are to be taken, the collotype plate is soaked in cold water and then "etched" in a solution composed either of

Glycerine	20 parts
Water	20 ,,
Ammonia	1 part
Common Salt	1 ,,

Or of

Glycerine	1 part
Water	2 parts

With a few drops of oxgall.

After being allowed to act for about half an hour, by which time the film will have been thoroughly penetrated, the superfluous glycerine is dabbed off, the picture inked in with lithographic ink, and proofs taken on an Albion or other press. A lithographic machine is often adaptable for collotype, but an extra set of rollers and a mask-frame for the margins are essential; a special collotype machine is the best in the long run. Printing requires care and experience, and the plates have to be damped with fresh etching solutions after each 70 to 100 impressions, according to the quality of paper used. If the prints are glazed with white water varnish or a label varnish, and then dried in moderate heat, they will closely resemble ordinary P.O.P., or albumen paper, according to the colour of the varnish employed. Only a limited number of copies can be obtained from each film before it wears out.

The above may serve as an outline of collotype methods, but in the hands of individual firms the process has been brought to the very highest perfection. A simplified process for the use of amateurs, substituting gelatine ready coated on parchment sheets for the heavy glass plates, was introduced a few years ago. We have not heard any news about this lately. Collotype prints of good quality are worthy of all praise; inferior work is not remunerative, as it cannot compete with photo-lithography, produced at a quarter the trouble and expense.

Among the leading works on photo-engraving, etc., may be mentioned *The Half-tone Process*, by Julius Verfusser, and *Photo-Mechanical Processes*, by W. T. Wilkinson.

CHAPTER XLV

RETOUCHING

WAS there ever a time when the use of pencil or knife on the photographic negative was not protested against as bad taste and bad art? We cannot recollect any such epoch. The retoucher has always been an individual under a cloud, so to speak; and this is not altogether a matter to be wondered at. Professional photographers of the common type send their negatives in batches to a trade retoucher, who, in consideration of a fee by contract of perhaps threepence or fourpence each, works his sweet will upon them. From under his hand all emerge plump, blooming, and youthful, if somewhat characterless specimens of humanity. It is not to be denied that much retouching is bad in principle, and that a well-posed and lighted portrait ought not to need to undergo retouching at all.

On the other hand, we must concede that the average person who goes to have his photograph taken does so with the idea of securing a more or less flattering portrait. Nay more, he employs the photographer just because a really good oil-painting or etching by an accomplished artist is beyond his means. It is a well-understood convention that portraiture should be flattering: hence the necessity for a compromise between the camera and the hand artist. For the camera positively declines to stoop to flattery. The youth or maiden will often be content to take their picture printed direct from the untouched negative; the veteran of three-score-and-ten has no wish to see his wrinkles smoothed away; but what about the man or woman of forty? These it is that the camera so cruelly portrays, exaggerating the lines scarcely visible to the eye into deep furrows, showing up peculiarities of complexion as horrible disfigurements. The retoucher, it is true, looms less important than in the days of long exposure, when hardly any subject could avoid showing some signs of the torture undergone in the efforts to keep still. But we cannot altogether ignore him. All we can do is to keep him in his proper place.

The retoucher's work should consist chiefly in correcting obvious defects in the negative, contrasts between colour of dress and complexion, giving true emphasis to prominences which, owing to colour, are too dark and would appear to recede in the print, exaggeration of freckles and pock-marks, etc. Not that freckles and other complexion marks should be wholly removed, but that they should not be allowed to record themselves in the portrait as something much worse than the truth. Such judicious retouching cannot be condemned by sensible people. Of course, to be worthy of trust, the retoucher should acquire the knowledge that an artist acquires regarding the anatomy of the human figure, and, more important still, should not be expected to retouch the portrait of an individual whom he has never set eyes on. Yet this is what a thousand professional retouchers are expected to do every day; and it is just this that has brought the art into discredit.

Materials.—Let him who aspires to become a retoucher first satisfy himself that he possesses the requisite artistic sense, and also an eyesight strong enough to bear the very serious strain that the work involves. Next he must get a retouching desk. A good one consists of an easel, which can be inclined to any angle at pleasure, an upper frame to shut off all front and side light, and a set of carriers, or adjustable ledge, to take the negative. One good pattern, at least, is provided with a drawer underneath to take all tools. These latter consist chiefly of pencils of varying hardness (H, HB, and B to begin with), spotting brushes, retouching knife, sandpaper to sharpen pencils finely, retouching medium, and a silk rag to rub it in with. The best retouching medium is ordinary powdered resin dissolved in turpentine, 30 grains to the ounce of the latter. It improves with age, and fresh turpentine may be added to compensate for evaporation.

The Use of the Knife.—The few notes given in this chapter must be rather taken as suggestions than definite directions. Every retoucher must make his own methods, and, above all, decide whether such and such a device is legitimate art or whether he can apply it to advantage. Work, if possible, at a window with a north light; incline the desk to an angle which suits your own special convenience, though about 60° with the table is generally acceptable. Examine the negative carefully and decide, before varnishing, whether it is worth while to scrape any part away. For instance, some undesirable feature in the background may have escaped the operator's attention when he focussed the picture. Slight movement of the subject may sometimes be advantageously removed with the knife. Grayness or white patches on the upper part of the hair and over-prominence of the jaw or cheeks can often be scraped down. There are proper retouching knives, but a good sharp penknife will serve very well. Practise on old negatives before attempting anything important, but the work is not very difficult, and the thick deposit of silver lies near the surface of the film. Do not be in a hurry; tone down the heavy part slowly and cautiously. Work with the point of the knife as, for instance, when taking out the "fishyness" of blue eyes recorded on a non-orthochromatic plate, or reducing the width of fingers, demands the greatest precision and delicacy of touch.

Pencil Work.—Having satisfied yourself that all the scraping away advisable has been done, apply the medium, rubbing it on with a circular motion as finely as possible. Very little will give a surface for pencilling, if it is of the right consistency and "ripe." And now comes the difficult part of the work. With modern plates and modern lenses, the operator can convey so much that the foolhardy retoucher will destroy. Think twice before attempting the retouching of a human face. It is a question not only of lines, but of tone; not features merely, we may add, but of individual complexion. For when you commence with the pencil there is no turning back. Strengthen first the high lights before touching the shadows and half-tones, in order not to lose gradation of lighting. Each part of the face has one, and only one, bright light, and this must not be lost. When filling up obvious imperfections be careful that the modelling of the features is not altered by your additions.

As to manner of working with the pencil, let each man adopt the way that suits him best. Some adhere to cross-hatchings, after the manner of line etchers, others make little dots and short marks, while yet others prefer the round-and-round scribble. All arrive at the same end.

A few hints borrowed from Mr. Robert Johnson's work on artistic photography, published some twenty years ago, are still worth repeating. "Lines drawn in a certain direction, along or across any surface, lead the eye in that direction; a necklace round a lady's neck makes the neck look rounder; so with a bracelet on the arm. The lines across the chest of a soldier's tunic make his chest look broader; vertical lines on a lady's dress make her appear taller. So, if in retouching your work with a series of lines, they happen to print, let them be in such a direction that the surface they are upon is improved by them. For instance, do not make vertical marks on a cheek that is already thin; if the lines show in printing, the cheek will look thinner. Lines across a forehead are not objectionable, that is, if your work shows at all; even if it does not, it is as easy to handle the pencil so that there can be no possibility of its conveying a wrong impression. But above all, do not aim at giving all faces one common texture; such treatment is absurd. Try by your handling to reproduce the texture that is already there."

