

were seen in *Tabacum* and *Triticum* haplonts were observed. Suspended *I-A* stages followed by equational division were not infrequent and were reflected in the occurrence of dyads at the tetrad stage. Otherwise, division of univalents at *I-A* rarely, if ever, took place according to *II-M* counts, which uniformly gave a total of 12 units in the two plates. *II-M* counts also showed that all types of distribution, on the basis of random assortment at *I-A*, occurred—6-6, 7-5, 8-4, 9-3, 10-2, 11-1 and all 12 in a single *II-M* plate having been observed. Further cytological studies of the *glutinosa* haplont are in progress and will be reported on at a later date.

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² Hollingstead, L., *Amer. Nat.*, 62, 1928.

³ Blakeslee, A. F., Belling, J., Farnham, M. E., and Bergner, D., *Science*, N. S., 55, 646-7, 1922.

⁴ Ruttle, M. L., *Univ. Calif. Publ. Bot.*, 11, 12, 233-244, 1928.

⁵ East, E. M., *Biblio. Genetica*, 4, 244-320, 1928.

⁶ Levine, M., *Phytopath.*, 19, 97, 1929.

FURTHER REMARKS CONCERNING THERMIONIC
"A" AND "b," A REVISION AND EXTENSION

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This paper is written in continued support of the thesis that all the known facts regarding thermionic emission from metals are consistent with the original conception of Richardson, which assumed the emitted electrons to come from a body of free electrons sharing the energy of thermal agitation within the metal. In the course of the paper I shall have occasion to revise some remarks which I have made concerning the equality of "A" in different metals, and I shall consider the possibility that the photo-electric work function, represented by "b₀," is variable with temperature, but nothing that I have to say involves any departure from the fundamental conceptions of the dual theory of electric conduction which I so many times set forth in print.

There is a strong tendency at present to identify the thermionic work function and the photo-electric work-function, numerically at least. This tendency is represented on the experimental side by DuBridge¹ and Warner², and on the theoretical (thermodynamical) side by Bridgman.³ In the abstract of a recent paper⁴ Bridgman says, "The thermionic work-function and the photo-electric work function are found to

differ by a universal constant, which must be zero in the light of the work of Warner and the recent work of DuBridge."

All of this may seem highly unfavorable to my thesis that electric conduction in metals is carried on by electrons in two different states, the "free" electrons, or "thermions," which are the ones issuing in thermionic emission, and the "associated," or "valence," electrons, which are the ones expelled in photo-electric action. I shall, however, undertake to show that all the evidence referred to, both experimental and thermodynamical, is entirely consistent with the thesis just stated above.

I shall deal with Bridgman's argument first, and show that his definition of work-function is something essentially different from that which holds in actual experiments upon emission. Let ϕ represent, in ergs, the thermionic work function, which I shall define as the amount of work which must be done against opposing forces in the escape of one electron thermionically from the metal. Let ϕ_0 represent, in ergs, the photo-electric work function, which I shall define as the amount of energy which must be supplied in order to take an electron photo-electrically from the metal. I assume, in accordance with Richardson's original "classical kinetic theory," that in thermionic emission the thermal energy of the electron is the same after emission as before—namely, that of a monatomic gas molecule corresponding to the temperature of the metal and the surrounding space. For simplicity in the present argument I shall suppose that the photo-electrically emitted electrons are left in exactly the same state of energy as those emitted thermionically, and, as my ϕ_0 does not provide for the thermal energy of the electron after emission, I must make an additional contribution of energy, θ let us call it, on this account. I assume, keeping thus to the view which, I think, has prevailed till recently, that thermionic emission uses electrons which have been already loosed from atoms within the metal, leaving an equal number of positive ions, while photo-electric emission takes electrons which are parts of atoms. I shall represent by λ' the amount of energy required to ionize an atom within the metal—that is, to change an atom into an ion and a "free" electron within the metal, this electron having after the operation the full quota of thermal energy corresponding to the temperature of the metal.

With the definitions given above we must by the first law of thermodynamics have

$$\lambda' + \phi = \phi_0 + \theta, \quad \text{or} \quad \phi = \phi_0 - (\lambda' - \theta). \quad (1)$$

Now let us take Bridgman's point of view. He considers emission from an electrically isolated piece of metal, and by work function he means not only the energy required for the act of emission but in addition what may be called the *heat of adjustment*, whatever supply of energy, positive

or negative, may be required to restore a state of equilibrium within the metal after its loss of electrons.

