C. ROBINSON AND R. M. CHAMNEY.

TELEPHONIC REPEATER.

APPLICATION FILED NOV. 18, 1919.

1,429,634. Patented Sept. 19, 1922.

6 SHEETS—SHEET 1.

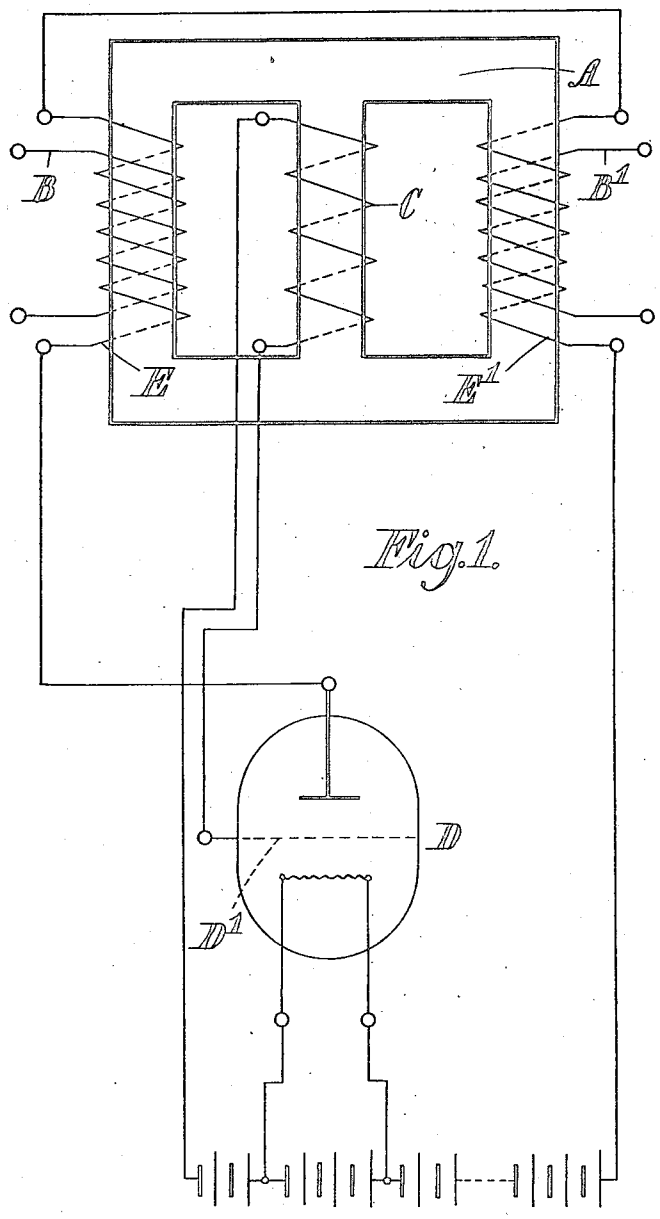


Fig. 1.

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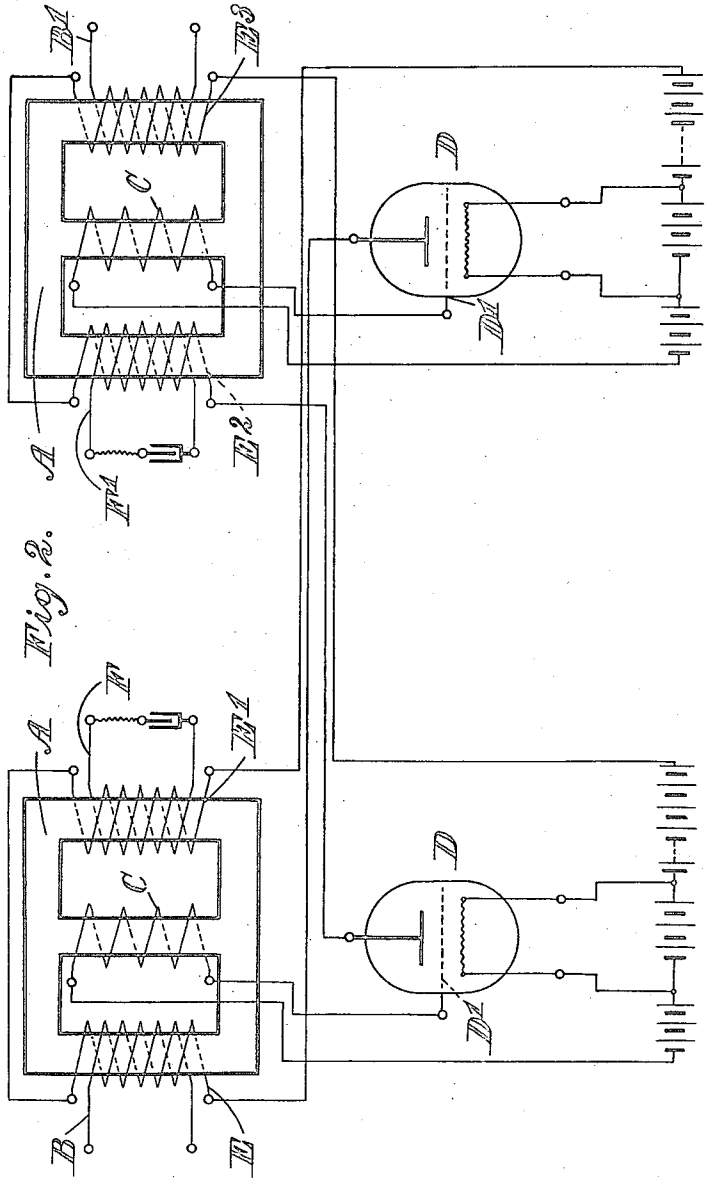


