



LVII. The effect of wave form on the alternate current arc

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another, with a double sliding-contact between them, as shown in fig. 2. Then, in whatever position the slider may be, the fundamental ratio $ay = bx$ is always maintained, and the first condition of the Kelvin bridge is mechanically fulfilled. The one adjustment consists in moving the double slider along the bridge until there is no deflexion of the galvanometer at g ; in which case

$$\frac{a}{b} = \frac{x}{y} = \frac{R}{r}.$$

Since writing the above, I have referred to the original paper of Lord Kelvin (Proc. Roy. Soc. vol. xi. p. 313, 1861), and find that he proposes the use of parallel slide-wires for his auxiliary conductors; I have no doubt he had in view some such apparatus as that which I have here suggested. A Kelvin bridge with a single slide-wire was used by Matthiessen and Hockin in their differential method; it is described by Clerk-Maxwell in 'Elec. and Mag.' vol. i. p. 406 (1873).

LVII. *The Effect of Wave Form on the Alternate Current Arc.*
By JULIUS FRITH, 1851 *Exhibition Scholar* *.

IN the paper by Dr. Fleming and Mr. Petavel, recently read before the Physical Society, on the Alternate Current Arc†, I think too little attention was paid to the wave form of the alternate current used.

It is known that if the arc is allowed to exert a preponderating influence at all on the alternate current circuit, it alters the wave form of both the current and the P. D. in a very marked degree.

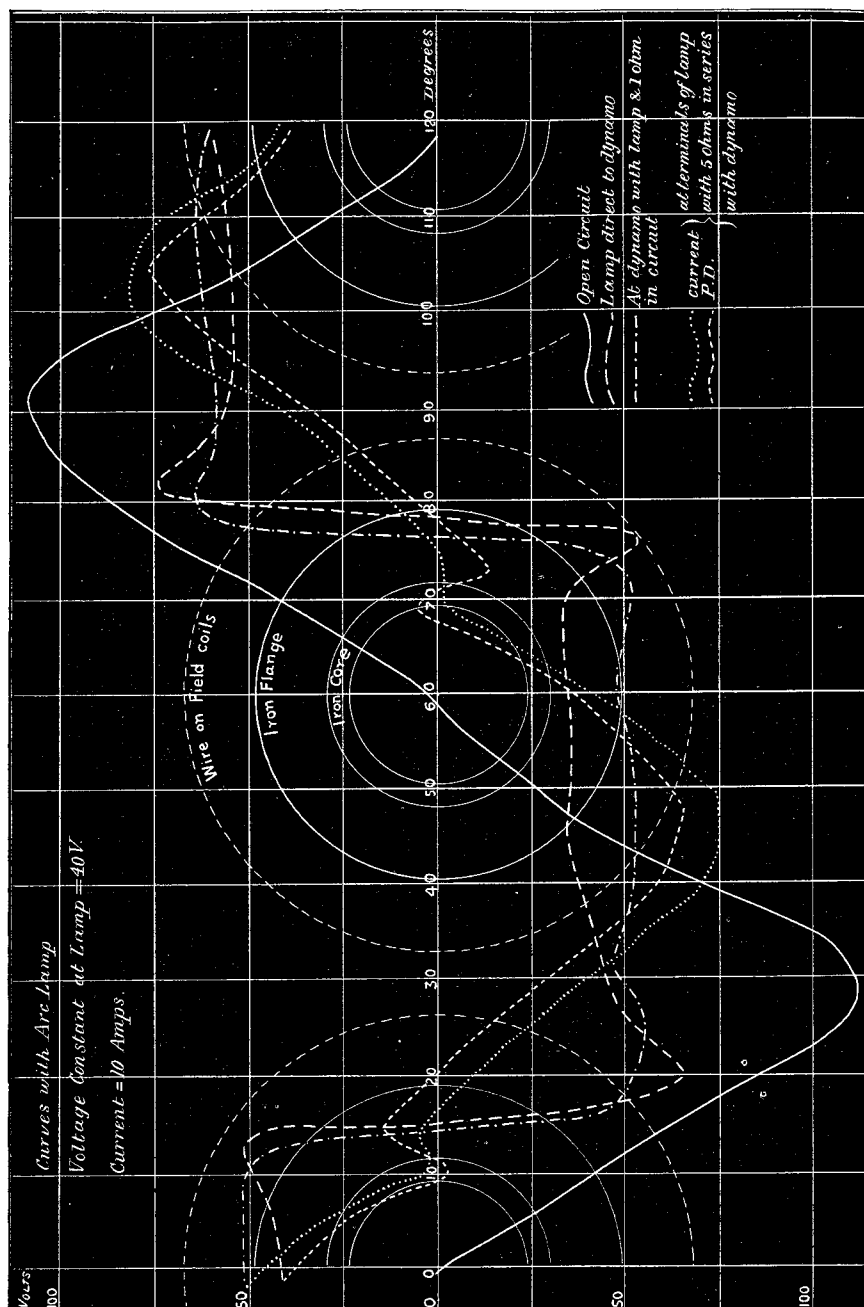
As an illustration of the change produced in the wave form by the character of the external circuit, I give some curves for alternate current arcs taken from a paper which I read before the Manchester Literary and Philosophical Society in March 1894.