Let us suppose, for example, that ν electrons have been expelled by thermionic action from the isolated metal. The heat energy called for in the emission operation proper is $\nu\phi$, but, if no adjustment were to occur within the metal, it would have ν less free electrons than at first, with an unchanged number of positive ions. Such a condition cannot last. The mass law of equilibrium requires that $1/2\nu$ atoms shall become ionized, so that in the final state there shall be $1/2\nu$ less free electrons and $1/2\nu$ more positive ions than there were in the metal at first. The amount of energy demanded for this ionization is $1/2 \nu\lambda'$, so that the total amount of energy which has been called for is

$$\nu\phi + 1/2\nu\lambda',$$

which is Bridgman's thermionic work function multiplied by ν .

Let us now suppose that the ν electrons had been expelled by photo-electric action. The energy requirement for the emission and thermal elevation of these electrons would be $\nu(\phi_0 + \theta)$, but the operation would, without adjustment, leave the metal containing ν more positive ions than at first, with no change in the number of free electrons. The mass law would come into operation, requiring $1/2\nu$ free electrons to unite with an equal number of ions, so that the final condition would be precisely that which followed thermionic emission, $1/2\nu$ fewer free electrons and $1/2\nu$ more ions than at the start. The union of the free electrons with the ions would yield $1/2\nu\lambda'$ in heat energy, and so we should have

$$\nu(\phi_0 + \theta) - 1/2\nu\lambda'$$

as Bridgman's photo-electric work function multiplied by ν . Evidently, since the initial and also the final state is the same in this case as in the preceding one, we must have

$$\nu\phi + 1/2\nu\lambda' = \nu(\phi_0 + \theta) - 1/2\nu\lambda', \quad (2)$$

or

$$\phi = \phi_0 - (\lambda' - \theta),$$

which is precisely my eq. (1).

Of course, the positive charge which results from the emission of electrons appears finally at the surface of the metal, the interior parts having at the end as at the beginning as many free electrons as positive ions per unit volume. In discussing the "heat of adjustment" we have been concerned with the so-called "surface heat" of charging.

Let us consider now the experimental evidence which may be supposed to show the numerical identity of the thermionic and the photo-electric work functions, the ϕ and ϕ_0 which have been defined above. I shall

deal with this matter at considerable length, in the hope of clearing up the mystification, or confusion of ideas, which seems to exist regarding the formulas of thermionic emission. If any readers are inclined to think that the modification of Richardson's equations by the introduction of my own peculiar notions must add to the confusion, I beg them to read my argument through before they reject it.

Starting with the conceptions of Richardson's "classical kinetic theory," as set forth on pages 33 and 34 of his *Emission of Electricity from Hot Bodies*, I shall let n equal the number of free electrons per cu. cm. within the metal, and n' the number of electrons per cu. cm. outside the metal, equilibrium conditions being assumed. Then, if ϕ has the meaning already given it in this paper and if $b = \phi \div k$, we have, according to the Boltzmann distribution law,

$$n' = n\epsilon^{-\frac{\phi}{kT}} = n\epsilon^{-\frac{b}{T}}. \quad (3)$$

In a previous paper⁵ I have, following Richardson's reasoning, shown that the thermionic emission current from one sq. cm. of the metal surface is

$$I = Fe.n'.T^{0.5}, \quad (4)$$

F being a constant, 1.56×10^5 , given, like the factor $T^{0.5}$, by the kinetic theory of gases, while e is the electron charge. Making use of eq. (3) we get from (4)

$$I = Fe.n.T^{0.5}.\epsilon^{-\frac{b}{T}}. \quad (5)$$

Now Richardson, near the top of page 34, assumes that

$$n = zT^{1.5}, \quad (6)$$

z being a constant. With this assumption we get from (5)

$$I = Fe.zT^{1.5}.T^{0.5}.\epsilon^{-\frac{b}{T}}, \quad (7)$$

or, if we put A for $Fe.z$, which is a constant,

$$I = AT^{1.5}.T^{0.5}.\epsilon^{-\frac{b}{T}} = AT^2\epsilon^{-\frac{b}{T}}, \quad (8)$$

which is one of the two familiar Richardson expressions for the emission current.

