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A schematic diagram of an electronic circuit, likely a vacuum tube amplifier or detector. The circuit includes a power supply section with a battery (2) and a variable capacitor (1) connected to a coil (15). The main circuit features a vacuum tube (4) with a filament (3) and a grid (4'). The tube is connected to a series of components: a coil (12), a battery (10), a coil (11), and a switch (13). The tube's internal structure is shown with a cathode (6), a grid (7), and a plate (8). The circuit is completed by a coil (14) and a switch (5).

A graph showing a function curve. The curve starts at the origin, rises to a peak labeled 17, then descends through a point labeled 16, reaches a local minimum labeled 19, and finally rises slightly towards a point labeled 18.

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UNITED STATES PATENT OFFICE.

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PRODUCING AMPLIFIED CURRENT VARIATIONS.

No. 921,930.

Specification of Letters Patent.

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To all whom it may concern:

Be it known that we, EZECHIEL WEINTRAUB, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, and MARIUS C. A. LATOUR, a citizen of France, residing at Paris, France, have invented certain new and useful Improvements in Producing Amplified Current Variations, of which the following is a specification.

It is desirable in many instances, as for example, in the arts of telegraphy, telephony and wireless telegraphy to be able to produce large current variations in response to small current disturbances or pulsations. The weak current impulses at the receiving station of a wireless telegraph system or at the receiving end of a telegraph line, by being thus magnified or reproduced in greater magnitude, may thus be rendered much more easily and readily detected.

Our present invention relates to a device suitable for accomplishing such purposes, though we wish it to be understood that its field of usefulness is not to be limited to the particular embodiment described.

In carrying our invention into practice we make use of the fact, observed by us, that the resistance, if we may so use the term, of a mercury vapor device or lamp, instead of being approximately inversely proportional to the current when such a lamp is operated normally with a mercury arc, is of widely different character when the current discharge or flow in the lamp is less than that necessary to maintain an arc. In such a case the voltage across the tube instead of being constant with variations of current decreases rapidly with increase of current. The resistance of the tube may thus be said to be negative. This property we utilize by connecting the tube in circuit in such a way that the voltage impressed thereon is varied in response to the signal currents or other currents which may be utilized to secure the desired amplified current variations. It will thus be seen that if the signal wave tends to increase the voltage in the circuit of the lamp or vapor device, there will be an extraordinary decrease in the resistance of the tube and a corresponding increase in the current. To secure the benefits of our invention we will point out that the current in the receiving lamp or vapor device must be less than that which would

produce and maintain an arc discharge, since it is only through this low current range of the volt-ampere characteristic that the voltage across the terminals of the tube decreases with increase of current.

The features of novelty which characterize our invention are pointed out with particularity in the appended claims. The invention itself, however, will be better understood by reference to the following description taken in connection with the accompanying drawings, in which—

Figure 1 represents diagrammatically one embodiment of our invention, while Fig. 2 is an explanatory diagram.

In Fig. 1 the source of current variations or signal currents is represented conventionally by a microphone or transmitter 1 of any suitable form associated with a local circuit containing a source of current such as the battery 2. It will be understood that such a source of current variation is intended merely as illustrative and that to any other source our invention may be applied according to circumstances. The transmitter 1 and battery 2 are arranged in local circuit including the primary 3 of a transformer and a vapor electric device 4. The primary 3 receives the current pulsations and transmits them inductively by means of the secondary winding 4' to any desired point distant or otherwise, where they may be received by a telephone receiver 5 or by any other suitable receiving device.

The vapor electric device 4 consists of an evacuated glass vessel or container of any suitable form and is provided with a plurality of electrodes. The electrode 6 of mercury is the main negative electrode or cathode and is provided with a small platinum wire 7 projecting from its surface to render the cathode spot of the arc discharge stationary. The arc discharge referred to is maintained constantly between this cathode 6 and the anode 8 of artificial graphite or other suitable material. An auxiliary electrode 9 of mercury arranged adjacent to the cathode 6 serves in a well-known way to permit the arc to be started between the electrodes 6 and 8. The source of current for this arc may be of any suitable character as for example, a battery 10. This battery is connected at one end to the cathode 6, while its other terminal is connected through the current-limiting resistance 11 to the

electrodes 8 and 9. When the arc between the auxiliary electrode 9 and electrode 6 is produced by shaking the apparatus to produce momentary contact, another arc is immediately formed between the cathode 6 and the anode 8. The starting arc being no longer necessary the auxiliary 9 may be cut out of circuit either by the presence of a resistance 12 or by a switch 13.