Here is shown, first the E.M.F. curve of the machine on open circuit, which is rather more peaked than a sine curve and involves the third harmonic largely. Next is shown the curve obtained under the same conditions, but with an arc lamp taking 10 amperes at 40 volts joined direct to the machine.

The lag recorded is due to the self-induction of the machine,

* Communicated by the Physical Society: read April 24, 1896.

† *Supra*, p. 315.



which was a "Wilde" alternator, the armature of which contained iron.

It will also be noticed that the first ordinates of the curves are not quite equal to the last ordinates; this is due to the curve being slightly asymmetrical. The whole period is only one third of the revolution of the alternator (shown as 120 degrees in the figure). In one complete revolution this lack of symmetry would of course disappear.

It is seen that the arc alters the wave form from a peaked curve to a very flat topped curve, changing sign almost instantaneously, and with two small maxima, which occur respectively just before and just after each reversal. The next curve shows the effect of adding a resistance of 1 ohm in series with the arc. This smooths out the two maxima, but otherwise does not affect the shape materially.

The current and P.D. curves with 5 ohms in series with the arc are next shown. Both waves now assume much more the form of the E.M.F. curve on open circuit, except at the zero line. Here the P.D. curve crosses the line twice in each direction, and the current curve runs parallel to the zero line for some way before crossing it.

These curves show, I think, the great effect that the arc has on the wave form, and also how this effect can be destroyed by placing resistance in series with the arc.

In a paper by Rössler and Wedding, which appeared in the 'Electrician' for August 31st, 1894, it was proved that an alternate current arc is more efficient, that is, gives a higher candle-power for the same electric power consumed, when the alternating current feeding it has a flat-topped than when it has a peaked wave form.

Rössler was, however, mistaken, I think, in assuming that the machine was making that curve. Indeed, this mistake runs through the whole of this otherwise most valuable paper. Rössler took three machines giving, as he thought, wave forms from the extremely peaked to the extremely flat wave, and determined the efficiencies of the same arc lamp for each of them. Whereas exactly the same results might have been obtained from one machine alone on causing it to give a higher voltage by increasing the field excitation and then absorbing the excess of voltage in resistance, exactly as in the case of the Wilde alternator above referred to.

I understand that in the experiments described by Dr. Fleming and Mr. Petavel there was always a resistance amounting to 7 ohms outside the arc, and hence a wave form was forced upon the arc which, as Rössler has proved, is not the most efficient one, and which the arc would convert into a

form better suited to itself if it had been allowed to do so, as it is in commerce. This consideration must affect, not only the efficiency, but also the curves which Fleming and Petavel obtained for the variations in the luminous intensity.

Further, this action of the arc in modifying the wave form may throw some light on the discrepancy between the efficiency of alternate current arcs as determined in the laboratory and that stated to be obtained in practice.

When an arc is run in the laboratory a large resistance is almost certain to be put in series with it to ensure that degree of steadiness which is essential to exact measurement, and hence the arc cannot alter the wave form. In the commercial use of arcs, on the contrary, the circumstances are widely different. In this case, for economic reasons, the arc must form a large percentage of the total "reactance" of the circuit, and therefore can easily alter the wave to the form required for the greatest efficiency.

It is interesting to note that the wave form giving the best result for the arc is almost exactly the opposite to that giving the best efficiency for transformers. In the former case a flat-topped wave is best, while for the maximum efficiency of transformers an exceedingly peaked wave is best, as lately found by Dr. Rössler.

This points to the building of alternators for use with transformers in such a way as to give peaked wave-forms.

In the case of the arc the building of machines to give the most efficient wave form is not so necessary, since, generally, the arc itself has the power of automatically converting *any* wave form into the one best suited to its requirements. Nevertheless, when the arc has to run in series with a large resistance it is of the utmost importance for obtaining the best efficiency that the machine should give a flat-topped wave.

City and Guilds of London Central Technical College,
April 2, 1896.

LVIII. *On the Calculation of the Conductivity of Mixtures of Electrolytes having a common Ion.* By DOUGLAS M^CINTOSH, Physical Laboratory, Dalhousie College, Halifax, N.S.*

IN a paper published in the April number of this Magazine (*supra*, p. 276) Prof. MacGregor showed how to obtain, by a graphical process, from observations of the electrical conductivity of a sufficient number of simple solutions

* Abstract of a paper read before the Nova Scotia Institute of Science on the 13th of April, 1896. Communicated by the Secretary of the Institute.