If, on the other hand, we assume that n is a constant independent of temperature and write $A = Fe.n$, we get from (5)

$$I = AT^{0.5}\epsilon^{-\frac{b}{T}}, \quad (9)$$

which is the other familiar Richardson equation.

I think this simple explanation of the relation between these two for-

mulas, (8) and (9), is not generally perceived. Of course, both equations cannot be right for the same metal, and, if experiment fails to decide which is the better, it may very well be that neither is the best possible expression of fact. I shall return to this idea farther on. Present custom inclines, I think, to use (8) rather than (9), and this may perhaps be interpreted as a tendency, not generally recognized as such, toward the acceptance of eq. (6). I shall make no further use in this paper of eq. (9).

Now as to the b in eq. (8), is it or is it not a constant, according to experimental evidence? This is a question which must not be answered hastily. Undoubtedly experimental evidence is in good agreement with a formula of the same type as eq. (8) having the A constant and having some constant where b is in (8). But does this constant which corresponds in place with b necessarily have the same meaning, the same definition, as that which is given above for b ? No.

Thus, let us suppose that b , as defined, is a function of temperature

$$b = b_0 - aT, \quad (10)$$

where b_0 and a are constants. From eq. (8) by means of (10) we get

$$I = AT^2 \exp \left[- \frac{b_0 - aT}{T} \right] = Ae^a T^2 \epsilon^{-\frac{b_0}{T}}. \quad (11)$$

Writing A_0 for Ae^a we get

$$I = A_0 T^2 \epsilon^{-\frac{b_0}{T}}. \quad (12)$$

It is, I think, this eq. (12), rather than eq. (8), which has been tested so often by means of thermionic emission data and has been found to hold fairly well. Of course, if it can be shown that the a of eq. (10) is zero, eqs. (8) and (12) are identical, A_0 being the same as A and b_0 the same as b , but proof that a is zero is entirely wanting.

In making this statement I am repeating, with some change of form, an argument which I published⁶ only a few months ago. I am now going over the matter again because I find that my previous discussion of it was misunderstood at first by at least one specialist in electronic emission, who thought I was merely repeating Bridgman's suggestion of a temperature variation in the *photo-electric* work function. What I am insisting upon is the possibility of a temperature variation of the thermionic work function even in cases where the photo-electric work function is independent of temperature. The difficulty I meet in trying to make my meaning clear is striking proof of the firmness with which the conception of identity between the two work functions is already established in the minds of some investigators in this field. I shall discuss later in this

paper the possible variation of the photo-electric work function with temperature.

This belief in the equality of the two work functions is based largely on the fact that the value of b_0 in the experimentally approved eq. (12) is found to be, within the limits of experimental error, in accord with the experimentally found value of the photo-electric work function. That is $b_0 = \phi_0 \div k$. Now the reader may well ask at this point whether my assumption that the b of eq. (8) is a different quantity from b_0 , as indicated by eq. (10), is anything more than the recognition of an academic possibility. Is there, then, any cogent argument tending to show that the a in eq. (10) is not zero?

I was led years ago by my study of thermo-electric effects and conduction data, with no reference to the phenomena of emission, to adopt as approximately true for moderate temperatures, between 0°C. and 100°C., this formula,

$$\lambda' = \lambda'_c + skT, \quad (13)$$

in which λ' represents, in ergs, the amount of energy needed to take an electron from an atom and leave it "free," with its full complement of thermal energy, within a metal. In this equation λ'_c and s were taken, provisionally, as constants for any given metal, and λ'_c was small compared with skT even between 0° and 100°C. This formula served me pretty well in dealing with the phenomena I was studying when I adopted it, and I found definite values, doubtless more or less inaccurate, for λ'_c and s in the case of many metals, values which I published⁷ eight years ago. When, later, I began to give serious attention to the phenomena of electron emission, it occurred to me to try the experiment of supposing this equation to hold, approximately, at the high temperatures of measurable emission. At such temperatures λ'_c would be negligible compared with skT , and so it would practically disappear from the equation.

This being understood, if we write ckT for the θ of eq. (1), this equation (1) becomes,

$$\phi = \phi_0 - (s - c)kT, \quad (14)$$

and dividing by k we get, according to definitions already given,

$$b = b_0 - (s - c)T = b_0 - aT, \quad (14^1)$$

which is eq. (10).

