

Nov. 15, 1938.

E. R. TAYLOR

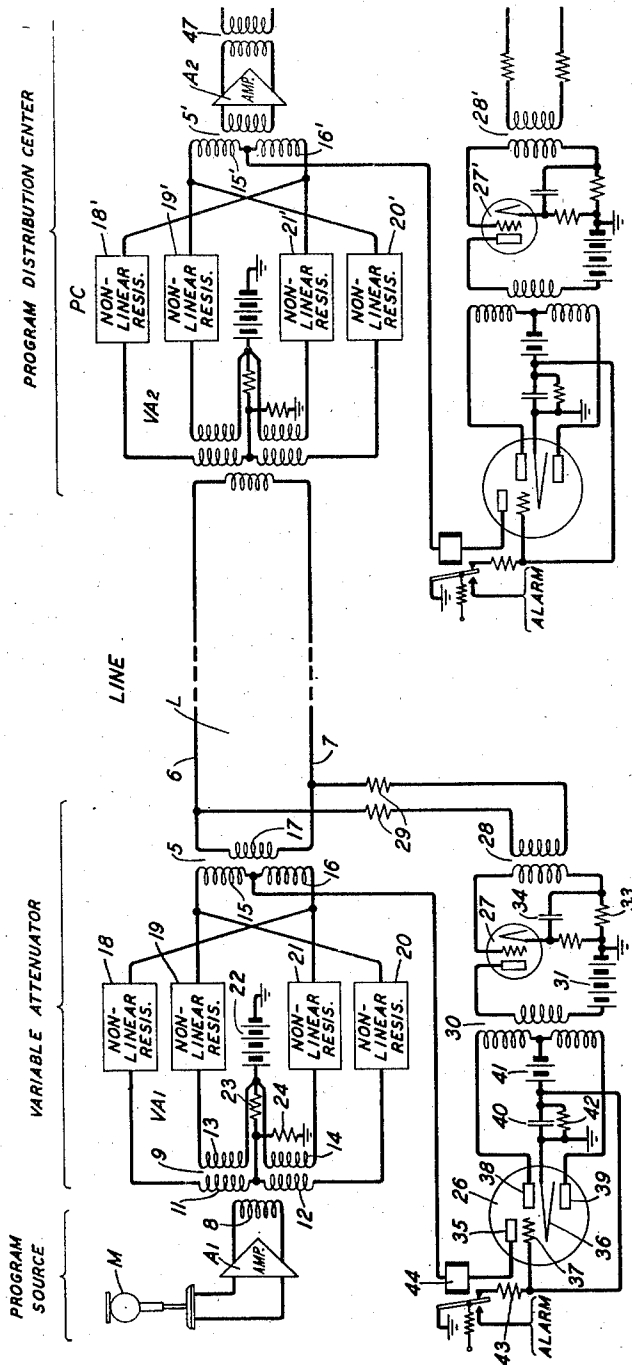
2,137,036

TRANSMISSION SYSTEM

Filed Oct. 31, 1936

3 Sheets-Sheet 1

FIG. 1



INVENTOR
E. R. TAYLOR
BY *E. R. Taylor*
ATTORNEY

Nov. 15, 1938.

