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R. C. MATHES

TRANSMISSION CIRCUITS

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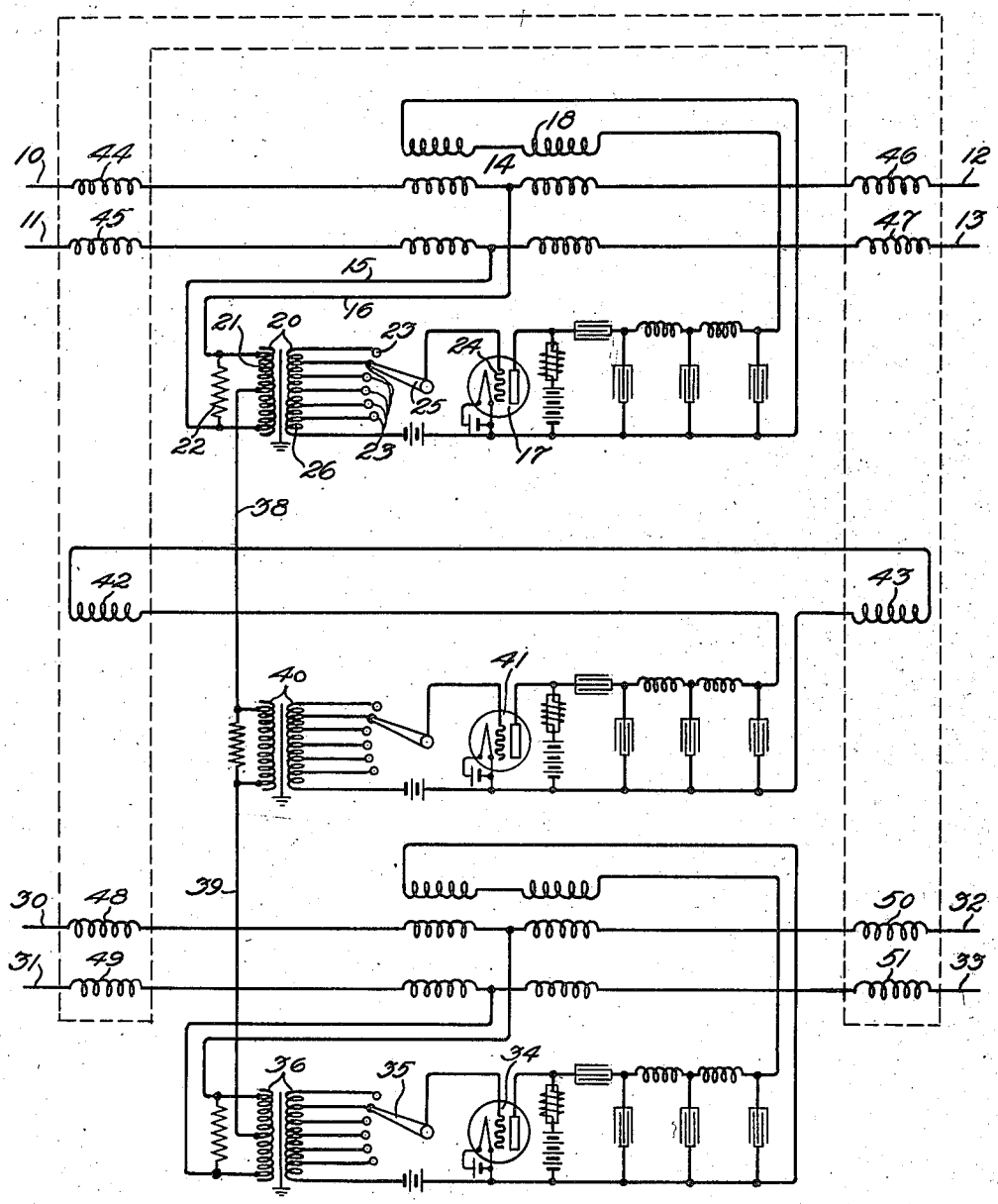

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by W. E. Beatty Atty.

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UNITED STATES PATENT OFFICE.

