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Two Shillings and Sixpence Net

below the rectifier unit are the four condensers used for smoothing out the current from the rectifiers. The single oscillating valve is placed to the right of the rectifiers and appears on the extreme right of Fig. 13. Fig. 14 shows the additional apparatus required to couple the valve to the existing aerial circuit, together with a further view of the oscillating valve on the left. In the centre of Fig. 14 is the grid coupling coil. One part of this is connected in series between the aerial tuning inductance and earth. The upper part is connected to the grid, and in this set a variable condenser is used in parallel with this inductance in order to tune the grid circuit. The cylindrical object at the back of this condenser is the resistance R_3 of Fig. 5. The small magnetic switch in the front of Fig. 14 is the switch changing over the aerial connections from the earth connection to the receiving instruments in the interval between the Morse signals.

Fig. 15 shows the complete set of additional apparatus required for use with a much more powerful installation.

The complete rectifier unit is on the right, with the smoothing condensers below.

Three oscillating valves are used in parallel, the three filament regulators being situated immediately beneath them.

The grid coupling coil and grid circuit tuning condenser are in the centre on the left, and the R_3 resistance is in the left-hand top corner. At the bottom, on the left, is the alternator field regulator, and between it and the smoothing condensers are two transformers supplying the filament current for the valves.

In conclusion, the author would like to add a word of thanks to the staff of the W/T Department of H.M. Signal School, Portsmouth, for the assistance given in the preparation of this paper.

A Trigger Relay Utilising Three-Electrode Thermionic Vacuum Tubes.

By W. H. ECCLES, D.Sc., and F. W. JORDAN, B.Sc.

Paper read before Section G (Engineering) of the British Association.

In a well-known method of using a triode for the amplification of wireless signals an inductive coil is placed in the filament-to-anode circuit, and another coil magnetically coupled with this is introduced into the filament-to-grid circuit. This "back-coupling," as it is sometimes conveniently called, if it is arranged in the right sense, greatly exalts the magnification produced by the tube in any alternating E.M.F. applied to the grid; for the induced E.M.F. passed back to the grid is in correct phase relation to add directly to the original alternating E.M.F. applied there. If, instead of using inductive retroaction of this kind, we attempt to use resistance back-coupling, then the retroactive E.M.F. applied to the grid is exactly opposite in phase to the original alternating E.M.F., and the amplifying action of the triode is reduced. Since, however, one triode can produce opposition in phase in the manner indicated, it is clear that two or any even number of similar triode-circuits arranged in cascade can produce agreement in phase. Hence we conclude that retroactive amplification can be obtained by effecting a back-coupling to the first grid from the second, fourth, and so on, anode circuit of a set of triodes arranged in an ohmically-coupled cascade.

It is possible to take advantage of the fact above stated for obtaining various types of continuously-acting relay, but the purpose of the present communication is to describe what may be called a one-stroke relay which, when operated by a small triggering electrical impulse, undergoes great changes in regard to its electrical equilibrium, and then remains in the new condition until re-set.

In what follows, the circuit comprising the space in the tube between anode and filament, the external conductors and the source of E.M.F., will be called the anode circuit, and the current flowing in it the anode current. The circuit comprising the space in the tube between the grid and the filament, external conductors and a source of E.M.F., will be called the grid circuit, and the current flowing in it the grid current.

The operation of the relay is most easily explained when two tubes, each with resistances and battery in its plate circuit, and with a resistance and battery in its grid circuit, are used and interconnected in the manner shown in Fig. 1.

The electrical stimulus from outside which it is desired to detect and magnify is applied in the grid circuit in the first tube so as to make the grid transiently more positive in potential relative to the filament. This causes an increase of current in the plate circuit of the first tube, and consequently an increase of the P.D. between the terminals of the plate circuit resistance. This increased P.D. is transferred to the grid circuit of the second tube in such a manner that the grid becomes more negative than before relative to its filament. Consequently the plate current of the second tube decreases, and the P.D. between the terminals of its plate circuit resistance decreases also. This decrease of P.D. is now transferred to the grid circuit of the first tube in such a manner that it tends to make the grid more positive relative to the filament. The result of these processes is that a positive stimulus from outside given to the grid of the first tube initiates a chain of changes which results finally in the plate current of the first tube attaining the highest value possible under the E.M.F. of its battery, and the plate current of the second tube falling to its lowest possible value. This condition, therefore, persists after the disappearance of the initial stimulus. In the initial condition, with the two-tube arrangement just described, the plate current of the first tube is made very small, and that of the second tube large; after the reception of the outside stimulus on the grid of the first tube the final condition is a large plate current in the first tube and a small plate current in the second tube. Either the decreases or the increases of plate current can be used for indicating. In order to restore the initial conditions it is easy to interrupt for an instant the linkage between the tubes, or to stop the operation of one or both of the tubes, as, for instance, by dimming its filament.