The Complexion.—Of course, the retoucher will have a good proof before him—not a haphazard one, but one so printed as to bring out all the qualities of the original negative. Twenty years ago the manufacture of plates was a different thing from what it is to-day. A good modern plate will often show the true texture of the skin; in the old times this department was part of the function of retouchers. Old people as well as children have often complexions of great beauty, only lined with years; and this is another reason why the photographs of the aged should rarely have any retouching. Freckles in children, too, are not a disfigurement unless they print out black; to retouch them out is to destroy the pure transparency of the skin. More difficult to deal with are those complexions of high colour in which the veins appear with too great prominence, or those in which freckles and skin-marks appear in the proof but are invisible to the eye upon the subject themselves.

Lines.—These also want thoughtful and delicate handling. We must discriminate between lines of character and those lines which are unduly accented by the lighting. Most lines have to be shortened and softened, especially in adults of a certain age. There is a line which appears on almost every face at about the age of twenty, running from the base of the nose to the corner of the mouth. The camera always exaggerates the depth and length of this line. Besides this, there are lines under the eyes and between the eyebrows needing attention. Lines across the forehead must be dealt with according to the character of the subject. The retoucher must feel that he is an artist, and that his duty is to illustrate the character of his subject in the best possible way.

In certain branches of commercial photography the retoucher will be called upon to perform miracles in the correction of the abnormal features of sitters. Humanity continues to be human, and is not likely to care whether a particular treatment is "legitimate" in the eyes of the advanced critic. The man with a crooked nose expects it straightened out in the proofs submitted to him; large mouths and thick lips must be judiciously mitigated. But in the better-class studio these devices are rarely made use of. It is the business of the operator to discover how, by proper lighting and posing, he can conceal, or at least disguise any abnormal qualities in his subject. And the greater the difficulties the greater the opportunity for the true artist to show his genius in surmounting them.

The best practical work for the higher education of the retoucher is undoubtedly Mr. George E. Brown's *Finishing the Negative.*

Enlargements.—Now that enlargements are so cheap we should much like to witness a reform which would displace the negative retoucher altogether in favour of the retoucher of enlargements. Here he would find a definite and legitimate scope for the exercise of his abilities, leaving the work of the operator alone to speak for itself. He might be allowed his own methods, soft pencil, black and white chalk, charcoal, and the very ingenious air brush. So effective an instrument is this latter that the cheap advertised "enlargements" are often prepared entirely with it, copying direct from the small print sent by the customer, without going through the form of taking a negative and enlarging in the camera. The aerograph is especially effective for colour work in the hands of a good artist. Given a rather chalky bromide of moderately coarse grain, with the shadows not too dark, some very beautiful colour pictures can be made with the aerograph. The print must be very well fixed and washed, or yellows may afterwards make themselves apparent. One special advantage of the aerograph is that it will distribute the tints so minutely over the surface. A very small number of pure colours is advisable, because mixture effects are obtained so easily by going over the parts again and again with the separate pigments. But as these matters concern the limner and the sciagrapher rather than the photographer, we must not occupy any further space in discussing them here.

CHAPTER XLVI

PHOTOGRAPHY BY THE X-RAYS

We do not feel called upon in this brief chapter to indulge in a philosophical treatise on the nature of the X-rays, nor even to describe very fully the apparatus by which they are produced. The details of these matters concern the electrician rather than the photographer. The latter is, however, often invited to assist in the purely photographic manipulations, and a few directions with regard to this department will therefore be of possible service to him.

Suffice it then to say that these rays are incidental to the passage of electricity at considerable electromotive force through highly rarified gases. Rays analogous in their properties are also emitted by certain radio-active minerals, such as some salts of uranium and thorium. The exposure, however, necessary to affect a photographic plate with these substances would occupy several hours, and the cost be a prohibitive one.

The primary source of electricity for a first-class X-ray installation should be an accumulator, a dynamo, or a bichromate battery which is capable of a continuous, unidirectional supply at high pressure, and the demands made upon it will be very considerable. The induction-coil must give at least a 3 in. spark, and a 5 in. or 6 in. coil will allow of the use of most ordinary tubes with moderately short exposures. A less inexpensive method is to employ a Holtz or Wimshurst machine, which will not require the coil. A 2 in. machine will produce the rays, while a 3 in. or 4 in. Wimshurst machine, with the usual Leyden jars and sparkregulator, needs only to be connected with the Crookes tube on a test-tube stand, by means of two spirals of fine copper wire. Full instructions how to make a Wimshurst machine of this capacity, with the various accessories, were given in the *Year Book of Photography* for 1902, by Mr. S. R. Bottone.

The Röntgen Ray Tubes.—A great variety of tubes is available, termed *soft* or *hard*, according to the amount of resistance offered to the passage of the discharge. Very soft tubes produce rays having little penetrative power, and the radiographs taken with them will have the appearance of under-exposed plates, showing no structural detail in the substance of the subject. Hard tubes, on the contrary, require considerable E.M.F., and the radiographs will lack contrast; they are therefore only suitable when detail in bones, rather than surrounding flesh, is required. An ordinary focus-tube is the best type for the small-spark apparatus, but the choice of a tube is a matter requiring special knowledge and experience. The best way is to consult a responsible dealer, explaining the nature of the source of electrical supply and the peculiar purpose for which the tube will be employed.

Fluorescent Screens.—Procure a piece of stiff cardboard about 10 in. by 12 in., or stretch a piece of good parchment on a frame, and coat well with celluloid varnish. Powder about 1 oz. of barium platino-cyanide in a mortar, and sprinkle evenly on the sticky surface by means of a sieve. When dry, another coat of varnish may be very carefully added. If the screen is not intended for demonstrations, but only to test the actual presence of the X-rays, crystallised calcium tungstate may be substituted for the expensive cyanide salt.

The Plates.—Many firms, including the Ilford Company, Edwards, Lumière, etc., etc., have a special plate suitable for the X-rays, though, in case of need, any good extra rapid plate will do, subject to length of exposure. The plate must be enclosed in a pair of Tylar's light-tight bags, the inner one yellow, the outer one black; and up to the time of exposure should be kept in a metal case. No plates, films, or other sensitive surfaces, even in dark slides, are safe in the vicinity of an X-ray apparatus, unless they are isolated by a metal partition. Operations should never be conducted in an apartment closely adjoining the photographer's store-room or dark room. The best shutter for controlling exposures is a piece of thin sheet lead.[1]

Testing the Presence of the Rays.—Presumably the electrical connections will be superintended by a practical electrician. There ought to be a considerable distance between the coil and the tube, and the spiral wires connecting the two must be securely fixed in such a way also that they will not be liable to touch the glass. Adjustments of apparatus, we need hardly remark, must not be made while the current is on.