E. R. TAYLOR

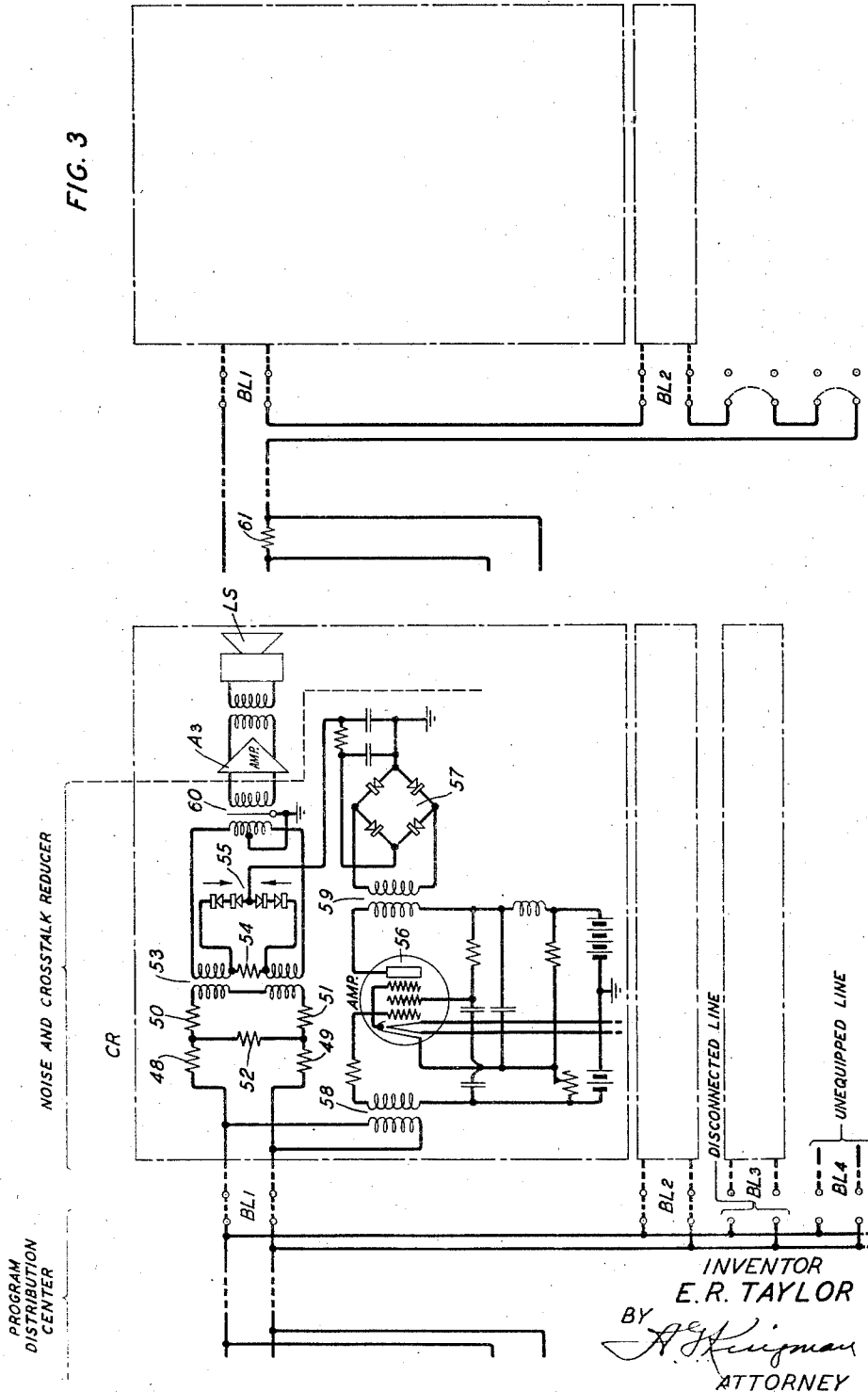
2,137,036

TRANSMISSION SYSTEM

Filed Oct. 31, 1936

3 Sheets-Sheet 2

FIG. 3



INVENTOR
E. R. TAYLOR
BY *A. H. Kuigman*
ATTORNEY

Nov 5, 1938.

