March 9, 1926. 1,575,658

M. E. STRIEBY

VOLUME CONTROL FOR PROGRAM DISTRIBUTION SYSTEMS

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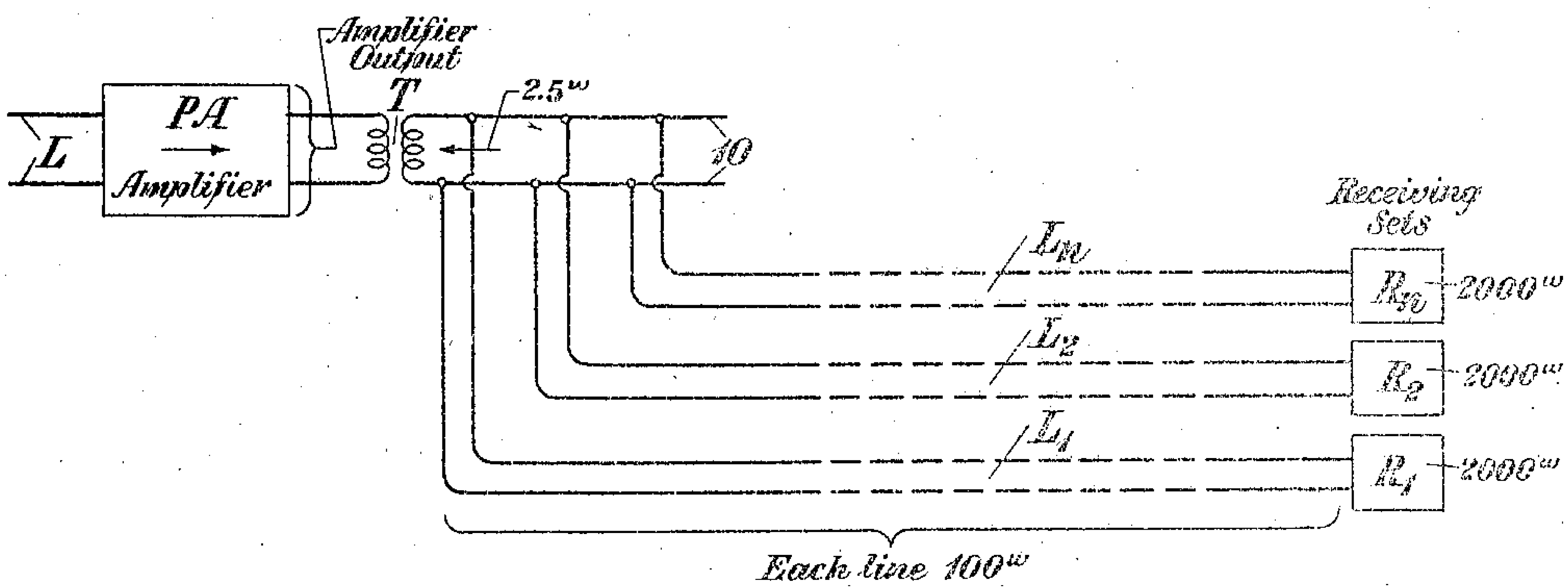