Switch on the current for a moment, and observe the effect. If the light in the tube is weak, and assumes a violet glow, the sparking gap probably needs increasing; mottlings and patches, with fluorescence, opposite the anti-kathode show that the current must be reversed. A constant, bright, greenish-yellow light, filling at least half the tube, is an indication that the right condition of affairs is established; an orange glow, with sparks discharging outside the tube, shows that the spark gap is too wide.

Now take the fluorescent screen, and hold it, coated side towards the spectator, a few inches in front of the tube, and place the hand just behind it. The ligaments and bones should be plainly discernible, standing out as blacker in colour than the shadow of the surrounding flesh.

Exposure.—The plate, in its two light-tight bags, is now brought in and laid in position, film side uppermost (the film side must be noted when the plate is inserted in the bags). For experimental purposes the best distance is about 8 in., if the subject to be radiographed is not of too bulky character. Of all subjects the human hand is the favourite with beginners; it is in itself always an interesting one, and a friend will generally volunteer to provide it.

[1] Plates are now treated with nonactinic dyes, so that they may be handled in daylight and are sensitive only to the X-rays.

Place the hand on the black band covering the sensitive plate, keeping it perfectly still, and switch on the current. At the expiration of, say 100 sec., cover the hand with the lead sheet, switch off, and remove the plate for development.

Time of Exposure.—This is not easy to decide offhand. The nearer the tube the shorter the exposure; on the other

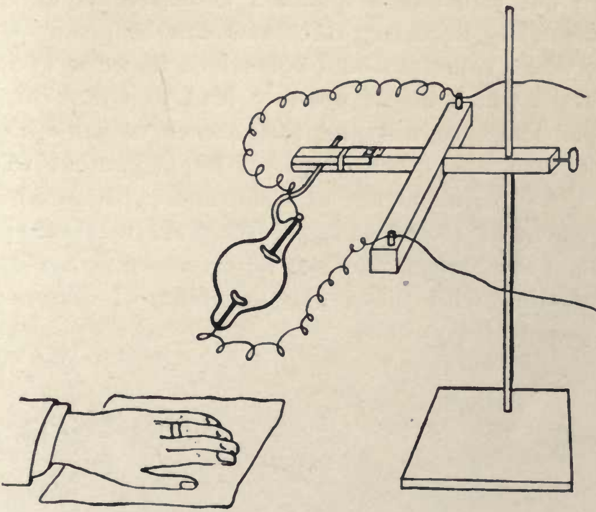


FIG. 75.—THE HAND IN POSITION.

hand, a certain distance from the tube is necessary to avoid great distortion of the resulting image. Much depends also on the nature and bulk of the subject. If a hand requires 90 sec., a foot will require 4½ minutes, and the forearm about 5 minutes. The trunk and abdomen may take anything between 30 minutes and 1 hour. Trial exposures may be given by exposing the subject in sections, shifting the lead sheet 1 in. for each 15 sec. backwards or forwards, in the same manner as with trial exposures in ordinary photography.

Development.—No great difference will be found between the development of ordinary negatives and radiographs. As in photo-micrography, the adoption of a slow, detail-forming agent, such as glycin or rodinal, is indicated; prolonged development with either of these will often reward the operator's patience by producing detail in the shadows and internal structure which would otherwise be absent.

In conclusion, we must once more reiterate the suggestion that the production of X-rays is not an undertaking likely to turn out well unless qualified assistance is obtainable. The absolutely necessary directions can be given in a few pages; whole volumes would not suffice to warn against all the pitfalls which might possibly lead to failure or worse mishap. The tyro will find this branch of work no more difficult than any other, provided he is content to work under the superintendence of some one experienced in the management of electrical apparatus. As to the supposed dangers of the X-rays, they may be dismissed as non-existent when dealing with tubes, like the 3 in., of comparatively small penetrative powers.

CHEMICALS IN GENERAL USE IN PHOTOGRAPHY

(For Developing Agents, see Chapter XI)

The figures following the chemical symbol show the molecular weight

Acetic Acid, $C_2H_4O_2$, 60.—A colourless liquid with strong vinegar smell. The glacial quality is that employed in photography. Solidifies at 34° Fahr. Specific gravity 1·066. A corrosive poison, blistering the skin in concentrated form.

Acetone, C_3H_6O, 58.—Also called methyl-acetyl. A volatile, highly inflammable liquid, with pleasant odour. Generally prepared by dry distillation of calcium acetate. Sp. gr. 0·792. Sometimes used as a substitute for alkali in developers. A solvent of celluloid, and therefore used in repairing celluloid films and making celluloid varnish. Sometimes added to sensitiser for carbon tissue in order to promote rapid drying.

Alcohol, C_2H_5OH, 46.—A highly volatile, colourless liquid, prepared by distillation from fermented sugars or any vinous liquid. Absolute alcohol contains up to 5 per cent. of water, rectified spirit about 10 per cent., or 58 degrees over proof. Sp. gr. ·834. Used in dissolving collodion and varnishes. Methylated spirit contains, in addition to 10 per cent. of wood spirit, a certain quantity of petroleum. It is not therefore suitable for any chemical purposes, though often employed for drying negatives and carbon prints. There is always a danger of oily streaks on the film, and this must be taken into account when negatives dried with spirit have subsequently to be intensified.

Alum.—A general name given to double salts of aluminium sulphate in combination with other sulphate salts, all the leading varieties having the same property of hardening gelatine, though in varying degree. All crystallise in octahedra. Potash alum, $K_2SO_4Al_2(SO_4)_3 24H_2O$, is the one usually sold commercially, though ammonia alum, in which $(NH_4)_2$ is substituted for the K_2, is frequently supplied, and is rather more soluble (1 in 8 of cold water). In alcohol and ethers potash alum is practically insoluble. Used for clearing and hardening baths for gelatine film, generally in conjunction with an acid. Forms an insoluble precipitate in the hypo bath. Chrome alum, $K_2SO_4Cr_2(SO_4)_3 24H_2O$, is a deep purple salt, crystallising in the same form, solubility varying from 1 in 6 to 1 in 10 in cold water, used chiefly for hardening dry-plate emulsions. Aluminium sulphate, $Al_2(SO_4)_3 18H_2O$, has also been recommended as a substitute for these variable forms for hardening films and emulsions.

Ammonia, NH_3, 17.—An extremely pungent gas, usually supplied in the strong aqueous solution sp. gr. ·880. A highly irritant poison, the fumes of which cause serious trouble if persistently inhaled. Antidote: vinegar and water. Weak solutions are used in most photographic processes, although ammonia is now considered less suitable than potassium or sodium salts for development purposes.

The aqueous solution of ammonia, being but slightly ionised, is a much weaker base than soda and potash, which in dilute solutions undergo complete ionisation. Ammonia combines with most silver compounds, either as a gas on the dry solid, or in solution on a precipitate, to form bodies of the type $AgCl(NH_3)_x$ wherein x may be either 1, 2, or 3. These compounds are mostly soluble.

Ammonium Bichromate $(NH_4)_2Cr_2O_7$, 252.—Sometimes used in place of the potash salt for chromate printing processes. But in practice it is generally simpler to make up the solution with potassium bichromate and then add ammonia by degrees until the liquid becomes a light yellow colour.

Ammonium Bromide, NH_4Br, 98.—Crystals, colourless, becoming yellowish on exposure to air. Solubility 1 in 1·4 of cold water, very soluble in hot water. Frequently adopted in place of potassium bromide for emulsions.

