Electrician quite recently and I still (as I mentioned at the time to Miss Jones who was staying with me when they appeared) do not see how the second law of thermo dynamics can enable us to distinguish between negative resistance and an adjuvant E.M.F whose value is proportional to the current when there is also a back E.M.F in the same circuit.

Gray takes the view that (as you will see from his last letter in the Electrician) the name resistance must be given to the coefficient of the dissipation term: and, therefore if experiment shows that the rate of change of electric energy into heat in the arc for a particu-

41, Kensington Park Gardens.
W.

November 28th 1896

Dear Fitzgerald, 26/41

Have you had time yet to glance at Frith and Rodgers' paper on the "Resistance of the Arc" published in this month's Phil. Mag. and reprinted a fortnight ago in the Electrician There also appeared a second very interesting letter by A. Gray of Bangor?

In any case I enclose you a copy of the paper on the arc, as well as of another communication which also appeared in this month's Phil. Mag.

As mentioned by you in the first of your two letters to the Electrician, the leader in that paper of some months ago quite disposes of S.P. Thompson's objection that a negative resistance cannot, of course, exist alone; indeed I tried to hammer that into people at the Physical Society's Meeting before S.P. Thompson's paper appeared, but I suppose they were in a fog.

But now comes a more important question; if it be admitted that I never suggested that an apparent negative resistance existed in the arc without a back E.M.F., is your objection quite valid, viz. that a conversion of heat into electric energy cannot exist without difference of temperature, and therefore that a negative resistance is an unsuitable name for the effect which I referred to at the B.A. meeting at Ipswich in 1895?

In other words does the second law of thermodynamics help us in the least, if it be once admitted that in the arc two things take place viz a conversion of heat into electric energy (called by me the effect of a negative resistance) accompanied with a conversion of a greater amount of electric energy into heat due to the back E.M.F. which I started by assuming to exist for the purposes of discussion.

I have read your two letters in the

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made up of a term $-\underline{a} A \times A$ a of two terms as Gray says, $-\underline{a}_1 A \times A + \underline{a}_2 A^2$; I see no reason for not calling the coefficient $-\underline{a}$ a negative resistance

What rather surprises me is that people seem quite prepared for a proof, should such be forthcoming, that what is called the resistance of a wire should be called the $\int \frac{e}{A} dl$ where A is the current flowing, and $\underline{e}$ the back E.M.F. in the wire per unit length, but they totally scout the idea that if electric energy be converted into heat at a rate equal to EA and heat into electric energy at another part of the circuit at a rate equal to $-\underline{a} A^2$, $\underline{a}$ may be called a negative resistance Very sincerely Yours

W. H. Eyston

current of value A amperes, & given by

$$EA - aA^2 \text{ watts,}$$

it follows that the term $\underline{a}$ must be the physical sum of two coefficients $\underline{a}_1$ and $\underline{a}_2$, of which $\underline{a}_1$ is the greater; so that the rate of conversion of electric energy into heat becomes

$$EA - a_1 A^2 + a_2 A^2 \text{ or } (E - a_1 A) A + a_2 A^2.$$

And he considers that $a_1 A$ is part of the back E.M.F.

But here again it seems to me that, although Gray's letters are infinitely more suggestive and scientific

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than those of S. P. Thompson; the question is really settled by Fray on the basis of a pre arranged definition

My position on the other hand is different, and I should be much obliged if you would tell me whether there is anything contrary to the laws of thermodynamics in my way of putting the matter thus:— if it be desired to express the power given to an arc by two terms one of which is proportional to the current and the other to the square of the current; experiments show that in the case of an arc between solid carbons the coefficients may be found for any current which remain constant for small variations in the current, but that in the case of the arc between solid carbons the coefficient of the term giving always the square of the current is negative

Now when we have no other means of discriminating between a resistance and an E.M.F. than by finding out whether the power varies as the first or the second power of the current we call the coefficient of the rate of transformation a resistance when the power varies as the square of the current, even although, as in the case of the ordinary wire, what we call the effect of resistance may be due to a distributed back E.M.F.

Hence failing any test which shows that the term — a A^2 in an arc is really

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