Fig. 1

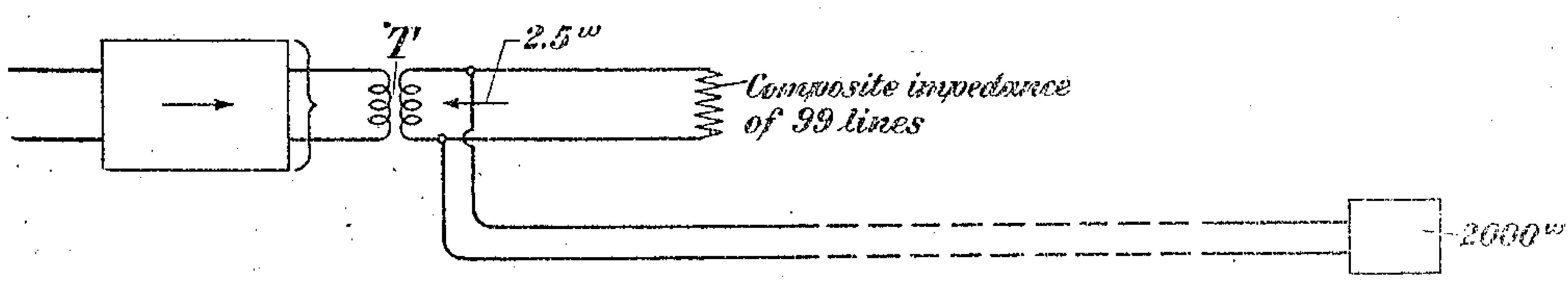

Fig. 2

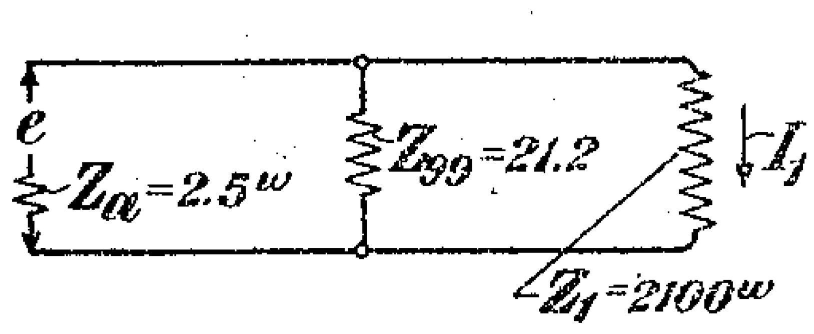

Fig. 3

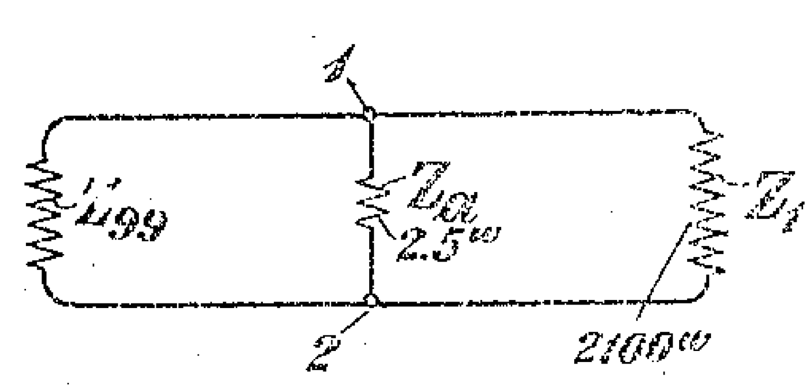

Fig. 4

INVENTOR
M. E. Strieby
BY
[illegible]
ATTORNEY

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UNITED STATES PATENT OFFICE.

MAURICE E. STRIEBY, OF MILLBURN, NEW JERSEY, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

VOLUME CONTROL FOR PROGRAM-DISTRIBUTION SYSTEMS.

Application filed September 7, 1923. Serial No. 661,482.

To all whom it may concern:

Be it known that I, MAURICE E. STRIEBY, residing at Millburn, in the county of Essex and State of New Jersey, have invented certain Improvements in Volume Controls for Program-Distribution Systems, of which the following is a specification.

This invention relates to wire program distribution systems, and more particularly to arrangements for the maintenance of constant volume at the receiving stations of such systems.

In a wire program distribution system, the usual arrangement is to have a number of lines extending to individual receiving stations, said lines being connected in parallel to the bus-bars at a central office, which bus-bars are in communication with a program source. A power amplifier usually intervenes between the bus-bars and the program source for the purpose of bringing the transmission to the desired level. The number of subscribers' lines actually connected to the bus-bars will, of course, vary from time to time and one requirement for satisfactory operation of a program system of this character is that the volume received at any subscriber's station will remain substantially constant independent of any change in the number of stations which may be listening to the program.