Ammonium Carbonate.—A somewhat variable substance, the normal of which is $(NH_4)_2CO_3$, volatile and caustic, smelling strongly of ammonia. Occasionally prescribed for developing solutions, but not to be recommended, except in minute proportions, for adding warmth to tones with hydroquinone on bromide papers.

Ammonium Chloride, NH_4Cl, 53·5.—Known in commercial form as Sal Ammoniac. Small white crystals, or fibrous masses. Used for salting various printing-out papers in place of sodium chloride. Solubility 1 in 3 of cold water.

Ammonium Citrate $(NH_4)_2C_6H_6O_7$, 226.—An extremely deliquescent salt, and not easy to keep in any form. It is expedient to prepare as required by neutralising 12 parts of citric acid with 11 parts strong ammonia, added gradually, and then making up to 24 parts with distilled water. Used as a restrainer in developing over-exposed plates, and in some emulsion formulæ.

Ammonium Iodide, NH_4I, 145.—Solubility 1 in 0·6 of cold water, 1 in 4 alcohol, and very soluble in ether or mixtures of alcohol and ether.

Ammonium Persulphate $(NH_4)_2S_2O_8$, 228.—Large colourless crystals. Strongly acid. Solubility 1 in 1½ cold water. Used chiefly in solutions of about 2 per cent. as a reducer of the high lights in negative. A solvent of gelatine.

Ammonium Sulpho-Cyanide, NH_4CNS, 76.—Colourless deliquescent crystals. Best preserved in solution. Solubility 1 in 0·6 cold water. Used for toning gelatino-chloride papers, and is also a fixing agent, but its high price prevents any competition with the ordinary "hypo."

Amyl Acetate, $C_7H_{14}O_2$, 130.—An amyl ester boiling at 140°, and having the odour of jargonelle. Is used in dissolving pyroxyline when preparing celluloid.

Anthion.—A name under which potassium persulphate is marketed for the elimination of hypo from plates and films.

Aqua Fortis.—Nitric acid.

Aqua Regia.—A mixture of nitric acid 1 part, hydrochloric acid 3 parts, used for dissolving gold and platinum.

Barium Chloride, $BaCl_2 2H_2O$, 244.—Tabular transparent crystals. A solvent of gelatine, used for making baryta paper and fine-grained focussing screens for photo-micrography. Sometimes also added to salting solutions for albumenised paper.

Benzole, C_6H_6, 78.—Also known as benzine. A colourless, volatile liquid, with a smell much resembling coal-gas, obtained by distillation of coal-tar. Gives off an explosive vapour, and boils at about 178° Fahr. Used for removing grease and oil, for making certain varnishes, and also as a vehicle for bitumen in engraving processes.

Borax, see *Sodium Borate.*

Calcium Carbonate, $CaCO_3$, 100.—Occurs in nature as common chalk, but for photographic purposes is precipitated artificially. It is used principally for neutralising chloride of gold solutions.

Calcium Chloride, $CaCl_2$, 111.—Chiefly used in the anhydrous state in the calcium tube for preserving platinotype and similar papers from the effects of damp. It is a very powerful absorbent of water, and when moist has only to be heated in an oven to render it ready for use again.

Citric Acid, $C_6H_8O_7H_2O$, 210.—Colourless, odourless crystals with strong acid taste. Prepared from the juice of fruits, such as lemon and lime. Solubility 1 in $\frac{3}{4}$ of cold water. Used as an acidifier in various sensitised papers and clearing solutions.

Copper Bromide, $CuBr_2$, 223·5.—Gray-blue powder or light-blue needle crystals. Deliquescent, and very soluble. As used in intensifying solutions is prepared generally from the sulphate salt by mixing solutions of copper sulphate and potassium bromide, filtering off the precipitated potassium sulphate.

Copper Sulphate, $CuSO_4 5H_2O$, 249·5.—Blue copperas, or blue vitriol. Large bright blue crystals. Sometimes used as an accelerator to the ferrous-oxalate developer, in which it retards oxidisation of ferrous sulphate.

Eau de Javelle.—A hypochlorite of sodium or potash, made by stirring up an ounce of chloride of lime with about 2 oz. of potassium or sodium carbonate in 10 oz. of water, and filtering.

Ether, $C_4H_{10}O$, 74.—Commonly called sulphuric ether. A colourless, very volatile liquid, of characteristic smell. Evaporates quickly, and when applied to the skin leaves sensation of extreme coldness. Boils at 95° Fahr. A solvent of rubber, and collodion, in the preparation of which lies its chief value to the photographer.

Ferric and Ferrous Salts, see *Iron*.

Formaline.—A 40 per cent. solution in water of formic aldehyde, CH_2O. A colourless, somewhat volatile liquid, with a very pungent, irritant odour. Used for hardening gelatine films in hot weather, a 5 per cent. solution rendering plates and films practically safe from injury, even in boiling water. It also adds brilliancy when employed in place of alkali in pyro and some other developers.

Glycerine, $C_3H_5(OH)_3$, 92.—A colourless, odourless syrup of sweet taste, obtained from animal and vegetable fats during the process of saponification as a bye-product. Soluble in water and alcohol. Chiefly employed in photography to render gelatine films more pliable, and to prevent them from splitting.

Gold Chloride, $AuCl_3$, 303.—The commercial forms usually obtained are either (1) bright yellow crystals, consisting of the chloride in combination with one equivalent of hydrochloric acid, made by dissolving gold in *aqua regia* and evaporation; (2) potassio-chloride, yellow hexagonal needles; (3) sodio-chloride, yellowish-brown deliquescent needles, the latter being the variety most commonly sold. The anhydrous chloride is of a yellowish brown colour. The comparative values are shown by the table below:

Gold.	Gold Chloride.	Cryst. Gold Chloride.	Gold Potassio-Chloride.	Gold Sodio-Chloride.
1·000	1·54	1·80	2·13	2·02
·64	1·00	1·17	1·38	1·31
·55	·84	1·00	1·18	1·11
·47	·72	·84	1·00	·94
·49	·76	·89	1·05	1·00

Gold chloride solutions are sensitive to light, and must therefore be kept in the dark.

Hydrochloric Acid, HCl, 36·5.—The commercial impure forms, known as muriatic acid or spirits of salt, are unsuitable for most photographic purposes. Colourless, fuming liquid, with strong smell of chlorine. A dangerous corrosive poison. *Antidotes*: Milk, gruel, etc., with magnesia, chalk, or other carbonates.

Hydrogen Peroxide, H_2O_2, 34.—A colourless solution of sharp taste. Powerful oxidiser and bleacher. Used in extremely weak solutions as a hypo eliminator (1 in 1000 parts of water).

Hydrofluoric Acid, HF, 34.—A colourless gas, generally supplied in hydrated form, obtained by heating fluorspar with sulphuric acid in a leaden or platinum retort. Even when dilute, it causes very painful ulcers on skin and nails. Must be stored in rubber bottles, as it dissolves glass, hence its use in detaching the gelatine film from glass plates.