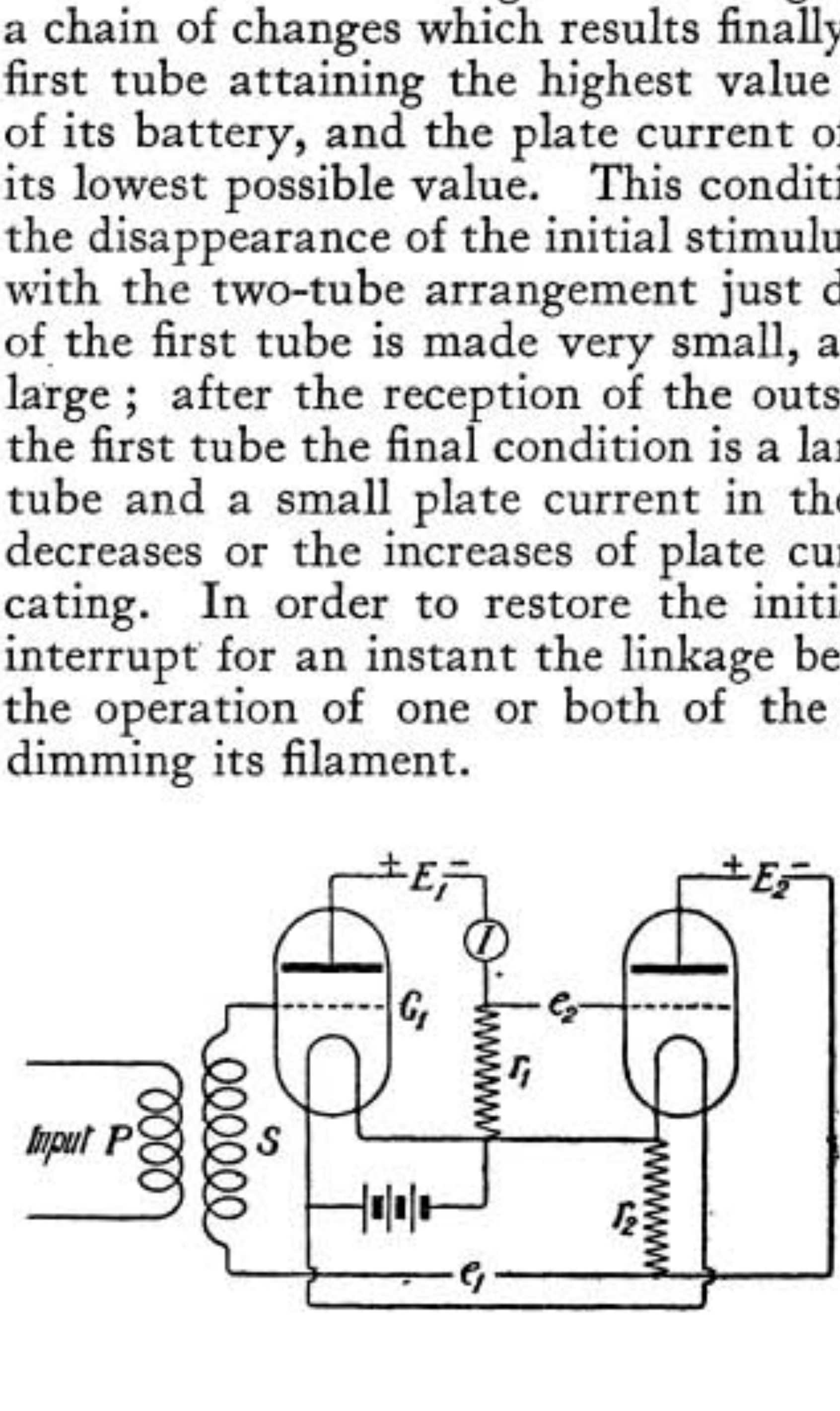

FIG. 1.