I wish especially to emphasize the fact that eq. (13), together with another equation, (15), presently to be given, has proved useful in the explanation of thermo-electric phenomena, for this is no inconsiderable argument in its favor. Thermo-electric effects are small but they are uncompromisingly real and big enough to wreck any electron theory of metals that is framed in disregard of them.

The second equation referred to in the preceding paragraph is

$$n = zT^q, \quad (15)$$

which closely resembles eq. (6), the only difference being the substitution of q in place of 1.5 as the exponent of T . In the studies to which I have already alluded I was led to adopt this eq. (15), with values of q varying from 1.2 in bismuth and in iron to 1.6 in nickel, palladium, and platinum, the mean of all the values being 1.47, a number strikingly close to the value 1.5 assumed by Richardson as holding for metals in general. If now, seeking to revise Richardson's emission formula in accordance with my own notions of electric conduction, I return to eq. (5), I get from it by use of eqs. (10) and (15)

$$I = Fe \cdot \epsilon^a \cdot zT^q \cdot T^{0.5} \cdot \epsilon^{-\frac{b_0}{T}}. \quad (16)$$

Then, putting A' for the approximately constant quantity $Fe\epsilon^a z$, I have

$$I = A'T^q \cdot T^{0.5} \epsilon^{-\frac{b_0}{T}}. \quad (17)$$

Here again I am reproducing, with some changes of form, matter that I have already published.⁸ I have shown (see eq. (23) of the paper just referred to) that according to my theory the factor $\epsilon^a z T^q$ of (16), and so the factor $A'T^q$ of (17), should be the same for all metals. But, as q is different for different metals, A' cannot be the same for all metals.

My conclusion that the factor $\epsilon^a z T^q$ should in general be the same for different metals follows from my conception of the Volta effect between metals, and it can be reached, though it was not so reached in my previous discussion of the matter, without any reference to the phenomena of electron emission. Perhaps the argument is worth giving here. In a paper called *Conditions of Electric Equilibrium at Boundary Surfaces*⁹ are given the two equations

$$e(P + P_a)_\alpha + \kappa_\alpha = e(P + P_a)_\beta + \kappa_\beta \quad (18)$$

and

$$\frac{n_\alpha}{n_\beta} = \exp \left[-e \frac{(P + P_f)_\alpha - (P + P_f)_\beta}{kT} \right]. \quad (19)$$

In these equations subscript α indicates one metal and subscript β another metal, the two metals being supposed in contact with each other; n_α is the number of free electrons per unit volume in α , n_β the number in unit volume of β . For the meaning of the other terms and for the derivation of the two equations here reproduced I will refer the reader to the paper cited.

I rewrite (18) in the form

$$e(P_\alpha - P_\beta) = (eP_a + \kappa)_\beta - (eP_a + \kappa)_\alpha. \quad (20)$$

Substituting for $e(P_\alpha - P_\beta)$ in (19) the value given by (20), I get

$$\frac{n_\alpha}{n_\beta} = \exp \left[- \frac{(e(P_f - P_a) - \kappa)_\alpha - (e(P_f - P_a) - \kappa)_\beta}{kT} \right]. \quad (21)$$

Now the definition of the various terms here involved is such that, λ' being defined by (13),

$$(eP_a + \kappa + \lambda')_\alpha = e(P_f)_\alpha + 2.5 kT,$$

whence

$$(e(P_f - P_a) - \kappa)_\alpha = \lambda'_\alpha - 2.5 kT, \quad (22)$$

where $2.5 kT$ is the total thermal energy acquired by an electron when it is "freed" within the metal. A like equation holds for β .