Iron Ammonio-Citrate (Brown), $4\,FeC_6H_5O_7 3(NH_4)_3C_6H_5O_7$ $3Fe(OH)_3$, 2030. (Green), $5FeC_6H_5O_7 2(NH_4)_3C_6H_5O_7NH_4$ $C_6H_7O_7 2H_2O$, 1956.—Small, shiny, reddish-brown scales of hygroscopic character. Prepared by dissolving ferric hydrate in citric acid, and adding ammonia till neutral. Solubility, 1 in 0·5 parts water. Chiefly used for the blue prussiate printing-paper.

Iron Ammonio-Oxalate (Ferric), $(NH_4)_3Fe(C_2O_4)_3 3H_2O$.—Greenish-white crystals, decomposed by light. Prepared by dissolving ferric hydrate in acid oxalate of ammonium solution. Employed in some platinotype processes.

Iron Oxalate (Ferric), $Fe_2(C_2O_4)_3$, 376.—Obtained by precipitation, or by mixing ferric hydrate in the syrupy state with finely crystallised oxalic acid, and keeping for a few days in a dark, cool place. Not very soluble in water, but soluble in oxalic acid or alkaline oxalates. The sensitising agent in most platinotype processes.

Iron Oxalate (Ferrous), $FeC_2O_4 2H_2O$, 180.—A light-yellow crystalline powder. Almost insoluble in water. Rarely used dry, and is usually created as a developing agent by the admixture of neutral potassium oxalate and acid ferrous sulphate.

Iron Perchloride (Ferric), Fe_2Cl_6, 325.—Yellowish-red opaque masses; very deliquescent. Solubility, 160 per cent. in cold water; also soluble in alcohol and ether. Used as a reducing agent in copper etching, and also occasionally as a sensitiser. From its property of hardening gelatine, which becomes again soluble when, on exposure to light, the salt is converted into a ferrous chloride, perchloride of iron was formerly recommended for the making of negative transparencies by the carbon process.

Iron Sulphate (Ferrous), $FeSO_4 7H_2O$, 278.—Green vitriol or copperas. Green crystals, which absorb oxygen from the air, when they become covered with a brownish rust. This must be rejected. Solubility, 1 in 1·5 of water. Used for the developer in the wet-plate process, and also as a constituent of the ferrous-oxalate developer.

Lead Acetate, $Pb(H_3C_2O_2)_2 3H_2O$, 379.—White prismatic crystals of sweet taste; poisonous.

Lead Nitrate, $Pb(NO_3)_2$, 331.—White opaque octahedral crystals; poisonous.

Both of the above are sometimes added to combined toning baths, but are of doubtful value. They are also added to the fixing-bath ($\frac{1}{2}$ oz. to the pint) for the purpose of direct toning by the deposition of sulphide of lead on the image. A few drops of nitric or acetic acid are required with these salts, to dissolve the certain amount of basic salt present in the solid crystals.

Magnesium, Mg, 24.—A silvery white metal, commercially obtainable in the form of wire, ribbon, or powder. Used in measured quantities for flashlight, as it ignites readily and gives an extremely actinic light. The powder is used in flash-lamps, or as a flash-powder, mixed with about one and a half times its bulk of chlorate of potash.

Mercury Bichloride, $HgCl_2$, 271.—Corrosive sublimate. Heavy crystalline masses, or fine white powder. Solubility, 1 in 16 of cold water. Used for intensification of negatives. Dangerous corrosive poison, 3 grains being fatal, and may be partially absorbed through the skin. *Antidote*: White of egg, or in emergency flour-paste and milk.

Nitric Acid, HNO_3, 63.—Aqua fortis. A colourless liquid, fuming in the air; stains hands and nails yellow. Used as a preservative for pyro, for making pyroxylene, clearing negatives, etc., etc. Corrosive poison. *Antidote*: Chalk, magnesia, bicarbonate of soda, etc., etc.

Oxalic Acid, $H_2C_2O_4$, 126.—Colourless prisms of strong acid flavour. Solubility, 1 in 10 of cold water. Used principally in dissolving the oxalates. Very poisonous. Antidotes as above.

Picric Acid, $C_6H_2(NO_2)_3OH$, 139.—Bright yellow plates or crystals of bitter taste, which explode when heated quickly. Picric acid is sometimes added to flashlight powders. Ammonium and sodium picrate are often recommended for making yellow orthochromatic screens.

Platinum Perchloride, $H_2PtCl_66H_2O$, 516·4.—Small, brownish-red, deliquescent masses. Often used in platinum toning formulæ. Very soluble.

Potassium Bichromate, $K_2Cr_2O_7$, 294.—Bright orange-red crystals, giving a very deep-coloured solution. Poisonous, and the cause of unpleasant eruptions on the skin—any stains on the fingers should be promptly washed off with the aid of a little ammonia. Solubility, about 1 in 10 parts cold water; decomposed by alcohol. Used as a sensitiser in carbon and similar processes, as a restrainer in developers, for intensifying, reversing, and toning negatives, bromide papers, etc., etc.

Potassium Bromide, RBr, 119.—White cubical crystals of salt taste. Solubility, 1 in 1½ parts cold water. Used as a restrainer in developers, and also in the manufacture of dry-plate emulsions.

Potassium Carbonate, K_2CO_3, 138.—A white crystalline powder, caustic to the taste, generally containing about 15 per cent. of water of crystallisation. Deliquescent. Used as an accelerator in development. Solubility, about 1 in 0·9 part cold water. The corresponding sodium carbonate is generally to be preferred in developing formulæ.

Potassium Chloro-platinite, K_2PtCl_4, 413·4.—Ruby-red, four-sided prisms, very soluble in water, and somewhat deliquescent. Used for sensitising platinotype paper, and also for toning various printing-out papers.

Potassium Cyanide, KCN, 65.—Irregular, hard, opaque masses, with slight smell of prussic acid. A dangerous poison, especially on account of the symptoms, which are not easily diagnosed in time to apply the antidotes, a very dilute (½ per cent.) solution of potassium permanganate with cold affusion over the head and neck. Fainting, difficulty of respiration, dilated pupils, and spasmodic closure of the jaws are the chief characteristics of cyanide poisoning. If absorbed through a cut or sore, sulphate of iron should be immediately applied. Used in fixing wet collodion plates, and in combination with iodine for the removal of the silver image, after the latter has been drawn on in the waterproof ink for line work.

Potassium Ferricyanide, $K_3Fe(CN)_6$, 329.—Red prussiate of potash. Deep red crystals, which become covered with a yellowish powder on exposure to the air. This must be rinsed off before using. Solubility, 1 in 2½ parts of cold water. Used for intensification and reduction; also in many printing and photo-mechanical processes.

Potassium Ferrocyanide, $K_4Fe(CN)_63H_2O$, 422.—Yellow prussiate of potash. Large yellow plates or crystals. Solubility, 1 in 4 of cold water. Occasionally added to pyro developers with the alkalis to increase brilliancy of effect.

Potassium Hydrate, KHO, 56.—Caustic potash. White deliquescent sticks. Solubility, 1 in ½ of cold water. Used as an alkali in developers, etc., etc.

Potassium Iodide, KI, 166.—White or transparent cubical crystals of sharp taste. Solubility, 1 in 0·7 of cold water. Is used in emulsion-making, as a solvent for iodine, etc., etc.

