R. V. L. HARTLEY.

ELECTRICAL CIRCUIT.

APPLICATION FILED SEPT. 13, 1915.

1,183,875. Patented May 23, 1916.

Fig. 1

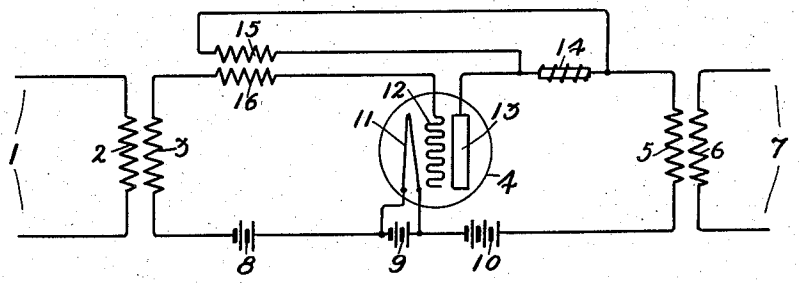
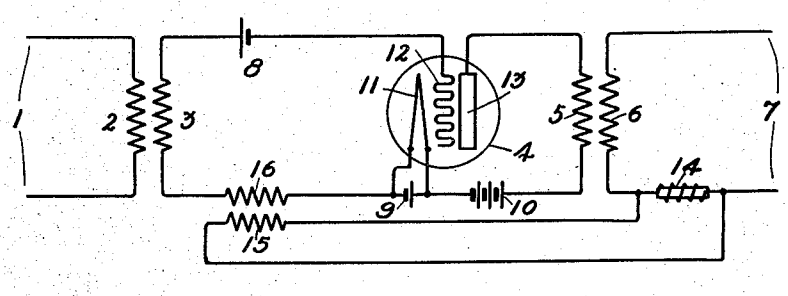


Fig. 2.



Witnesses:

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by A. C. Stanwell Atty.

UNITED STATES PATENT OFFICE.

RALPH V. L. HARTLEY, OF NEW YORK, N. Y., ASSIGNOR, BY MESNE ASSIGNMENTS, TO WESTERN ELECTRIC COMPANY, INCORPORATED, A CORPORATION OF NEW YORK.

ELECTRICAL CIRCUIT.

1,183,875. Specification of Letters Patent. Patented May 23, 1916.

Application filed September 13, 1915. Serial No. 50,441.

To all whom it may concern:

Be it known that I, RALPH VINTON LYON HARTLEY, a citizen of the United States, residing at New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Electrical Circuits, of which the following is a full, clear, concise, and exact description.

This invention relates to electrical circuits containing amplifiers, in particular to such circuits in which an electrical coupling exists which is capable of transferring power from the output terminals of an amplifier to its input terminals. As is well known, the effect of such a coupling is to produce a tendency toward free oscillation or "singing" of the system, which is undesirable in those cases in which the network is to be used to faithfully reproduce in amplified form the power impressed upon its input terminals. It is further well known that in some amplifiers, notably in those of the three-element "audion" type, such a coupling cannot be avoided, being due to the mutual capacity of the elements of the structure, and the object of this invention is, therefore, to provide means for overcoming or neutralizing the effect of this coupling, to the end that a greater amplification of input power may be obtained without resulting instability of operation.

As an aid in understanding this invention, the following facts concerning amplifying networks are cited. In any amplifying network, power is introduced into the input terminals, amplified or increased in amount, and passed out from the output terminals. If there is some electrical path leading from the output circuit back to the input circuit, some of this amplified power is again applied to the input circuit and is re-amplified. This process is then repeated and goes on without limit. It will be obvious that if the amplifying power of the repeater is so large that the power lost by passage back from the output circuit is less than the power gained in going from input to output circuit, an unstable condition will be set up in which the power in the output circuit is maintained independently of any source of power in the input circuit; that is, singing is set up, in which case the system is evidently unfit for use as a repeater. The amplification allowable before such singing takes place is, therefore, greater the less direct is the connection between circuits; in fact the allowable amplification is inversely proportional to the mutual impedance of the two circuits. It therefore follows that no singing can occur for any amplification whatever if this coupling is sufficiently small, that is, if the electromotive force induced in the input circuit by currents in the output circuit is small. Now, in the thermionic repeater it is impossible to eliminate this coupling, and the present invention contemplates introducing still another electromotive force into the input circuit and so adjusting it, as to amplitude and phase, that it shall annul the effect of the electromotive force introduced by the first mentioned unavoidable coupling inside the repeater itself. The application of this idea to amplifying networks containing some such unavoidable coupling is illustrated in the drawings, in which—