Accordingly, (21) reduces to

$$\frac{n_\alpha}{n_\beta} = \exp \left[\frac{\lambda'_\beta - \lambda'_\alpha}{kT} \right]. \quad (23)$$

But, as λ' at high temperatures becomes practically skT , we get for such temperatures

$$(n\epsilon^s)_\alpha = (n\epsilon^s)_\beta, \quad (24)$$

and so, by use of equation (15),

$$(\epsilon^s z T^q)_\alpha = (\epsilon^s z T^q)_\beta, \quad (25)$$

or, since $a = s$ minus c , a universal constant (see eqs. (14) and (14¹)),

$$(\epsilon^a z T^q)_\alpha = (\epsilon^a z T^q)_\beta. \quad (26)$$

Of course, if $\epsilon^a z T^q$ is the same for all metals at the same temperature, $F\epsilon^a z T^{(q+0.5)}$ of eq. (16), or the $A'T^{(q+0.5)}$ of eq. (17), is the same for all metals at the same temperature. If now we choose to give the quantity A_0 such a meaning that always

$$A_0 T^2 = A' T^{(q+0.5)}, \quad (27)$$

A_0 must be the same for all metals. But by use of (27) we reduce (17) to the exact form of (12), the familiar Richardson equation. So we must conclude that the A_0 in (12) is a universal constant. Of course, if q is not 1.5, A' and A_0 cannot both be strictly independent of temperature. My s of eq. (13), and so my ϵ^a factor in the value of A_0 and A' , may vary somewhat with temperature; so, too, may my q of eq. (15). A_0 , as a "universal constant," may seem more imposing than my A' , but its advantage in dignity is gained by a loss of physical definiteness. It has an artificial, though exalted, status.

On the other hand, the A of eq. (8) cannot be the same for different metals, unless the a of eq. (10) is the same for all metals.

Thus far I have ignored the possibility that the photo-electric work-function, ϕ_0 , and so $\phi_0 \div k$, which is the b_0 of eqs. (12) and (17), may be a function of T . But Du Bridge¹⁰ has found by experiment a temperature change in the photo-electric work-function of platinum, and Bridgman, in a paper¹¹ already referred to, has discussed the consequences of such a variation. I have nothing to add regarding this matter to what these investigators have discovered, but I will comment briefly upon it in order to bring out clearly the relation of this variation to that variation of the thermionic work-function which I have indicated in eq. (10).

Let us suppose that the following relation holds:

$$\phi_0 = \phi'_0 - \gamma kT, \quad (28)$$

ϕ'_0 and γ being constants. Then we should have also, after dividing by k ,

$$b_0 = b'_0 - \gamma T. \quad (29)$$

Using this value of b_0 , we get from eq. (12)

$$I = A_0 \epsilon^\gamma T^2 \epsilon^{-\frac{b'_0}{T}}, \quad (30)$$

and from (17)

$$I = A'_0 \epsilon^\gamma T^{(a+0.5)} \epsilon^{-\frac{b'_0}{T}}. \quad (31)$$

Now I have been able to show, by use of eq. (26), that the A_0 of eq. (12) is, after absorbing the factor ϵ^a which results from eq. (10), a "universal constant." But I have no equation, corresponding to (26), for showing that $A'_0 \epsilon^\gamma T^a$, of eq. (31), should be the same for all metals, and so I have no way of proving that $A_0 \epsilon^\gamma$ of eq. (30), is a universal constant. If we choose to put A'_0 for $A_0 \epsilon^\gamma$, we get from (30)

$$I = A'_0 T^2 \epsilon^{-\frac{b'_0}{T}}. \quad (32)$$

This eq. (32) is of precisely the same type as eq. (12), if the b_0 of (12), like the b'_0 of (32), is a constant. But metals which in their emission behavior conform to eq. (32) may have an A'_0 value which, because of the absorbed factor ϵ^γ , will be very different from the "universal constant" value of A_0 .

To put the matter in another way, the question whether a in eq. (10) has a value differing from zero cannot be tested by means of emission data, because the presence of a factor ϵ^a in the A_0 of eq. (12) will not cause the value of A_0 to depart from the "universal constant" standard. But the question whether γ in eq. (29) is different from zero can be tested by

emission data, for the factor ϵ^γ in the A'_0 of eq. (32) will, if γ is not 0, cause A'_0 to have an "abnormal" value different from the "universal constant."

Accordingly I cannot by means of electron-emission data test the truth of my proposition that ϕ and ϕ_0 are numerically different, a proposition of great importance in my theory of dual conduction. I can merely show, as I believe the arguments of this paper, taken with those I have previously made,¹² have shown, that no facts already known to us through the study of emission presents any obstacle to the acceptance of this proposition. The evidence in favor of it, and so in favor of my dual conduction theory, is to be sought elsewhere, particularly in the phenomena of thermo-electric action and in the Volta potential-difference. I believe that no uniformitarian theory of conduction in metals has dealt successfully with these effects.