Potassium Metabisulphite, $K_2S_2O_5$, 222.—White crystals, which become powdery on exposure to air, as the substance absorbs oxygen. Solubility, 1 in 3 cold water. Used in place of sodium sulphite (or in combination with it as a preservative). Becomes strongly acid in keeping. Used also in making up acid-fixing baths.

Potassium Oxalate, $K_2C_2O_4$, 164.—Colourless crystals, neutral or slightly acid in solution. (The commercial oxalate, known as salts of sorrel, is a double oxalate, and unsuitable for photographic purposes.) Solubility 1 in 3 of cold water. The usual developer in the platinotype process; also an ingredient of the ferrous-oxalate developer.

Potassium Permanganate, $KMnO_4$, 158.—Dark red and purple crystals, of needle shape, from which a deep red liquid flows on immersion in water. Known in solution as Condy's Fluid. Solubility, 1 in 16. Used to intensify negatives or carbon prints, and in very minute solutions as a hypo eliminator. To test for the presence of hypo make up a solution of 2 gr. in 20 oz. of water, and add 15 gr. caustic soda. Soak the negatives or prints for a few moments in water, and then add a few drops of the test solution. The pink colour will change to green if hypo is present.

N.B.—Permanganate stains are readily removed by a solution of oxalic acid.

Potassium Persulphate, $K_2S_2O_8$, 270.—Often used as a hypo eliminator, as it converts the hypo into the harmless sodium tetrathionate. Must be employed very cautiously in solutions, not exceeding ½ per cent. All hypo eliminators have a tendency to bleach, by oxidising the silver image.

Silver Bromide, AgBr, 188.—An insoluble, light-yellow salt, usually prepared in emulsions by double decomposition, between nitrate of silver and one of the soluble bromide salts. Soluble in solutions of certain alkaline and cyanide salts. Becomes a grey colour by prolonged exposure to light with liberation of bromine.

Silver Chloride, AgCl, 143·5.—A white insoluble salt, prepared in a similar manner to the bromide, by direct admixture of nitrate of silver with one of the soluble chloride salts. Soluble in ammonia, and the same solutions as silver bromide. On exposure to light remains unchanged in the pure dry state; but in the presence of organic matter becomes gradually dark in colour with liberation of chloride, and is partially converted into metallic silver, together with, probably, a subchloride and oxychloride. Forms the principal sensitive salt in many emulsions and printing-out papers.

Silver Iodide, AgI, 235.—A white or light-yellow insoluble salt, prepared by precipitation in emulsions in a similar way to the silver salts mentioned above. Less important in gelatine dry-plates than in wet-plate collodion, but in small quantities adds sensitivity and density-giving properties to bromide emulsions.

Silver Nitrate, $AgNO_3$, 170.—White tabular crystals which, when pure, are neutral or very slightly acid. Darkens on exposure to light in contact with organic matter. Solubility, 1 in 0·44 distilled cold water. Precipitates in common water. Used in preparing nearly all emulsions, sensitive silver papers, etc., etc. An irritant poison. Antidote: common salt, followed by emetics. Produces black stains on the skin, removable only with potassium cyanide.

Sodium Acetate, $NaC_2H_3O_23H_2O$, 136.—White crystals, slightly hygroscopic. Solubility, 1 in 3 cold water. A favourite alkali in gold toning baths.

Sodium Carbonate, Na_2CO_3, 106.—Solubility (anhydrous), 1 in 6. Usually met with in the monohydrated form of large white crystals, which whiten on exposure to air, losing part of their water of crystallisation. Some formulæ suggest the commercial form of common washing soda, but this varies much in quality, often contains sulphate, and is liable to give stains. Care must be taken when purchasing from ordinary chemists not to mistake this salt for the bicarbonate, of little value to the compounder of developers. Sodium carbonate is the most valuable alkali, being of moderate energy and reliable action. When substituting for potassium carbonate, the following are the relative quantities required according to Bolton's table:

Sodium Carbonate (anhydrous)	·76
„ „ (monohydrate)	·85
„ „ (crystallised)	2·07
Potassium Carbonate (anhydrous)	1
„ „ (crystallised)	1·26
Ammonium Sesquicarbonate	2·1
Caustic Soda	·29
Caustic Potash	·40

Sodium Chloride, $NaCl$, 58·5.—Common salt. The ordinary block quality often contains sulphates and magnesia salts. Solubility, 1 in 3 cold water. Used for chloride emulsions and papers; also in first washing water of prints to convert free nitrate, which might otherwise cause an insoluble yellow stain after fixing.

Sodium Thiosulphate, $Na_2S_2O_35H_2O$, 248.—Large, irregular crystals, or, in purer form, small white crystals. The yellow efflorescent crystals should be rejected. Known commercially as hyposulphite of soda, or in photography as "hypo." Manufactured by passing sulphurous acid gas through sodium sulphide. Solubility, 1 in 0·6. Its discovery as a fixing agent, dissolving out the superfluous silver salts, was discovered by Sir William Herschel.

Sodium Phosphate, $Na_2HPO_412H_2O$, 358.—Large, bright, colourless crystals. Efflorescent on exposure to air. Solubility, about 1 in 6. Used as an alkali in gold toning baths.

Sodium Phosphate (Tribasic), $Na_3PO_4 12H_2O$, 380.—Recommended by Lumière as a substitute for ordinary alkalies in development (*see* Developing Formulæ), and is said to prevent pyro stains. In substitution of salts, 100 parts of sodium carbonate should have the chemical equivalent value of 133 parts tribasic phosphate.

Sodium Sulphite, Na_2SO_3, 126.—Large, clear crystals, efflorescent by absorption of oxygen when exposed to the air, or anhydrous as a white powder; the latter need only be used in half the quantity prescribed for the more common crystals. Used as a preservative for developing agents, and also to prevent stains on the film in development. Solubility, 1 in 2 (crystals), 1 in 4 (dry).

Thiocarbamide, $CS(NH_2)_2$, 76.—Small prismatic crystals. Solubility, 1 in 11. A weak solution, acidified with citric acid, is recommended by some makers for brightening bromide prints, but must not be used until all traces of hypo have been removed from the paper; it is also added to developers for lantern (bromide) plates, and gives blue and violet tones. As a developer it often causes reversal.

Sulphuric Acid, H_2SO_4, 98.—A heavy liquid. The commercial qualities of oil of vitriol contain impurities. For most photographic purposes it is expedient to substitute the less dangerous nitric or hydrochloric acid. It is highly corrosive, and great care must be taken in mixing it with water. The acid should be poured into the water drop by drop; water must never be poured into the acid. Antidotes: Chalk or bicarbonates. Water must not be administered in the early stages of vitriol poisoning.

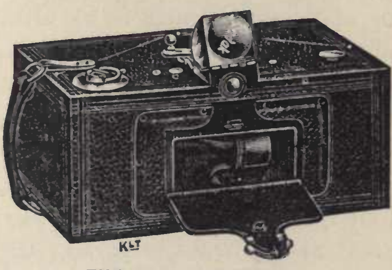
Uranium Nitrate, $UO_2(NO_3)_2 6H_2O$, 504.—Yellowish green deliquescent crystals. Prepared from pitchblende. Solubility, about 1 in 0·5 of water. Decomposed by light in contact with organic matter. As used for toning and intensifying, there seems some doubt as to the stability of the results. As a moderate reducer of overprinted P.O.P. paper, when added to the ordinary fixing bath it possesses a much higher value.