Fig. 2.

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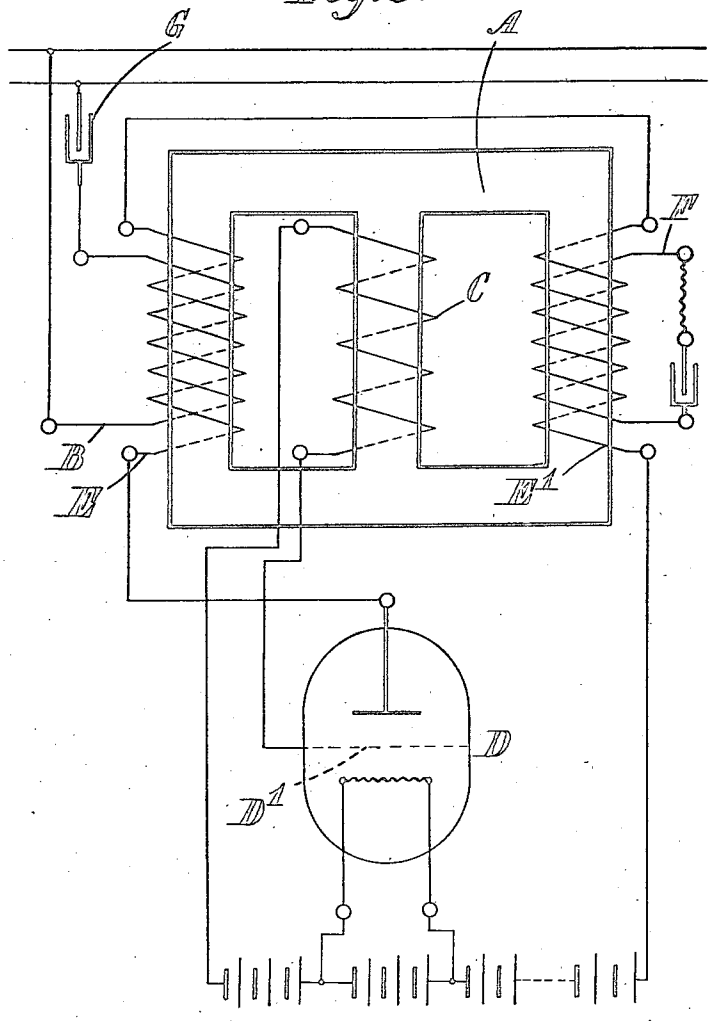
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6 SHEETS—SHEET 3.

Fig. 3.