In accordance with the present invention it is proposed to maintain the volume at each subscriber's station substantially constant by so arranging matters that the output impedance of the power amplifier will be small as compared with the impedance of the load consisting of the various subscribers' lines connected to the bus-bars in parallel. This result may be attained by interposing a transformer between the bus-bars and the power amplifier, said transformer having such a ratio as to make the output impedance of the amplifier as viewed through the transformer small in comparison to the composite impedance of the subscribers' lines. If the effective output impedance of the amplifier is small enough, the variation in volume will be so small that it will not be noticeable to the ear. Such an arrangement also has the inherent advantage that it provides a large degree of segregation between the subscribers' circuits.

The invention may now be more fully understood by reference to the following description thereof, when read in connection with the accompanying drawing, Figure 1 of which shows schematically the general layout of a wire program system embodying the principles of the invention; Fig. 2 of which shows a simplified circuit equivalent to the circuit of Fig. 1; and Figs. 3 and 4 of which are symbolical diagrams to aid in explaining the invention.

Referring to Fig. 1, L is a trunk circuit leading to a suitable program source of any type well known in the art. The trunk terminates in bus-bars 10 to which a plurality of subscribers' lines L_1, L_2, etc., may be connected in multiple. A power amplifier PA of any known type may be included in the trunk L for the purpose of impressing the program waves upon the subscribers' lines in suitable volume. Each subscriber's line terminates in a receiving set of any known type suitable for receiving program transmission, said receiving sets being indicated at R_1, R_2, etc.

In order that the current impressed upon the subscribers' lines may be substantially constant regardless of the number of lines connected to the bus-bars at any given time, a transformer T is included in the output circuit of the power amplifier PA and the ratio of this transformer is made such that the impedance looking into the output circuit of the amplifier through the transformer will be small as compared with the composite impedance of all of the parallel subscribers' lines connected to the bus-bars.

In order to understand the effect of the transformer T a numerical example will be given. Let us assume that the actual impedance of the output circuit of the power amplifier is 600 ohms and that the ratio of the transformer T is such as to step this impedance down to 2.6 ohms. Let us further assume that the impedance of each subscriber's line is 100 ohms, that the impedance of each subscriber's set is 2000 ohms and for simplicity, that both impedances have the same angle. The impedance looking into each subscriber's line individually will then be 2100 ohms.

The electrical condition for each subscriber's line when considered by itself is illustrated by the diagram in Fig. 2 which shows the amplifier connected through the transformer T to a subscriber's line of 2100 ohms, the circuit being shunted by the composite impedance of the other lines of the system which are at the moment connected to the bus-bars. The entire circuit may be represented symbolically as shown in Fig. 3, in which an electromotive force e is applied to a network consisting of impedances Z_{99}, Z_1 and Z_a the latter being the impedance looking into the output of the amplifier through the transformer, the impedance Z_1 being the impedance looking into the subscriber's line, and the impedance Z_{99} being the composite impedance of the other subscribers' lines connected to the bus-bars.

If but one subscriber's line is connected to the bus-bars, the impedance Z_{99} will be eliminated and I_1, the current flowing into the line, may be expressed as follows:

$$I_1=\frac{e}{2.5+2100}=\frac{e}{2102.5} \quad (1)$$

If, on the other hand, the total number of lines in the system is 100 and all are connected to the bus-bars, the impedance Z_1 will be 2100 ohms and the impedance Z_{99} will be 2.2 ohms. The current I_{100}, which is the current flowing in the bus-bars, may then be expressed as follows:

$$I_{100}=\frac{e}{2.5+21}=\frac{e}{23.5} \quad (2)$$

In the above equation 21 represents the resultant impedance of 100 lines connected in parallel, each having an impedance of 2100 ohms.

The current I'_1, flowing into an individual line will be 1/100 part of the total current I_{100} flowing in the bus-bars, and may be expressed as follows:

$$I'_1=\frac{I_{100}}{100}=\frac{\frac{e}{23.5}}{100}=\frac{e}{2350} \quad (3)$$

Comparing the values given by equations (1) and (3), it is seen that the current flowing in an individual line under the two extreme conditions met with will only vary about 10%, which is a variation so small that it can be scarcely observed by the ordinary ear.