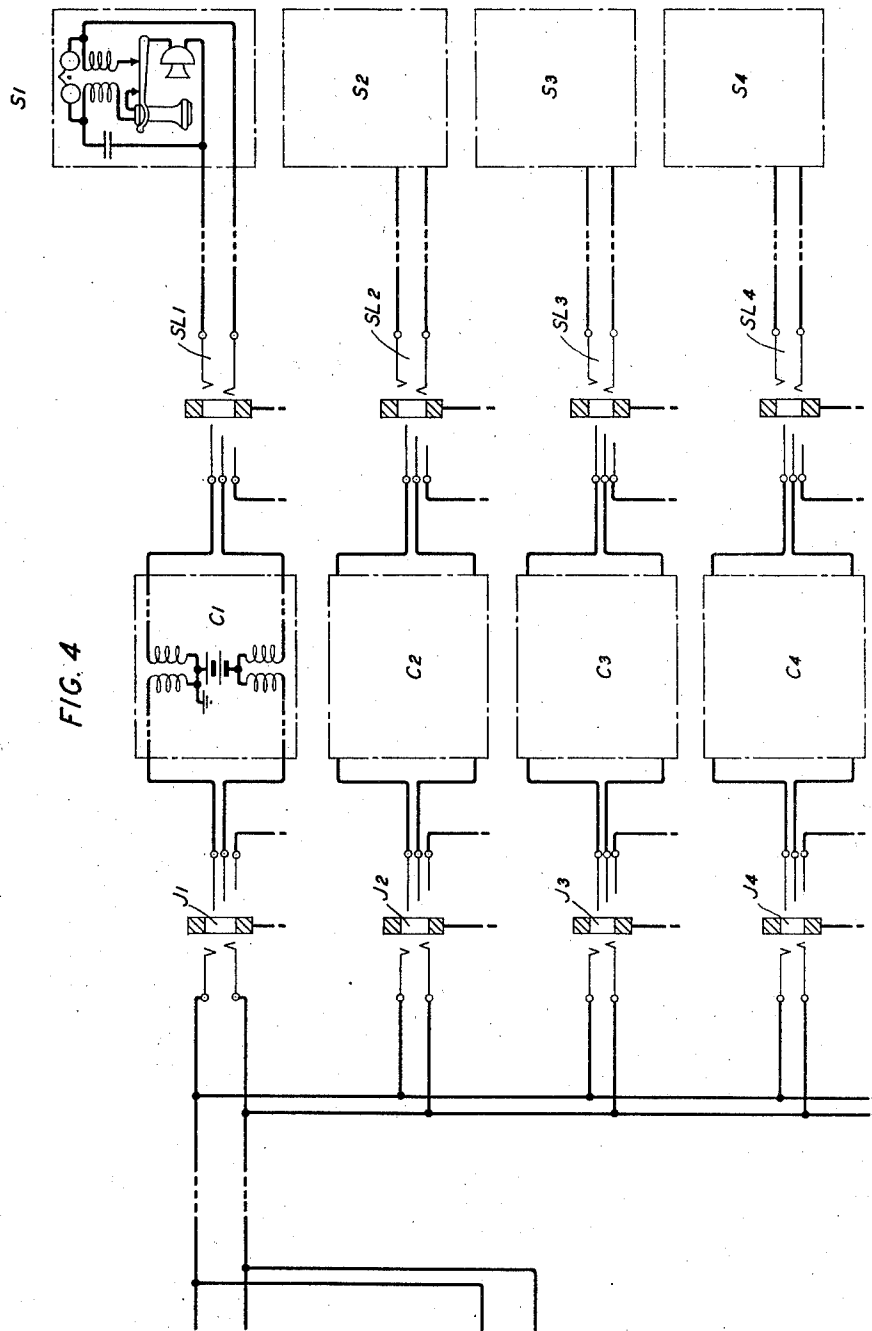
E. R. TAYLOR

2,137,036

TRANSMISSION SYSTEM

Filed Oct. 31, 1936

3 Sheets-Sheet 3



INVENTOR
E. R. TAYLOR
BY *A. G. Kingman*
ATTORNEY

UNITED STATES PATENT OFFICE

2,137,036

TRANSMISSION SYSTEM

Edmund R. Taylor, Mount Vernon, N. Y., assignor
to Bell Telephone Laboratories, Incorporated,
New York, N. Y., a corporation of New York

Application October 31, 1936, Serial No. 108,574

3 Claims. (Cl. 179—1)

This invention relates to transmission systems and more particularly to wire broadcasting systems, time of day announcement systems, and other systems of like character, wherein speech, music or other signals are transmitted over a line from a program or announcement source to a central distributing point, such as a telephone central office for example, where the signals are amplified and thereafter distributed to a plurality of branch lines terminating at subscribers' stations where the signals are either amplified and reproduced by means of loud-speakers, as in broadcast systems, or directly reproduced by telephone subscribers' receivers as in "time of day" announcements.

In systems of the foregoing character it is customary and desirable to connect the various lines in multiple, i. e. bridged relation, to the output of the amplifier at the central distributing point and, as the number of such branch lines so bridged to the amplifier output may vary from day to day or, in the case of time of day announcements, a single line may be connected at one moment and the next moment there may be a hundred lines connected, consequently, if it is assumed that the average impedance of the subscribers' lines, including protective resistance, is 1600 ohms and the maximum number of lines which can be connected to the amplifier is 100, the load impedance will vary all the way from 1600 ohms to 16 ohms, thereby causing a wide variation in the transmission volume as the number of connected lines changes, unless special precautions are taken to prevent it.