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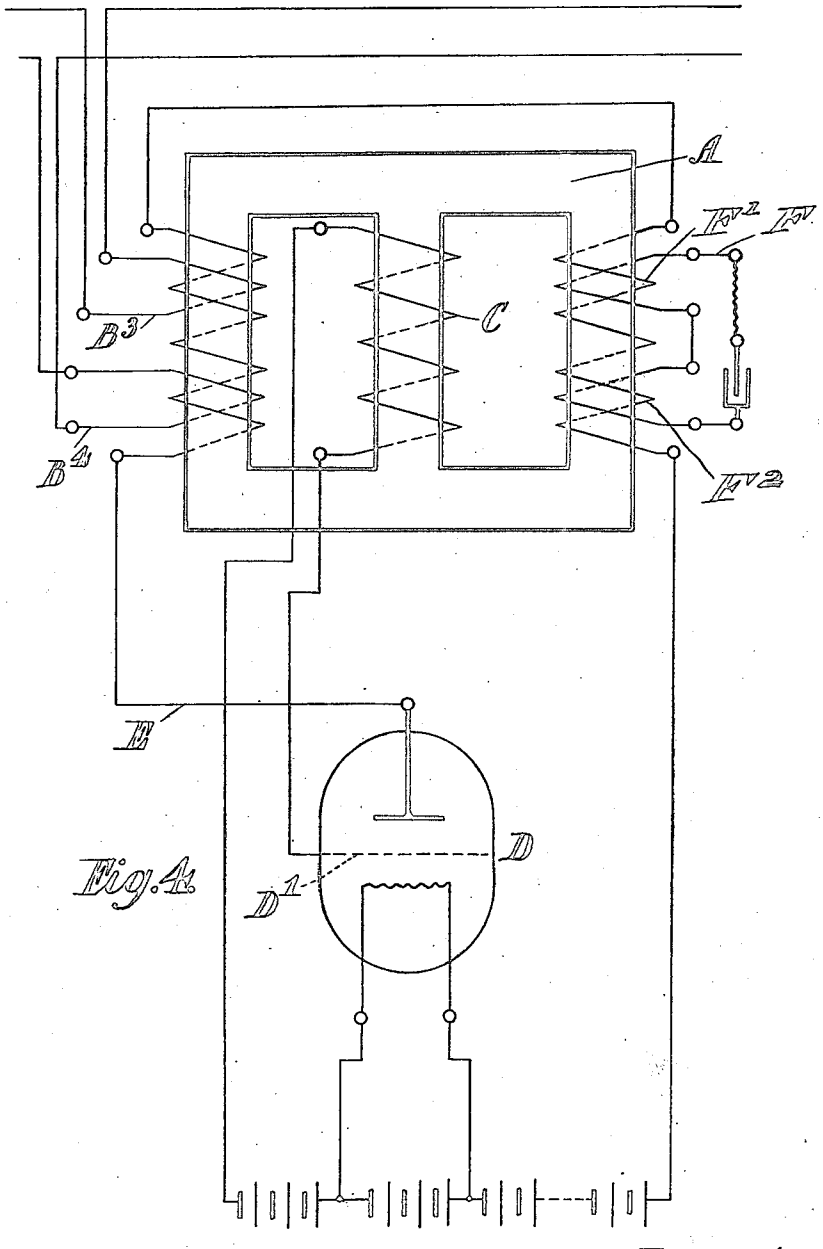


Fig. 4.