Sodium Borate, $Na_2B_4O_7 10H_2O$, 382.—White crystals or powder, of sweet taste and slightly alkaline. Solubility, about 1 in 12. Used as a restrainer in pyro developers, but acts as an accelerator with eikonogen and hydroquinone. A favourite alkali for gold toning formulæ, but the bath does not keep well.

Sodium Hydrate, NaOH, 40.—Caustic soda. Very soluble. Sometimes specified in developing formulæ, and for other purposes when a strong alkali is required.

MISCELLANEOUS NOTES AND FORMULÆ

Panoramic Cameras.—There have been several inventions from time to time with the object of taking on a single plate a picture of much wider angle than can be included by the lens. Some, like Damoiseau's Cyclograph, and Moïssard's Cylindrograph, include a very wide angle—upwards of 180°. The best known for the ordinary flat glass plate is that of Johnson and Harrison, originally invented by the former gentleman about 1870, but improved very greatly during later years. The lens moves on a vertical axis in front of a casing with vertical slot, and the motion of the plate is geared harmoniously; so that the portion under the action of the lens at any one time is always in sufficiently true position on the circumference of the circle described by the slit, which need only be about a $\frac{1}{4}$ in. wide. In the Panoram Kodak, a much simpler but sufficiently accurate instrument for ordinary purposes, the lens swings on a pivot during exposure, and the shutter is so adjusted as to give even illumination throughout. The larger size will take views embracing an angle of 142°, and is adapted for high waterfalls, mountain peaks, and lofty towers, as well as for broad stretches of landscape.



THE PANORAM KODAK.

Double Photographs.—An instrument called a duplicator is frequently used in order to enable the subject (one or more persons) to appear twice in the same picture in different or contradictory attitudes—*e.g.* a man playing a game of chess, or fighting in a duel with his own double. It consists of an ordinary lens hood, either of cardboard or metal, from which a small segment of the plane disk is cut away on one side by a straight, true line. The hood is first placed on the lens to the left, the subject posed on that side immediately opposite the aperture, and the exposure made (rather more than three times the usual period); after which the cap is reversed, and a fresh exposure made with the subject in his new position on the right side of the picture. If the aperture is of the proper size (about $\frac{1}{5}$ measured across the diameter) the two exposures will blend accurately into one. Double pictures, without the duplicator, are often made for other purposes. Thus "ghost" pictures of a very startling character may be created by previously exposing a plate on the person who is to represent the ghost, and then photographing the landscape or apartment which is to form the scene of his untimely wanderings. The first must obviously be an under-exposure to secure proper effects.

For a more legitimate use of the double photograph we are indebted to a well-known American engineer, Mr. C. Francis Jenkins. He was requested to ascertain, approximately, the thrust of a bridge, in going over which the brakes of a railway train were applied to stop it at a station a few hundred yards beyond. The quickest and most convincing way that occurred to him was to take a double exposure of the bridge on the same plate, first before the train reached the bridge, and then again while crossing. The developed negative showed conclusively that the bridge had moved several inches during the passing of the train.

Developers Dry for Tourists.—Some developers are readily kept in dry form, the simplest way being to enclose in small, well-corked bottles a sufficient quantity to make up 4 oz. in water. Marking-ink bottles, cleared of all traces of silver by means of potassium cyanide, will sometimes serve for the purpose. A good dry developer, which will keep for some considerable time if preserved from damp and air, is composed of—

Amidol	10 gr.
Sodium Sulphite (anhydrous)	60 „

Another one-solution developer, which may be kept without danger of spoiling for several months in the dry state, is—

Glycin	18 gr.
Sodium Sulphite (anhydrous)	30 „
Sodium Carbonate (anhydrous)	95 „

Of two-solution developers one of the simplest is pyrocatechin, but for nearly all it will be necessary to mix the developer with anhydrous sodium sulphite in one bottle, and to keep the alkali, also anhydrous, in a separate receptacle.

Collodion Enamel.—

Gun Cotton (soluble)	25 gr.
Sulphuric Ether	2 oz.
Alcohol	2 „

Bellows, Varnish for.—Ordinary celluloid varnish, made by digesting old celluloid films in amyl-acetate or acetone, is as good as anything, being preservative and pliable for either leather or cloth bellows.

Black Varnish.—A dead-black varnish for coating any surface may be prepared with lamp-black mixed with a solution of sandarac in alcohol; fine lamp-black as used by artists is preferable. For camera bellows celluloid dissolved in amyl-acetate may be substituted for the sandarac.

Fogged Plates.—Plates which have accidentally been exposed to light may have their sensitiveness restored by the following solution:

A. Potassium Bichromate	10 gr.
Water	1 oz.
B. Potassium Bromide	10 gr.
Water	1 oz.

Soak the plate in a mixture of A and B, equal parts, and then wash in three or four changes of water. A weak solution of potassium bichromate, acidulated with hydrochloric acid, will also have a similar effect, but the chromate salt must be completely eliminated from the plate, which will be considerably less sensitive than it was originally.

Backing for Plates.—It is important that the backing should not only be in optical contact with the glass and absorb the actinic light which reaches it, but that it contain nothing injurious to the sensitive film. Nor should it chip or scratch off easily, so as to cause dust. Collodion mixed with some actinic dye answers fairly well, but is difficult to remove after development. The best for general use seems to be a composition with caramel, the usual proportions being—

Caramel	2 oz.
Gum solution	1 ,,
Burnt Sienna	1 to 2 oz.
Methylated Spirit	2 oz.

A little golden syrup is occasionally added. Grind together sienna and caramel in a mortar, add the other ingredients, and apply to back of plate with a flat hog-hair brush. Flexible backing pads will not often adhere uniformly, and therefore are not an efficient substitute for the soluble backing.

Stoppered Glass Bottles, to ease.—The stoppers may generally be loosened by one or other of the following expedients, according to the cause which has rendered them immovable: (1) Let a drop of sweet oil or warm water fall on the line formed by the junction of the stopper with the neck of the bottle. (2) Apply warm water or heat in some way to the neck of the bottle. (3) Tap the stopper smartly all round with a piece of wood.

Prints: Finishing Off.—When prints are taken from the final washing water they may be surface-dried with clean, hard blotting paper, and hung up to dry, or squeegeed on pulp slabs to give them a glossy appearance. Prints should never be cut with scissors, but trimmed with a sharp knife against a glass-cutting slab, to ensure integrity of line.

Mountants for Prints.—(1) Gulliver's Paste is probably the very best for ordinary use. It keeps well, and prints do not cockle.

Picked White Gum Arabic	½ oz.
Dextrine	2¼ ,,
Ammonia	4 drops
Carbolic Acid	1 dr.
Water	8 oz.

The gum arabic is pounded in a mortar, and mixed well with the dextrine; then triturate with 2 oz. of water till quite smooth, when the rest of the water is added, and the whole boiled for 10 minutes. When nearly cool, add ammonia and carbolic acid, and bottle off.