Various expedients have been used in the past to overcome this difficulty such as making the amplifier output impedance considerably higher than the impedance of the load circuit at its heaviest load, but this is a very inefficient arrangement as the transmission volume still varies to a large extent and also the efficiency of the amplifier is impaired due to the imperfect impedance match at full load. Another arrangement is to insert series impedance in each branch of the bridging arrangement ahead of the branch line and so arrange the circuit that when any branch line is disconnected an impedance equivalent to that of the disconnected line will replace. Such an arrangement is described in Patent 1,900,106 to H. S. Hamilton et al., issued March 7, 1933.

In the present arrangement the impedance looking into the output circuit of the amplifier is designed to match the minimum impedance

of the load circuit (i. e. the impedance at maximum load), and impedance elements having non-linear characteristics are connected in series with and in shunt to the input circuit of the amplifier, the resistance of said impedance elements being controlled by a feedback amplifier-detector arrangement responding to voltage variations in the load circuit whereby the amplitudes of the signal waves in the output of the distribution center amplifier are limited in such a manner that the wave peaks approach but do not exceed a predetermined maximum.

It will be understood that although the branch lines have been described as connected in multiple to the main line amplifier at the distributing center, they can be equally as well connected in series in which case the variable attenuator will be controlled on a current basis, i. e. the resistance of the impedance elements of the attenuation network will be regulated responsive to current variations in the output of the amplifier instead of variations in voltage in the case of the bridged or multiple arrangement.

An object of the invention is therefore to maintain a substantially constant signal volume in the connected branch lines irrespective of the number of lines connected.

Another object is to limit the energy volume of the signals emanating from the program source, which is accomplished by connecting non-linear impedance elements in series with and in shunt to the line between the program source and the distributing center and controlling the resistance values of these elements by means of a feedback circuit which is connected to the line between the impedance elements and the distributing center. A volume limiter suitable for this purpose is disclosed and claimed in U. S. Patent 2,089,346, issued August 10, 1937, to Stephen Doba, Jr.

It is well known that cross-talk and other interfering sounds are more noticeable and objectionable when occurring alone than when accompanied by signals of greater intensity which mask them out. On this account noise or cross-talk currents are more objectionable during pauses in broadcast transmission than when a program is being received.

Another object of the present invention is, therefore, to reduce or suppress cross-talk and other disturbing currents and prevent their being heard by the subscriber during silent periods or pauses in the transmission of a program. This is accomplished in the present invention by providing means in each of the

branch lines for causing the transmission efficiency of the circuit to vary so that cross-talk currents will be greatly attenuated and currents of signal energy will be transmitted with little or no attenuation. The specific manner in which the foregoing object is obtained will be apparent from the following description.

The invention will be understood from the following description and appended drawings:

Figs. 1 and 2, when joined with Fig. 2 to the right of Fig. 1, show a wire broadcasting line from a program source extending to and terminating in an amplifier at a distributing center and a number of branch subscribers' lines adapted to be multiply connected to a bus-bar or bridging circuit supplied from the output circuit of the amplifier. At the program source end of the line (Fig. 1) is shown a variable attenuator which serves to limit or reduce variations in the volume of the program signals transmitted.

At the subscriber's end of each branch line (Fig. 2) a noise and cross-talk reducer is shown connected therein for the purpose of substantially eliminating cross-talk, and other extraneous disturbances induced in the system, during pauses in program transmission.

Further, at the distributing center (Fig. 1), where the branch lines are connected to the main line, a variable attenuator in accordance with the principal feature of the invention, is shown, for the purpose, as hereinbefore stated, of maintaining a substantially constant signal volume in the branch lines regardless of the number of branch lines connected at any one time.

Fig. 3 shows a system similar to that of Fig. 2 except that the branch lines are connected in series, instead of multiple, at the distributing center and signal control is effected responsive to variations in current in the output of the amplifier, instead of variations in voltage, as in the bridged or multiple arrangement.

Fig. 4 shows an arrangement similar to that of Fig. 2 except that it is adapted for use in time of day announcing systems, the branch lines being regular telephone subscribers' lines which are connected, as desired, by suitable switching means (shown as manual cord circuits) to the bridging circuit or bus-bars at the distributing center. In this case the noise and cross-talk reducers at the subscriber station, being unnecessary, are eliminated.