ROBERT C. MATHES, OF NEW YORK, N. Y., ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

TRANSMISSION CIRCUITS.

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To all whom it may concern:

Be it known that I, ROBERT C. MATHES, a citizen of the United States, residing at New York, in the county of Bronx, State of New York, have invented certain new and useful Improvements in Transmission Circuits, of which the following is a full, clear, concise, and exact description.

This invention relates to transmission circuits employing amplifiers or repeaters, and more particularly it relates to varying or adjusting the gain of the circuit.

One of the objects of the invention is to vary the voltage impressed upon the amplifying element while maintaining fixed the impedance of the gain adjusting means and the element as seen from the incoming line. A further object is to provide such a gain adjusting coupling circuit for a repeater to its incoming line that the impedance offered by the coupling circuit is independent of the frequency over a considerable range, so that uniform transmission of a band of frequencies such as those composing speech is secured.

In accordance with this invention, the preferred form of this coupling circuit comprises a transformer, which is usually of the step-up type, having its primary side shunted by an artificial line such as a resistance, of a value preferably equal to the impedance of the incoming line and arranged symmetrically with respect to both the incoming line and the primary winding. The effective secondary voltage of the transformer which is impressed upon the amplifier may be varied by transformer taps to the secondary winding, for example.

This invention will be better understood by reference to the following detailed description taken in connection with the accompanying drawing, which represents the preferred form of this invention embodied in a "21" repeater circuit.

The drawing discloses two physical circuits and the derived phantom circuit of a signaling system provided with repeaters of the "21" type which have gain adjusting means of the type preferred by this invention. One of the physical circuits comprises a line section 10, 11, and a second line section 12, 13. A "21" type repeater circuit for these two line sections is provided by taking off connections 15 and 16 from the midpoints of the line windings of the three-winding transformer 14 to the input terminals of a vacuum tube amplifier 17, the output terminals of the amplifier being connected to the third winding 18 of the three-winding transformer 14. As is well known in the art, such an arrangement provides for the amplification of signals from either line section 10, 11, or line section 12, 13, the incoming weak signals being impressed across the midpoints of the line windings of the three-winding transformer upon the input circuit of the amplifier, thereby being amplified and impressed by winding 18 upon both line sections 10, 11 and 12, 13. Line section 10, 11 of course should present the same impedance as line section 12, 13, in order to prevent repeater 17 from singing.

Inasmuch as it is frequently desirable to vary the effective amplification or gain of repeater 17 to meet conditions in line sections 10, 11 and 12, 13, and particularly to adjust repeater 17 so that it may be employed for repeating between a plurality of line sections requiring different degrees of amplification, the repeater 17 is provided with the gain adjusting means of this invention. This gain adjusting means for coupling repeater 17 to the midpoints of the line windings of the three-winding transformer 14 comprises an input transformer 20, preferably of the step-up type, which has its primary winding 21 shunted by a fixed resistance 22. The secondary winding 26 is provided with a plurality of taps 23, to any one of which the control electrode 24 of the repeater may be connected by a movable arm 25. It is obvious from the drawing that when arm 25 is moved in either direction, a variation takes place in the amount of input potential impressed upon the repeater 17 so that the variation of the position of arm 25 serves to control the intensity of the amplified currents in the output circuit of the repeater.

As previously stated, transformer 20 should preferably be of the step-up type, and in particular it will be found preferable to employ a transformer having an impedance ratio of about 1:600. The resistance 22 should preferably have such a value as to equal the combined impedance of line sections 10, 11 and 12, 13, as seen from the input connections 15 and 16. Since these two line

sections as seen from connections 15 and 16 are connected in parallel it follows that resistance 22 should have a value equal to one-half the impedance of one of the line sections 10, 11 or 12, 13. Due to the fact that the impedance between the input terminals of the repeater 17 is of a high order of magnitude, it follows that the impedance of the secondary winding as seen from connections 15 and 16 is practically the same as if the secondary winding were open-circuited. Any variation, therefore, in the position of arm 25 will not affect appreciably the impedance of the gain adjusting means and the repeater as seen from the connections 15 and 16. The coupling means of this invention therefore presents a nearly fixed impedance to the incoming line, so that the impedance relations therebetween are unaffected by adjustments that are made to vary the voltage impressed upon the amplifier. Due to the uniform impedance relations previously specified, this coupling circuit just described also enables repeater 17 to give a uniform transmission of a band of frequencies such as those composing speech.