(2) A gelatine mountant which forms a strongly adhesive liquid may be prepared by dissolving ordinary flake or sheet gelatine in a 15 per cent. solution of barium chloride. The latter is then precipitated by the addition of sodium sulphate, when barium sulphate is left as a white deposit, and the clear liquid may be poured off.

(3)	Gelatine	3 oz.
	Water	20 ,,
	Glycerine	2 ,,
	Methylated Spirit	10 ,,

Soak the gelatine till soft, when apply heat sufficient to melt it, and add the other ingredients, stirring rapidly. When using, place the bottle containing the mountant in warm water.

(4) Dextrine Mountant: Mix a pound of best white dextrine into a stiff, even paste with cold water; then add ½ pint of warm water and 1 dram oil of wintergreen; bring the mixture to the boil, and decant into pots. It will be ready for use in about 12 hours, and will keep for some months.

Encaustic Paste.—A preparation to be rubbed on the finished and mounted print as a preservative, and also to give a glossy surface. Polish on with a piece of cotton-wool or soft silk handkerchief. Dr. Eder's prescription is:

Pure White Wax	100 gr.
Oil of Turpentine	100 min.
Gum Dammar Varnish	40 "

Burnishing.—A method of finishing prints not at present in great favour. The prints are first prepared by being rubbed over with a lubricator, consisting of 15 gr. castile soap in 2 oz. methylated spirit, applied with a soft flannel. When dry they are drawn steadily through the burnisher, the iron of which must be clean and free from scratches, and just hot enough for the hand to bear comfortably. Uniform motion is the great secret of success in burnishing; marks and scratches are produced by stoppages or jerky movements.

Glass, to clean.—

Powdered Chalk	2 oz.
Ammonia	½ "
Water	1½ "

is as good a mixture as any, 1 oz. fine pumice powder being sometimes added. Rub on with a piece of wash-leather, and finish with soft rag or paper.

Baryta Paper.—A hard-surfaced paper, used as a support for gelatine printing-out emulsions and in collotype. The formula generally given is:

A.	Gelatine (Heinrich's)	90 gr.
	Barium Chloride	30 "
	Distilled Water	5 oz.
B.	Ammonium Sulphate	15 gr.
	Distilled Water	2½ oz.

Soak the gelatine, and dissolve by heat, adding the barium; then add solution B by degrees, shaking between each addition. Allow emulsion to set; break into small pieces, and wash thoroughly. Lastly, add about 7½ gr. chrome alum, dissolved in a little water.

Silvering Mirrors.—

A.	Silver Nitrate	175 gr.
	Distilled Water	10 oz.
B.	Ammonium Nitrate	262 gr.
	Distilled Water	10 oz.
C.	Pure Caustic Potash	1 „ (437½ gr.)
	Distilled Water	10 „
D.	Pure Candied Sugar	½ „
	Distilled Water	5 „

Dissolve the sugar-candy in the water, and add 50 gr. tartaric acid. Boil for a few minutes, and, when cool, add alcohol 1 oz., and make up to 10 oz. with distilled water. For use, mix equal parts of A and B and equal parts of C and D in two separate flasks. Then mix the two in the silvering dish, and suspend the glass plate, which must be spotlessly clean and free from grease, face downwards.

BRITISH WEIGHTS AND MEASURES

Avoirdupois Weight

437½ grains = 1 ounce.
16 ounces = 1 pound = 7000 grains.

Fluid Measure

60 minims = 1 drachm.
8 drachms = 1 ounce.
20 ounces = 1 pint.
1 fluid ounce weighs 437½ grains.
1 minim weighs ·91 grains.

CONVERSION OF METRIC INTO BRITISH WEIGHTS AND MEASURES

Grammes into Grains and Ounces

Grammes.	Grains.	Grammes.	Grains.
0·065	1	3	46·3
0·1	1·5	4	61·7
0·2	3·1	5	77·2
0·3	4·6	10	154·4
0·4	6·2	14·17	½ oz.
0·5	7·7	21·26	¾ oz.
1	15·43	28·35	1 oz.
2	30·9		

Cubic Centimetres into Minims and Ounces

Cubic Centimetres.	Minims.	Cubic Centimetres.	Minims.
·06	1	4	67·6
·3	5	5	84·5
·6	10	10	169
·9	15	14·17	½ oz.
1	16·9	28·35	1 oz.
2	33·8	50	1 oz. 365 min.
3	50·7	100	3 oz. 250 min.

Millimetres to Inches

Millimetres.	Inches.	Millimetres.	Inches.
1	·04	10	·39
2	·08	20	·79
5	·2	25·4	1·0

COMPARATIVE SIZES OF ENGLISH AND FOREIGN PLATES

	Centimetres.	Inches.
English Quarter Plate . .	10·8 × 8·25	$4\frac{1}{4} \times 3\frac{1}{4}$
French ,, ,, . .	9 × 12	4·72 × 3·54
English Half Plate . . .	16·5 × 12	$6\frac{1}{2} \times 4\frac{3}{4}$
French ,, ,, . . .	13 × 18	7 × 5·12
English Lantern Plate . .	8·25 square	$3\frac{1}{4}$ in. square
French ,, ,, . .	10 × 8	3·85 × 3·2
American ,, ,, . .	10·16 × 8·25	$4 \times 3\frac{1}{4}$

DIAPHRAGM NUMBERS

UNITED STATES SYSTEM COMPARED WITH FOCAL EQUIVALENT SYSTEM

The United States system corresponds with the relative exposure required.

Focal Number . .	4	5·6	8	11·3	16	22·6	32	45·2
United States Number	1	2	4	8	16	32	64	128

THERMOMETRIC TABLE

Centigrade.	Réaumur.	Fahrenheit.	
100	80	212	Boiling point of water
95	76	203	
90	72	194	
85	68	185	
80	64	176	
75	60	167	
70	56	158	
65	52	149	
60	48	140	
55	44	131	
50	40	122	
45	36	113	
40	32	104	
35	28	95	
30	24	86	
25	20	77	
20	16	68	
15	12	59	
10	8	50	
5	4	41	
0	0	32	Freezing point of water

TABLE OF DISTANCES FOR ENLARGEMENTS

Focus of Lens.	Times of Enlargement.							
	1	2	3	4	5	6	7	8
3	6	9	12	15	18	21	24	27
3½	7	10½	14	17½	21	24½	28	31½
4	8	12	16	20	24	28	32	36
4½	9	13½	18	22½	27	31½	36	40½
5	10	15	20	25	30	35	40	45
5½	11	16½	22	27½	33	38½	44	49½
6	12	18	24	30	36	42	48	54
7	14	21	28	35	42	49	56	63
8	16	24	32	40	48	56	64	72

The figures in the above table give the distance required between centre of lens and sensitive surface; to find distance between lens and transparency divide the figure given by the number of times. Thus with a 3-in. lens for same size, distance between negative and centre of lens must be 6 in., for double size 4½ in., for three times 4 in., etc., etc. Directions for ascertaining focal length are given on page 38. These figures reversed will serve also for reductions.

TABLE OF COMPARATIVE SPEED NUMBERS OF PLATES

Hurter and Driffield.	Watkins.	Wynne.
10	15	24
20	30	28
40	60	49
80	120	69
100	147	77
140	206	91
200	294	109
300	441	134
400	588	154

INDEX

D

E

R

S

2

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