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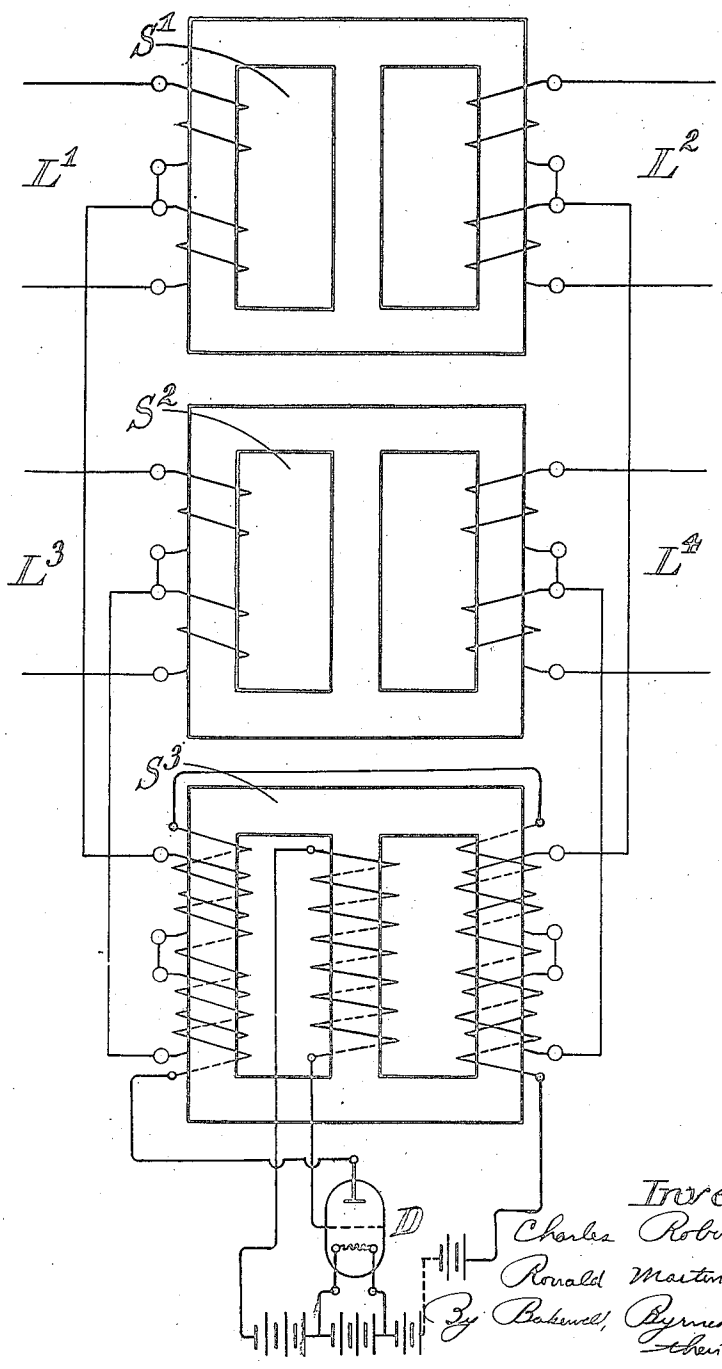
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6 SHEETS—SHEET 5.

Fig. 5.



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6 SHEETS—SHEET 6.

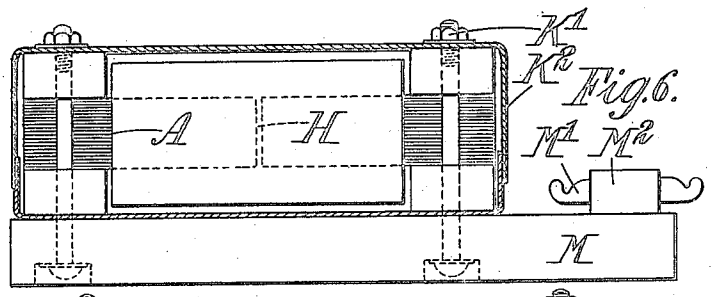


Fig. 6.

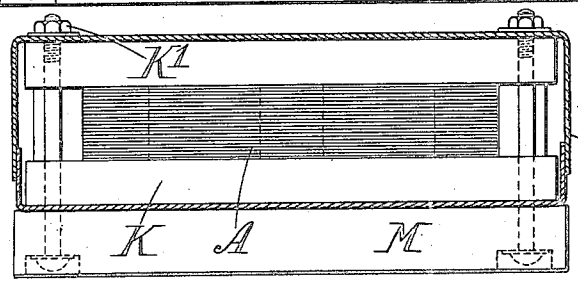


Fig. 7.

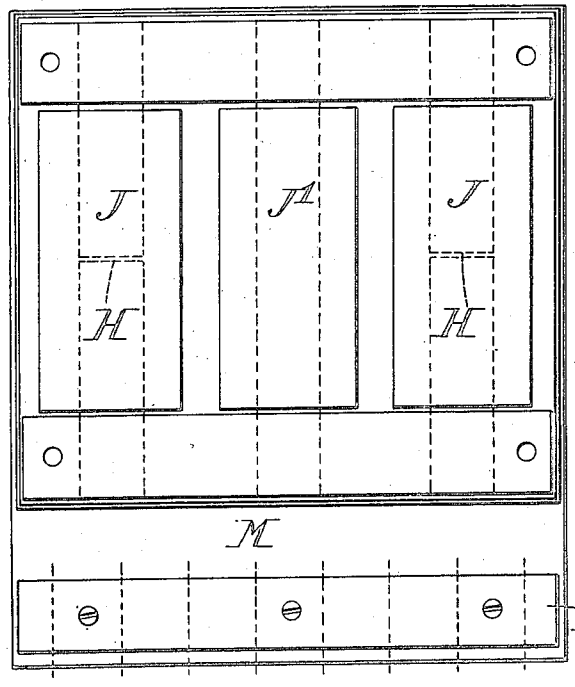


Fig. 8.