The necessity for making the impedance looking into the output circuit small as compared with the composite impedance of the lines connected to the bus-bars will be apparent from a consideration of an assumed case, in which the ratio of the transformer is such as to make the impedance looking into the output circuit of the amplifier through the transformer equal to the composite impedance of all the lines or, in other words, equal to 21 ohms. Under these circumstances, if but one line is connected to the bus-bars, the current flowing will be given by the following equation:

$$I_1=\frac{e}{21+2100}=\frac{e}{2121} \quad (4)$$

On the other hand, if 100 lines are connected to the bus-bars, the total current I_{100} will be as follows:

$$I_{100}=\frac{e}{21+21}=\frac{e}{42} \quad (5)$$

and the current in a single line will be

$$I'_1=\frac{\frac{I}{100}}{100}=\frac{\frac{e}{42}}{100}=\frac{e}{4200} \quad (6)$$

Comparing equations (4) and (6), it is apparent that with only one line connected to the bus-bars, the volume will be almost 100% greater than when 100 lines are connected.

Making the impedance looking into the output circuit of the amplifier through the transformer small as compared with the composite impedance of the lines has the inherent advantage that it provides a large degree of segregation between subscribers' circuits. In order to understand this, let us consider again the equivalent circuit shown in Fig. 2, which represents the electrical condition of an individual subscriber's line when the other lines of the system are connected to the bus-bars. The circuit may be symbolically represented as shown in Fig. 4 and comprises a network of three impedances Z_{99}, Z_a and Z_1 connected in parallel. The effect produced in a given line of impedance Z_1 will depend upon the voltage at the terminals 1 and 2 of the diagram of Fig. 4. Obviously, if one of the lines whose composite impedance is represented by Z_{99} is open circuited, a change in the composite impedance will occur. If the impedance Z_a were large as compared with Z_{99}, it is obvious that a change in the impedance of the latter will affect the current flowing in Z_1. On the other hand, if the impedance Z_a were zero, a change in the impedance Z_{99} would have no effect upon the current flowing through Z_1. The latter condition is approximated by reason of the fact that the impedance Z_a is very small compared with Z_{99}, being only 2.5 ohms in the assumed case. Consequently, a change in the impedance Z_{99} does not appreciably affect the single line represented by Z_1. From similar considerations it will also be apparent that if any one of the lines making up the composite impedance Z_{99} be shortcircuited at some point sufficiently distant from the bus-bars, so that it does not amount to a dead shortcircuit across the terminals 1 and 2 of Fig. 4, no appreciable effect will be produced upon the line whose impedance is represented by Z_1. It will also be apparent that if any line connected to the bus-bar is subject to interference, the voltage or current so induced in it will be largely prevented from appearing in any other circuit by the very low impedance Z_a which is bridged across the bus-bar.

It will be obvious that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated without departing from the spirit of the invention as defined in the following claims.

What is claimed is:

1. In a program distribution system, a program source, an amplifier to amplify currents from said source and impress them upon bus-bars, a variable number of subscribers' lines connected to said bus-bars, and means to make the impedance looking into the output of said amplifier small as compared with the composite impedance of said subscribers' lines when all of the lines are connected to the bus-bars.

2. In a program distribution system, a program source, an amplifier to amplify currents from said source and impress them upon bus-bars, a variable number of subscribers' lines adapted to be connected in parallel to said bus-bars, and a transformer between said bus-bars and said amplifier having a ratio such that the impedance looking into the output of the amplifier through the transformer will be small as compared with the composite impedance of all the subscribers' lines.

3. In a signaling system, a circuit over which currents are transmitted, an amplifier in said circuit, a variable number of transmission lines arranged to be associated with the output of said amplifier, and means whereby the impedance looking into the output circuit of said amplifier will be small as compared with the composite impedance of the transmission lines.

4. In a signaling system, a transmission circuit, an amplifier included therein, a variable number of transmission lines adapted to be connected to the output circuit of said amplifier, and a transformer between said lines and said amplifier having a ratio such that the impedance looking into the output of said amplifier will be small as compared with the composite impedance of the transmission lines.

In testimony whereof, I have signed my name to this specification this 1st day of September, 1923.

MAURICE E. STRIEBY.