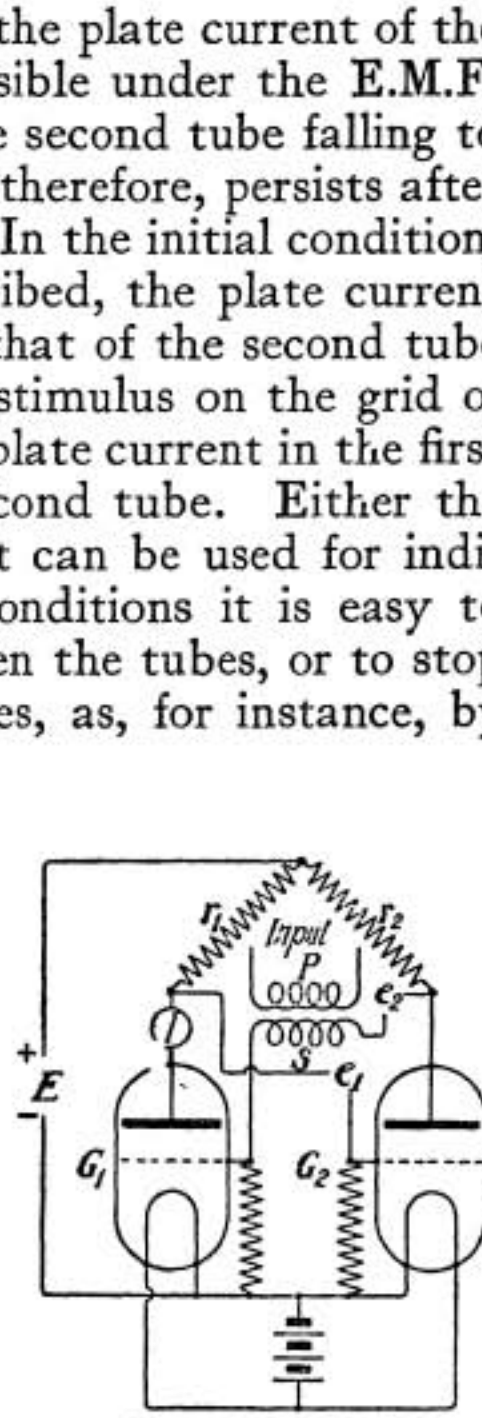

FIG. 2.

The external stimulus is led into the primary P of transformer PS, of which the secondary is connected to grid G_1. The plate circuit of this first tube contains the indicating instrument I, such as an ammeter or a moving tongue relay. The resistance r_1 in the plate circuit of the first tube has its terminals connected to the filament and grid of the second tube. Similarly, the resistance r_2 in the plate circuit of the second tube has its terminals connected to the filament and the grid of the first tube. The plate circuits contain batteries E_1, E_2, and the grid circuits batteries e_1, e_2. The following values are typical, and show the performance of the relay :—

$E_1=78$ volts.	$E_2=74$ volts.
$r_1=22{,}000$ ohms.	$r_2=12{,}000$ ohms.
$e_1=31$ volts.	$e_2=17{\cdot}5$ volts.

The change in the indication of an ammeter at I is from $0-2{\cdot}5$ micro-amperes.

The sensitiveness of the arrangement depends on the transformer PS to some extent. Using a telephone transformer of the kind made for Army C Mk. III. Amplifier with 20 ohms resistance in the primary, and with the primary connected to a Brown telephone of 60 ohms resistance, the relay is operated with certainty by snapping the thumb and finger at a distance of five feet from the telephone.

Fig. 2 shows another mode of inter-connection of two tubes. The stimulus from outside is introduced to the grid of the first tube through a transformer, as before, and the indicating instrument is again placed in the plate circuit of the first tube. The two plate circuits are in parallel with a common battery E, and the connections are such that the changes of P.D. between the anode and the filament of the first tube are imposed between the filament and grid of the second tube, and the changes of P.D. between the anode and filament of the second tube are imposed between the filament and grid of the first. In order to help to maintain the grids' advantageous potentials, grid leak resistances are connected as indicated.

The following numerical values are typical dimensions :—

$$E=80 \text{ volts}$$
$$r_1=r_2=100{,}000 \text{ ohms.}$$
$$e_1=e_2=40 \text{ volts.}$$

The sensitiveness of this relay could be made greater than that of Fig. 1, when these large resistances are used.

The devices just described were the subject of a patent, numbered 10290/1918, taken out by the Admiralty, and the description is now published by permission.