First, considering the wire broadcast system as shown in Figs. 1 and 2, the program source, indicated by the microphone M and its associated amplifier A1, is connected to the line L extending to the program distribution center PC through the variable attenuator VA1.

The variable attenuator VA1 is similar in structure and operation to the volume limiter arrangement shown in U. S. Patent 2,089,346 issued August 10, 1937 in the name of Stephen Doba, Jr. and consequently a repetition of its description and operation is not necessary, it being sufficient to mention that by means of this arrangement program signals delivered at the output of amplifier A1, which are above a predetermined level, are either compressed or reduced, depending on their amplitude, by the variable attenuator so that the signals transmitted over the line L do not exceed a predetermined value regardless of the sound energy delivered at the microphone.

The other end of the line L terminates at the program distribution center in a circuit arrangement VA2 similar to the variable attenuator VA1, the object of which is to maintain a substantially

constant signal volume in the circuits connected to the output circuit of the amplifier A2 regardless of the load thereon, which depends on the number of branch lines BL1, BL2, etc., connected to the amplifier output.

The branch lines BL1, BL2, etc. extend to the subscribers' premises where they pass through individual noise and cross-talk reducers CR and after amplification by amplifiers such as A3, terminate in loud-speakers such as LS.

Let us assume that an announcer speaks into microphone M with varying volume, first in a low or normal strength of voice and suddenly raises his voice to a high volume. When the signals are below a predetermined upper limit no charge will be impressed on the control condenser 40 and, as described in the Doba specification above referred to, there will be no current flow through impedance elements 18 and 20, but there will be a maximum current flow through impedance elements 19 and 20 so their resistance values will be reduced to a minimum. Hence, the low intensity signals will pass through and into the line L with only slight attenuation.

As the announcer raises his voice volume so that the amplified signal waves go above the predetermined upper limit, for short periods, the resistance of impedance elements 19 and 21 is increased and the resistance of elements 18 and 20 is reduced. Accordingly, the high wave peaks are compressed or held down in accordance with the increased volume.

If it is assumed the signal wave peaks only rise above the predetermined upper limit for short periods, compression of the signal waves will be effected for short intervals, there being no appreciable reduction in the average volume of the signals.

If, however, the microphone M is subjected to very loud sounds, thereby causing the signal wave peaks to rise much higher, above the predetermined upper limit, the volume of the signals will be reduced as fully described in the specification mentioned.

It is therefore seen that the signal volume transmitted over the line and received at the distribution center is substantially constant due to the characteristics of the variable attenuator VA1.

The signal waves now pass through the second lattice network or attenuator VA2, similar in structure to that of VA1, and are then amplified by the amplifier A2, the output thereof passing through the transformer 47 at which point the branch lines BL1, BL2 are connected.

As the impedance looking outward from the secondary winding of transformer 47 toward the branch lines varies in accordance with the number of branch lines connected, the output impedance of the amplifier is so designed as to match the line impedance at greatest load, i. e. the impedance when the maximum number of branch lines is connected.

Now, under this condition when the load is a maximum, i. e. when the maximum number of branch lines is connected, the attenuator VA2 offers a minimum impedance to the signals and they therefore pass through with slight attenuation and into the branch or multiply connected lines and thence to the respective stations, the reason for this being that the voltage across the secondary of the output transformer 47, at full load, is at a minimum. Consequently there will be maximum current flow through impedance elements 19' and 21' of variable attenuator VA2

and hence their resistance will be at a minimum and there will be no current flow in impedance elements 18' and 20', hence their resistance will be high thereby causing little or no shunting effect on the signal.

Now, as the number of connected branch lines decreases the impedance of the load on the amplifier A2 increases, which causes an increase in voltage across the secondary of transformer 47, which in turn will result in increased energy supplied to the individual branch lines unless this increase is compensated for in the input circuit of the amplifier, which is accomplished in accordance with this invention by causing the increased voltage to control the resistance of elements 18' to 21' inclusive of the variable attenuator VA2 in the same manner as described in the Doba application above referred to, and consequently, as the voltage rises, the resistance of the impedance elements 19' and 21' increases and the resistance of elements 18' and 20' decreases thereby attenuating the signal current applied to the input of amplifier A2 with a consequent lowering of the voltage of the amplifier output and conversely, as the voltage of the amplifier output decreases, the attenuation of the signal currents is decreased thereby increasing the energy of the amplifier input and raising the voltage of the output. This arrangement maintains the voltage of the amplifier output substantially constant and as the impedance of the individual branch lines is unchanged and the average voltage applied thereto is held substantially constant, the energy delivered to the branch lines will also be substantially constant.