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Patented Sept. 19, 1922. 1,429,634

UNITED STATES PATENT OFFICE.

CHARLES ROBINSON, OF REIGATE, AND RONALD MARTIN CHAMNEY, OF LONDON, ENGLAND.

TELEPHONIC REPEATER.

Application filed November 18, 1919. Serial No. 338,361.

To all whom it may concern:

Be it known that we, CHARLES ROBINSON and RONALD MARTIN CHAMNEY, both subjects of the King of England, residing, respectively, at Reigate, in Surrey, England, and London, England, have invented certain new and useful Improvements in Telephonic Repeaters, of which the following is a specification.

This invention relates to telephonic repeaters of the transformer type comprising two sets of speaking-line-windings magnetically coupled together, an input winding which acts as a secondary to the speaking-line-windings and puts current into an amplifier, and an output winding to which the amplified current thus obtained is supplied, and which reacts by magnetic induction on the said line-windings.

Heretofore two transformers known as "input" and "output" transformer respectively have been employed in this type of repeater. One of these transformers, say the input, has been wound differentially, one half of the differential winding being connected to each half of the circuit or to one half of the circuit and a balancing circuit. The output transformer was connected to the centre point of the differential winding of the input transformer. In this arrangement, if the impedances on each side of the input transformer are equal, the magnified currents from the output transformer will divide equally between the differential windings of the input transformer and will not have the effect upon the repeater of tending to produce reaction or "howling."

This invention has for its object to simplify the construction of telephonic repeaters of the type referred to and, in one embodiment, to provide a repeater comprising one transformer only.

The expression "line-windings" is used herein to cover windings included either in an actual line-circuit or in an artificial or balancing line-circuit.

Conveniently, a double-amplifier repeater according to the invention and comprising two transformers may have the latter so cross connected that the magnified current from the amplifier fed by the one transformer is supplied to the other transformer, and one of the line-windings of each transformer is connected to an artificial line.

In the accompanying drawings—

Figures 1, 2, 3 and 4 are diagrams illustrating various embodiments of this invention,

Figure 5 is a diagram showing only the transformer arrangements for a modified embodiment of this invention,

Figure 6 is a longitudinal section,

Figure 7 is a transverse section, and

Figure 8 a plan illustrating one method of constructing a transformer in accordance with this invention.

Referring to Figure 1 which illustrates one method of carrying the invention into practice with a single-amplifier telephonic repeater comprising one transformer only, the iron core A of the transformer is built up of stampings, each having three limbs, i. e. one centre and two outer limbs magnetically in parallel with one another. The outer limbs are wound each with a line-winding B, B^1, and on the centre limb is wound a generator or input winding C, which is connected to one side of an amplifier, for example to the grid circuit D^1 of a thermionic valve D. The outer limbs are also wound each with one half of a booster winding in two halves E, E^1 connected in series with one another and having the three ends of the pair connected to the anode circuit of the valve D. The line-windings B, B^1 are equal and are connected to the "up" and "down" lines respectively.

The operation of this single-amplifier repeater is as follows:—

Speech currents passing through the one-line winding, say B, induce variations of the potential of the grid D^1 through the generator winding C. This causes variations of the discharge or amplified current passing through the two halves E, E^1 of the booster winding, which in turn induce magnified currents in both line-circuits. The magneto motive forces of the two halves E, E^1 are equal and so far as their action alone is concerned, they set up no difference of magnetic potentials across the limb carrying the input winding C.

If, therefore, the impedances of the two line circuits are equal, none of the flux due

to the amplified current in the booster winding E, E^1 will pass through the generator winding C which feeds the grid. The operation is similar in the case of speech currents traversing the other line-winding.

Referring to Figure 2 which illustrates a double-amplifier repeater according to this invention, two transformers, each similar to that described above, are used. The cores A, generator windings C, amplifier D, line-winding B and booster winding E are the same as before. In this case, however, an artificial line or a balancing circuit F, F^1, represented as having resistance and capacity, takes the place of one line in each transformer, and the anode circuit of the "up" valve is connected to the booster windings E^2, E^3 of the "down" transformer, while the anode circuit of the "down" valve is connected to the booster windings E, E^1 of the "up" transformer.