When the arc between the anode 8 and the cathode 6 is in existence the space between the cathode 6 and any other electrode, such as 14, is rendered conductive for current from any suitable source. In the arrangement shown, the source of current 2 in the local circuit connected across the electrodes 6 and 14 operates to cause a flow of current, normally of constant value, across the space between these electrodes. The resistance of this local circuit is adjusted, as for example, by a resistance 15, so as to keep the current at a value lower than that which would produce an arc between the electrodes 6 and 14 in the vapor device 4. The current which then flows is of the nature of a leakage current and obviously is of relatively small value. The volt-ampere characteristic of the vapor device or tube covering the range in which the current flow in the tube is never sufficient to produce an arc, is represented at 16 in Fig. 2 of the drawing in which ordinates of the curve indicate voltages across the tube, while abscissæ represent currents. In both cases the voltages and currents are reckoned from the origin 0. It will be noted that within that range on the curve 16 between the points 17 and 18, the voltage on the tube decreases rapidly with increase of current.

The local circuit in Fig. 1 being adjusted to come within the range of currents between 17 and 18, it will now be evident that a slight decrease of resistance, due to the action of the transmitter 1, will have the effect, in the first instance, of causing an increase of current in the local circuit. Coincidentally therewith the voltage across the terminals of the electrodes 6 and 14 will drop, as seen by the curve in Fig. 2, and the current will still further increase until the increased drop in resistance in the circuit external to the vapor device cuts down the voltage impressed on the tube to a point where a balance is reached. It will thus be evident that a much larger relative variation of current will be produced by the action of the transmitter 1 than would be the case if the resistance, so-called, of the device were not negative.

Where we have spoken of the resistance of the vapor device as being negative, we desire to distinguish from a condition which would be present if an arc were actually to be allowed to form in the device. If this

were the case the tube would then be working on the flat or rising portion 19 of the volt-ampere characteristics in which case, within working limits, the voltage across the tube would be practically constant irrespective of current variations. By working on that portion of the volt-ampere characteristic at which the tube voltage decreases with increase of current, we obtain a very great amplification of current variations. We are enabled to work on this portion of the volt-ampere characteristic by maintaining continuously an auxiliary arc from the cathode 6 and thereby secure the advantageous results before mentioned.

What we claim as new and desire to secure by Letters Patent of the United States, is,—

1. The combination of a vapor electric device, means for causing current to flow therein of a value less than would be sufficient to maintain an arc, and means for instituting current disturbances in the circuit of said vapor device, which current disturbances are greatly magnified by the negative resistance characteristic of the device.

2. The combination of a vapor electric device, means for initially operating said device at a current density less than that necessary to produce an arc, and means external to said device for varying the resistance in the circuit thereof.

3. The combination of a vapor electric device, means for rendering the same conductive for current, means for passing current therethrough of a value insufficient to maintain an arc, and means for instituting current variations in said circuit.

4. The combination of a vapor electric device, means for rendering the same conductive for current, means for passing current therethrough of a value insufficient to maintain an arc, means for instituting current variations in said circuit, and means for noting said current variations.

5. The combination of a vapor electric device, means for maintaining said device in a conductive condition, means for passing current therethrough of a value insufficient to maintain an arc, and means for instituting current variations in said circuit.

In witness whereof, WEINTRAUB has hereunto set his hand this 11th day of October, 1907, and LATOUR has hereunto set his hand this 9th day of November, 1907.

EZECHIEL WEINTRAUB.
MARIUS C. A. LATOUR.

Witnesses to Weintraub:

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