As previously stated, cross-talk and other interfering currents may be present in either the main line L or branch lines BL, BL1, BL2, etc. and during pauses in the program become noticeable and objectionable unless some steps are taken to eliminate them before they reach the loud-speaker.

To overcome this difficulty a cross-talk reducer CR (Fig. 2) is inserted in each branch line.

Cross-talk reducers per se are old and various arrangements for this purpose are shown in Patents 1,724,082; 1,811,915; 1,553,435, etc. The cross-talk reducer of the present invention, however, differs therefrom in several respects and may be briefly described as follows:

Inserted in each branch line is a fixed impedance improving pad comprising series resistances 48, 49, 50 and 51 and bridged resistance 52 and a transformer 53 including at the middle of its secondary winding a high resistance 54 shunted by a variable resistance element composed of four copper-oxide rectifier units in series, the two upper units being so directed as to permit currents to flow downward in the direction indicated by the arrow and the two lower units being connected in the opposite direction. A combination of the resistance 54 and the rectifier resistance 55 is called a "variable loss".

Due to the poling of the rectifier units, they normally offer a very high resistance to alternating current flowing in the line and if the resistance 54 is made sufficiently high, current flowing in the line will be attenuated to such an extent that, even when amplified, it will not be reproduced by the loud-speakers with sufficient volume to be distinguishable. This will be true both as regards currents of noise or cross-talk intensity, and also signal currents of speech intensity, unless some means is provided to reduce the attenuation when speech currents are received.

This discriminatory action or control of the "losser" is effected by the amplifier-rectifier arrangement consisting of vacuum tube amplifier 56 and bridge-type rectifier 57, connected in bridge of the line through a transformer 58. The secondary of transformer 58 is included in the input circuit of tube 56, the output of which is connected by means of transformer 59 to two points in the bridge rectifier 57. The remaining two points of the bridge rectifier are connected in a circuit which serially includes the upper and lower rectifier elements 55 in parallel, the upper and lower halves of the secondary winding of transformer 53 in parallel and the upper and lower halves of the primary winding of the input transformer 60 also in parallel.

By a proper selection and adjustment of the constants of the arrangement, the device can be made to introduce a loss of the order of twenty decibels in the line when only low intensity cross-talk or noise currents are present in the line and to reduce the loss to a negligible quantity when currents of signal intensity are transmitted, which is accomplished by making the resistance 54 sufficiently high so that, when the resistance of the rectifier shunt 55 is high, the desired attenuation in the input of amplifier A3 will be introduced to substantially suppress all signals and in so adjusting the circuit of amplifier tube 56 that low volume currents of cross-talk intensity will not cause sufficient direct current to flow through the rectifier element of resistance 55 to appreciably reduce its resistance, but when signal currents are present in the line, the rectified output of amplifier tube 56 will flow through the upper and lower halves of resistance 55 in parallel with sufficient volume to lower its resistance sufficiently to substantially short-circuit resistance 54 thereby reducing its attenuating effect on the line current to a very low value. The point at which the loss or attenuation of the line starts to change can be shifted at will by adjusting the gain of the amplifier tube 56.

When no signal is being received, no rectified current flows through the variable resistance or loss rectifier 55 and its resistance in series with the transmission circuit is very high, the loss in the circuit being determined largely by resistance 54, which in practice is in the order of twenty decibels. As alternating current of audible frequency is applied to the line, direct current flows in the bridge rectifier 57 through the loss rectifier 55 whose resistance decreases in proportion to the direct current flowing therein, thereby reducing the loss introduced in the line.

In practice the cross-talk reducer CR may be so arranged that, within certain limits, for each decibel of increase in the line current, the loss in the circuit decreases one decibel.

The arrangement indicated, but not shown in detail, in Fig. 3 is the same as that of Fig. 2 except the branch lines BL1, BL2, etc. are serially connected to the secondary winding of transformer 47 shown in Fig. 1 and the primary of input transformer 28' (Fig. 1) is connected in series with the secondary of transformer 47, i. e. across the end of a series shunt 61 (Fig. 3). Otherwise, Figs. 2 and 3 are identical in structure and operation and further description is not deemed necessary.