The invention is also applicable to the telephone systems described in the British Patents Nos. 131113 and 131114.

Referring to Figure 3, which shows an arrangement corresponding to that described in the British Patent No. 131113, the one-line winding B, preferably in series with a condenser G is connected in shunt across the telephone line. A suitable balancing circuit F is connected across the other line-winding. The operation of this arrangement is similar to that of the single-amplifier repeater described above.

Referring to Figure 4, which illustrates an arrangement corresponding to the telephone system described in the British Patent No. 131114, the one-line winding is divided into two equal parts B^3, B^4, which are connected one in each line of the telephone circuit. A suitable balancing circuit F is connected across the other line-winding, which is also divided into two equal parts F^1 and F^2. The other elements of the system are the same as before. The operation of this repeater is also similar to that of the single-amplifier repeater described with reference to Figure 1.

Figure 5 shows the application of our invention to provide a phantom-circuit superposed on two side circuits, all three circuits being relayed. L^1, L^2 represent the "up" and "down" lines of one circuit connected to the line-windings of the transformer S^1. L^3 and L^4 represent the lines of a second circuit connected to the line-windings of the transformer S^2. The line-windings of the transformers S^1, S^2 are wound direrentially, and centre points are connected to a third transformer S^3. An amplifying-valve is connected to each of the transformers S^1, S^2 and S^3 as shown in Figure 1. These connections are omitted from Figure 5 for the sake of clearness except to the lower transformer S^3. The arrangement shown as applied to transformer S^3 is merely duplicated for the transformers S^1 and S^2, the arrangement being in each case the same as shown in Figure 1 as far as the valve D is concerned. By means of this arrangement, speech currents in the circuit L^1 or L^2 are amplified by the valve connected to the transformer S^1; those in the circuit L^3 or L^4 are amplified by the valve connected to the transformer S^2, while those in the phantom-circuit are amplified by the valve connected to the transformer S^3. If the lines L^1, L^2, L^3 and L^4 and also the differential windings of the transformers are correctly balanced, there will be no interference between the three circuits.

Referring to Figures 6, 7 and 8, E-shaped stampings A of suitable magnetic material, such as "stalloy," are placed so as to form a magnetic core which is continuous with the exception of two narrow air-gaps H in the outer limbs of the core. This stalloy as analyzed by Prof. Turner in the University of Birmingham may comprise .03 carbon, 3.4 silicon, .04 sulphur, .01 phosphorus, .32 manganese and 96.2 iron. The width of these gaps is secured at the right value by means of a non-magnetic spacing-piece. The bobbins J surrounding the outer limbs of the core are wound with the line- and anode-windings. The bobbin J^1 on the centre limb of the core carries the grid-winding.

The stampings are firmly clamped between wood blocks K by means of the bolts and nuts K^1. A sheet-iron case K^2 encloses the transformer, so that when arranged in banks each shall be shielded from stray fields. The connections to the windings are taken through the base M to the connection tags M^1 mounted in the ebonite block M^2.

The number of turns in the windings used depends upon the characteristics of thermionic valve and also upon the characteristics of the circuit. For unloaded underground circuits and a valve having an internal impedance of about 26,000 ohms. the following windings are suitable:—

Grid winding	16,000 turns.
Anode winding	2 x 3,500 turns.
Line winding	2 x 700 turns.

An additional winding may be provided on one of the transformer limbs, if desired, for connection to a telephone so as to afford means for listening, at the repeater station, to the speech on the lines.

It will be appreciated that various modifications may be made in the forms described above without departing from the spirit of the invention. For example, in the single-amplifier repeater first described above the positions of the generator and booster windings on the inner and outer

limbs, respectively, of the transformer may be interchanged.

What we claim as our invention and desire to secure by Letters Patent is:—

1. In a telephonic repeater, the combination of a current-magnifying device, a magnetic core structure comprising three cores magnetically in parallel with one another between two yokes common to the two sets of concurrent ends of the cores, two line-windings, one upon each of two said cores, a booster winding in two equal halves in series to assist one another, each mounted upon one of the said two cores which carry line-windings and having their two free ends connected to one operative side of the said current-magnifying device, a generator winding mounted on the third said core of the said core structure, and connected to the other operative side of the current-magnifying device, substantially as described.