Summary.—If ϕ is the thermionic work-function, defined as the amount of work against opposing forces required to remove an electron from a metal by thermionic action, and if ϕ_0 is the photo-electric work-function, defined as the amount of energy which must be supplied in order to take an electron photo-electrically from the same metal, both experimental evidence and thermodynamic argument are in accord with the proposition that

$$\phi = \phi_0 - akT, \tag{A}$$

where a is a number, approximately constant, characteristic of the metal, and k is the gas constant for a single molecule. If we let $b_0 = \phi_0 \div k$, and $b = \phi \div k$, eq. (A) becomes

$$b = b_0 - aT. \tag{B}$$

Proof that (B) is in accord with experimental evidence, as furnished by emission data, has been given in a previous paper (see footnote 6); the thermodynamic argument is given for the first time in the present paper. It is there shown that, when Bridgman gives a thermodynamic proof that the photo-electric work-function and the thermionic work-function must be equal or must differ only by a universal constant, he is using a definition of work-function essentially different from that employed in the definitions given above for ϕ_0 and ϕ .

1. *If ϕ_0 , and so b_0 , is a constant independent of T :* In this case the author's ideas, applied in accordance with the general "classical kinetic theory" of thermionic emission originally framed, though later discarded, by Richardson, give as the expression for thermionic emission

$$I = Fe \cdot \epsilon^a \cdot zT^q \cdot T^{0.5} \epsilon^{-\frac{b_0}{T}}, \tag{C}$$

where Fe is a universal constant and zT^q , z and q being approximately

constants, represents n , the number of "free" electrons in unit volume of the metal. Putting A' for $Fe \cdot \epsilon^a z$, we get from (C)

$$I = A' T^q \cdot T^{0.5} \cdot \epsilon^{-\frac{b_0}{T}}. \quad (D)$$

It is shown that $A' T^q$ is the same for all metals at the same temperature, but, as q is different for different metals, though in most cases not far from 1.5, A' is not the same for all metals and is not, in general, strictly a constant for any given metal.

If we choose to give A_0 such a value that $A_0 T^{1.5}$ shall be always equal to $A' T^q$, then A_0 must be a universal constant, and with this substitution eq. (D) becomes

$$I = A_0 T^2 \cdot \epsilon^{-\frac{b_0}{T}}, \quad (E)$$

the familiar Richardson form.

2. If the photo-electric work-function is a function of temperature, to be represented now by $\phi_0 - \gamma kT$, where ϕ_0 and γ are constants: In this case we must put $b_0 - \gamma T$ in place of b_0 , and thus we get, in place of eq. (D),

$$I = \epsilon^\gamma \cdot A' T^q \cdot T^{0.5} \cdot \epsilon^{-\frac{b_0}{T}}. \quad (F)$$

and in place of (E)

$$I = \epsilon^\gamma A_0 T^2 \epsilon^{-\frac{b_0}{T}}.$$

The factor ϵ^γ corresponds exactly to the factor ϵ^a which Du Bridge, following a suggestion of Bridgman, has used in a recent paper. Du Bridge¹³ has nothing corresponding to the factor ϵ^a of eq. (C), or, rather, he treats this factor as 1 in all cases, assuming a , in eq. (B), to be zero.

¹ *Phys. Rev.*, **31**, 236, 1928.

² *Proc. Nat. Acad. Sci.*, **13**, 56, 1927.

³ *Phys. Rev.*, **31**, 90, 1928.

⁴ *Ibid.*, **31**, 862, 1928.

⁵ *Proc. Nat. Acad. Sci.*, **13**, 315-326, 1927.

⁶ *Ibid.*, **15**, pp. 126-127, 1929.

⁷ *Ibid.*, **7**, 98-107, 1921.

⁸ *Ibid.*, **13**, 315-326, 1927.

⁹ *Ibid.*, **11**, 111-116, 1925.

¹⁰ *Ibid.*, **14**, 792, 1928.

¹¹ *Phys. Rev.*, **31**, 862, 1928.

¹² See, for example, my discussion of "pulled out" electrons in *Proc. Nat. Acad. Sci.*, **15**, 241-251, 1929.

¹³ I think that Du Bridge, after a recent correspondence between us, makes no objection to the views which I have expressed in this paper, though he doubtless reserves judgment as to some of them.