The other physical circuit shown in the drawing comprises two line sections 30, 31 and 32, 33. The repeater element 34 for these two line sections is connected thereto in a similar manner as previously described for repeater 17. The gain of repeater 34 may be varied by moving arm 35 to a desired tap of the secondary winding of the step-up input transformer 36.

A "21" repeater for the phantom circuit derived from line sections 10 to 13 and 30 to 33 is provided by input connections 38 and 39 connected respectively to the midpoints of the primary windings of transformers 20 and 36. These connections 38 and 39 lead to an input transformer 40, the secondary winding of which is connected to the input circuit of a repeating element 41. The output circuit of repeater 41 is connected to an output transformer the primary windings of which are 42 and 43, and the secondary windings of which are located in the four line sections and comprise windings 44 to 51 inclusive. This arrangement for obtaining input and output connections for a phantom circuit is not a part of this invention, but is described and claimed in an application to Blackwell, Serial No. 300,556, filed May 29, 1919. The gain of phantom repeater 41 may be adjusted by selecting a desired tap on the secondary winding of the input transformer 40.

One of the advantages of the coupling means of this invention is that when the phantom tap is taken as shown from the midpoint of the primary winding of the input transformer for the physical circuit repeater, the gain of the phantom repeater may be adjusted independently of the gain of the physical circuit repeater and vice versa. Since there are no variable connections between leads 15 and 16 and primary winding 21, which is fixed, it follows that a variation in the position of arm 25 to vary the gain of repeater 24 will not affect the phantom currents flowing in parallel through connections 15 and 16 and connection 38 to the input transformer 40. It will be similarly apparent that a variation in the gain of repeater 41 will not affect the physical circuit currents flowing serially through connections 15 and 16.

It is to be noted that the input connections to the primary winding of the input transformer are not shown connected to the outside terminals of the primary winding, but are shown connected to intermediate points. This is to indicate that, if desired, the effective number of turns of the primary winding may be varied to vary the impressed voltage upon the repeater, or they may be set at the factory or by the installer to correspond to given circuit conditions. In this way a standard transformer becomes somewhat flexible and answers for various line requirements. This is particularly true in case it is not desired to obtain the phantom tap from the midpoint of the primary winding of the input transformer, for then the repeater gain may be adjusted by a variation in the effective number of turns of the primary winding without producing the interference mentioned above between the side circuits and the derived phantom circuit.

Input couplings for repeaters are known in which the secondary of the transformer is shunted by a high resistance having a potentiometer tap for taking off voltage, but the coupling of the present invention has considerable advantages over types heretofore known in that it is more economical to construct and more convenient to operate in practice. By having the balancing resistance across the primary winding, for example, the transformer carries less current than if the resistance is across the secondary, and the transformer coils can therefore be made of smaller gauge wire without excessive transmission losses. A smaller resistance also is required. Furthermore, where several repeaters are associated together in small space, as is usual in actual practice, there is less liability of crosstalk if the balancing resistances and their windings are located in the primary or low voltage side of a transformer rather than in the high voltage side.

It will be apparent to those skilled in the art that the specific embodiments of the invention described above may be variously modified without departing in any wise from the spirit of this invention as defined in the appended claims. While the invention has been described above in connection with a telephone repeater circuit of the so-

called "21" type, it is obvious that the gain adjusting means of this invention is applicable to other types of telephone or other signaling circuits, such as the "22" repeater type or four-wire circuit type.

What is claimed is:

1. The combination of an incoming line, a telephone repeater, and means having a substantially uniform transmission efficiency throughout a wide range of frequencies for coupling said repeater to said line, said coupling comprising a transformer between said repeater and said line, a resistance in shunt to said line, and adjustable terminals to various points on a winding of said transformer for varying the transformer secondary voltage while maintaining the amount of resistance included in said line substantially constant.