2. In a telephonic repeater, the combination of two current-magnifying devices, two magnetic core structures, each comprising three cores magnetically in parallel with one another between two yokes common to the two sets of concurrent ends of the cores, two line-windings, one upon each of two cores of the one said core structure, two line-windings one upon each of two cores of the other said core structure, a booster winding in two equal halves in series connected to assist one another, each said half mounted upon one of the two cores which carry line-windings on the one magnetic core structure and having their two free ends connected to one operative side of one said current-magnifying device, a similar booster winding on the corresponding two cores of the other core structure and having its free ends connected to the corresponding operative side of the current-magnifying device, two generator windings one upon each of the two third cores of the core structures and cross connected so that each is connected to the second operative side of the current-magnifying device whereof the first said operative side is connected to the booster winding on the other magnetic core structure, substantially as described.

3. In a telephonic repeater, the combination of a current-magnifying device, a magnetic core structure comprising three cores magnetically in parallel with one another between two yokes common to the two sets of concurrent ends of the cores, two line-windings, one upon each of two said cores, of which said line-windings one is connected to an artificial line and the other is connected to the speech-line in series with a condenser, a booster winding in two equal halves in series to assist one another, each mounted upon one of the said two cores which carry line-windings and having their two free ends connected to one operative side of the said current-magnifying device, a generator winding mounted on the third said core of the said core structure and connected to the other operative side of the current-magnifying device, substantially as described.

4. In a telephonic repeater, the combination of a current-magnifying device, a magnetic core structure comprising three cores magnetically in parallel with one another between two yokes common to the two sets of concurrent ends of the cores, two line-windings, one upon each of two said cores, whereof one is connected to an artificial line and the other is connected to one speech-line, a third line-winding connected to a speech-line and mounted on the same core as that which carries the winding of the first said speech-line, a booster winding in two equal halves in series to assist one another, each mounted upon one of the said two cores which carry line-windings and having their two free ends connected to one operative side of the said current-magnifying device, a generator winding mounted on the third said core of the said core structure and connected to the other operative side of the current-magnifying device, substantially as described.

5. In a telephonic repeater, the combination of a current-magnifying device, a magnetic core structure comprising three cores lying side by side in substantially one plane extending between two yokes magnetically common to the two sets of concurrent ends of the cores and of which cores the continuity of each of the two outer ones is interrupted by an air-gap, two line-windings, one upon each of the said two outer cores, a booster winding in two equal halves in series to assist one another, each half mounted upon one of the said two outer cores and having their two free ends connected to one operative side of the said current-magnifying device, a generator winding mounted on the center core of the said three and connected to the other operative side of the current-magnifying device, substantially as described.

6. In a telephonic repeater, the combination of a thermionic valve, a magnetic core structure comprising three cores magnetically in parallel with one another between two yokes common to the two sets of concurrent ends of the cores, two line-windings, one upon each of two said cores, a booster winding in two equal halves in series to assist one another, each mounted upon one of the said two cores which carry line-windings and having their two free ends connected to one operative side of the said thermionic valve, a generator winding mounted on the third said core of the said

core structure and connected to the other operative side of the thermionic valve, substantially as described.

7. In a telephonic repeater, the combination of two thermionic valves, two magnetic core structures, each comprising three cores magnetically in parallel with one another between two yokes common to the two sets of concurrent ends of the cores, two line-windings, one upon each of two cores of the one said core structure, two line-windings, one upon each of two cores of the other said core structure, a booster winding in two equal halves in series connected to assist one another, each said half mounted upon one of the two cores which carry line-windings on the one magnetic core structure and having their two free ends connected to one operative side of one said thermionic valve, a similar booster winding on the corresponding two cores of the other core structure and having its free ends connected to the corresponding operative side of the thermionic valve, two generator windings one upon each of the two third cores of the core structures and cross connected so that each is connected to the second operative side of the thermionic valve, whereof the first said operative side is connected to the booster winding on the other magnetic core structure, substantially as set forth.

In testimony whereof we have signed our names to this specification in the presence of two subscribing witnesses.

CHARLES ROBINSON.
RONALD MARTIN CHAMNEY.

Witnesses:
HAROLD H. SIMMONS,
HARRY G. GRIDEY.