Now referring to Fig. 4: When this figure is placed at the right of Fig. 1, we have the secondary of output transformer 47 of Fig. 1 connected in multiple to a plurality of telephone switchboard jacks J1, J2, etc. which may be con-

nected, at will, to telephone subscribers' lines SL1, SL2, etc. by means of conventional switch-board cord circuits C1, C2, etc.

If we assume that the program source (Fig. 1), in this case, is located at a time of day announcing desk in a telephone central office from which point a special operator announces the time of day at regular and frequent intervals, then the announcement signals will be transmitted over line L to the program distribution center PC where it passes through the volume equalizer or attenuator VA2 and from there may be connected at will by means of the cord circuits C1, etc. at the request of any or all of subscribers S1, S2, etc.

It will be obvious that in this case the load on amplifier A2 will be constantly changing as the subscribers S1, etc. request to be connected to the announcing circuit, i. e. to the output of amplifier A2, and therefore, the volume equalizer or attenuator VA2 is of particular value under this condition as, regardless of the number of subscribers' lines which are connected at any one instant, the signal volume of the announcement transmitted to each of the lines will be substantially constant.

What is claimed is:

1. In a signal transmission system, in combination, a source of signal frequency, a distributing center, a main line interconnecting said source and the distributing center, means between the source and the main line for limiting the energy volume of the signals transmitted over the line to a predetermined level, an amplifier at the distributing center having its input circuit connected to the main line, a load circuit, a plurality of branch lines, signal receiving means terminating each of said branch lines, means for connecting and disconnecting any of said branch lines to and from said load circuit, transformer means connecting the output of said amplifier with the load circuit, said amplifier being so constructed and arranged that the impedance of the output circuit thereof, as viewed from the primary winding of the transformer, substantially matches the impedance of the load circuit as viewed from the secondary winding of the transformer when the maximum number of branch lines are connected, a variable attenuator in said main line at the distributing center and ahead of the amplifier, and a feedback circuit connected to said load circuit for controlling said attenuator, said attenuator being so adjusted that it offers minimum attenuation to signals arriving over the main line when the maximum number of branch lines are connected.

2. In a signal transmission system, in combination, a source of signal frequency, a distributing center, a main line interconnecting said source

and the distributing center, means between the source and the main line for limiting the energy volume of the signals transmitted over the line to a predetermined level, an amplifier at the distributing center having its input circuit connected to the main line, a load circuit, a plurality of branch lines, signal receiving means terminating each of said branch lines, means for connecting and disconnecting any number of said branch lines serially in said load circuit, transformer means connecting the output of said amplifier with the load circuit, said amplifier being so constructed and arranged that the impedance of the output circuit thereof, as viewed from the primary winding of the transformer substantially matches the impedance of the load circuit, as viewed from the secondary winding of the transformer, when the maximum number of branch lines are connected in the load circuit, a variable attenuator in said main line at the distributing center and ahead of the amplifier, and a feedback circuit serially connected in said load circuit for controlling said attenuator, said attenuator being so adjusted that it offers minimum attenuation to signals arriving over the main line when the maximum number of branch lines are connected in the load circuit.

3. In a signal transmission system, in combination, a source of signal frequency, a distributing center, a main line interconnecting said source and distributing center, means between the source and the main line for limiting the energy volume of the signals transmitted over the line to a predetermined level, an amplifier at the distributing center having its input circuit connected to the main line, a load circuit, a plurality of branch lines, signal receiving means terminating each of said branch lines, means for multiply connecting and disconnecting any number of said branch lines to and from said load circuit, transformer means connecting the output of said amplifier with the load circuit, said amplifier being so constructed and arranged that the impedance of the output circuit thereof, as viewed from the primary winding of the transformer, substantially matches the impedance of the load circuit, as viewed from the secondary winding of the transformer, when the maximum number of branch lines are connected to the load circuit, a variable attenuator in said main line at the distributing center and ahead of the amplifier, and a feedback circuit connected in bridge to said load circuit for controlling said attenuator, said attenuator being so adjusted that it offers minimum attenuation to signals arriving over the main line when the maximum number of branch lines is connected to the load circuit.

EDMUND R. TAYLOR.