2. In combination, a signaling line, a repeater for repeating signals from said line, and a repeater gain adjusting means comprising a transformer having a winding in circuit with said line and a second winding in circuit with said repeater, one of said windings having a plurality of taps arranged between its extreme terminals and a movable member cooperating with said taps to vary the effective valve of said winding included in circuit with said line and repeater.

3. In combination, an incoming line, an outgoing line, a repeater for repeating between said lines, a transformer having primary and secondary windings between said incoming line and said repeater, a fixed resistance in shunt to said primary winding said resistance having a value sufficient to maintain substantially constant the impedance of said repeater as seen from the line, and means for varying the number of effective turns of one of the windings of said transformer.

4. In combination, an incoming line, an outgoing line, a repeater for repeating between said lines, a transformer having a primary and a secondary winding located between said incoming line and said repeater, a fixed resistance in shunt to said primary winding said resistance having a value sufficient to maintain substantially constant the impedance of said repeater as seen from the line, said secondary winding having one terminal permanently connected to one input terminal of said repeater, and an adjustable connection between another input terminal of said repeater and a point on said secondary winding.

5. In combination, an incoming line, an outgoing line, a vacuum tube repeater therebetween, a transformer between said incoming line and said repeater and having a primary and a secondary winding, and means for varying the effective number of turns of one of said windings when a change is desired in the gain of said repeater while maintaining balanced the two sides of said incoming line with respect to the midpoint of said primary winding.

6. In combination, a repeater, an incoming line therefor, a coupling circuit between said repeater and said line comprising a transformer having a primary and a secondary winding, and means for making said repeater have a substantially constant impedance for a wide range of frequency as seen from said line, one of said transformer windings having adjustable terminals for varying the effective number of turns of the winding.

7. In combination, a repeater, an incoming line, a coupling circuit between said repeater and said line comprising a transformer having a primary and a secondary winding, means for causing said repeater to present a substantially constant impedance for a wide range of frequency as seen from said line, and means for varying the effective value of one of said windings while maintaining substantially constant the impedance of said repeater as seen from said line.

8. In combination, a repeater, a signaling line, a coupling circuit between said repeater and said line comprising a transformer having a primary and a secondary winding, a resistance in shunt to one of said windings having a value sufficient to cause said repeater to present a substantially constant impedance as seen from said line, and means for varying the effective number of turns of one of said windings while maintaining substantially constant the impedance of said repeater as seen from said line.

9. In combination, an incoming line, a phantom circuit repeater for said line, a physical circuit repeater for said line, a coupling circuit between said line and said physical circuit repeater comprising a transformer having a primary winding and a secondary winding, a phantom tap from the midpoint of said primary winding to said phantom repeater, and means for varying the gain of said physical circuit repeater independently of the gain desired by said phantom repeater, said means comprising a plurality of taps to said secondary winding and a movable arm cooperating therewith.

10. In combination, an incoming line, a phantom circuit repeater for said line, a physical circuit repeater for said line, a coupling circuit between said line and said physical circuit repeater comprising a transformer having a primary winding and a secondary winding, an artificial line in circuit with said primary winding for causing the impedance looking into the physical circuit repeater to be equal to the impedance look-

ing into said line, a phantom tap from the midpoint of said primary winding to said phantom repeater, and means for varying the gain of said physical circuit repeater independently of the gain desired by said phantom repeater, said means comprising a variable connection from an input terminal of said physical repeater to a desired point on said secondary winding.

11. In combination, a line, a repeater therefor, and means for varying the effective gain of said repeater while maintaining fixed the impedance of said repeater as seen from said line, said means comprising a transformer having a plurality of taps to one of its windings.

12. In combination, an incoming line, a physical circuit repeater for said line, a phantom circuit repeater for said line, and means for varying the gain of said physical circuit repeater independently of the gain of said phantom repeater, said means comprising a transformer having a plurality of taps to one of its windings.

In witness whereof, I hereunto subscribe my name this 14th day of July A. D., 1921.

ROBERT C. MATHES.