Figure 1 shows a typical amplifying arrangement in which an inductive coupling of input and output circuits is secured by breaking the output circuit and closing this break through one winding of a transformer, whose other winding is included in the input circuit. Fig. 2 shows another form in which coupling is not made directly to the output circuit of the repeater but to a circuit coupled to it.

In these figures the same numerals denote corresponding parts.

In Fig. 1, 1 is an incoming line or circuit, the power of which is to be augmented; 2 is the primary of a transformer of which 3 is the secondary, said transformer serving to introduce power into the amplifying system; 4 is a thermionic repeater containing filament 11, grid 12 and plate 13; 8, 9, 10 are batteries for use as usual in connection with such repeaters; 14 is a high impedance choke coil which allows practically unobstructed passage of direct current; 15 is one winding of a transformer whose other winding is 16, the function of this transformer being to annul that coupling of input and output circuit which results from the association of elements inside the repeater itself. The action of the high inductance choke coil 14 is to cause the greater part of the alternating current in the output circuit to flow

through winding 15, thus inducing in 16 an electromotive force whose magnitude and phase may be adjusted by varying the coupling of the coils 15 and 16. 5 is a transformer winding in the output circuit of the repeater; 6, a second winding of the same transformer, and 7 an outgoing circuit to which power is communicated by the last mentioned transformer.

In Fig. 2, the choke coil 14 is shown connected in the outgoing circuit 7 instead of directly to the output circuit of the repeater. This choke coil may be often omitted in either circuit arrangement, since its only function is to prevent the flow of direct current in the transformer used for coupling input and output circuits.

In the operation of this network, an electromotive force impressed upon the input circuit produces a current in the output circuit, which current, through the agency of the coupling inside the repeater, induces a further electromotive force in the input circuit. As has been stated, the present invention consists in opposing to the last named electromotive force another which is obtained, in the typical cases illustrated, by the transformer coupling 15, 16. The method of using the invention consists in adjusting the coupling and impedance of the said transformer connection until the amplification of the repeater element can be increased to the value desired without introducing instability. This adjustment is ordinarily best made by varying the coupling rather than by introducing impedance into the transformer connections.

It is obvious that other methods of coupling may be adopted to accomplish the same object of annulling the effect upon the input circuit of currents in the output circuit without departing from the spirit of this invention.

What is claimed is:

1. An electrical network containing a thermionic amplifier having an input and an output circuit, said output circuit being adjustably coupled to said input circuit to oppose the effect upon said input circuit of currents in said output circuit.

2. In an electrical network containing an amplifier having an input circuit and an output circuit, said circuits being coupled to produce in said input circuit an effect due to currents in said output circuit, a further adjustable coupling of said circuits to oppose said effect upon said input circuit.

3. In an electrical network containing a thermionic amplifier having an input circuit and an output circuit, a portion of said output circuit so inductively and adjustably coupled to a portion of said input circuit as to oppose in said input circuit the effect of currents in said output circuits.

4. In an electrical network containing a thermionic amplifier having an input circuit and an output circuit, a transformer of adjustable mutual impedance coupling said circuits whereby the electromotive force induced in the input circuit by currents in the output circuit through the electrostatic coupling of the amplifier may be opposed by that electromotive force induced in said input circuit by currents in said output circuit through the inductive coupling of the windings of said transformer.

In witness whereof, I hereunto subscribe my name this 4th day of Sept., A. D. 1915.

RALPH V. L. HARTLEY.

Witness:

P. B. LYNCH.