

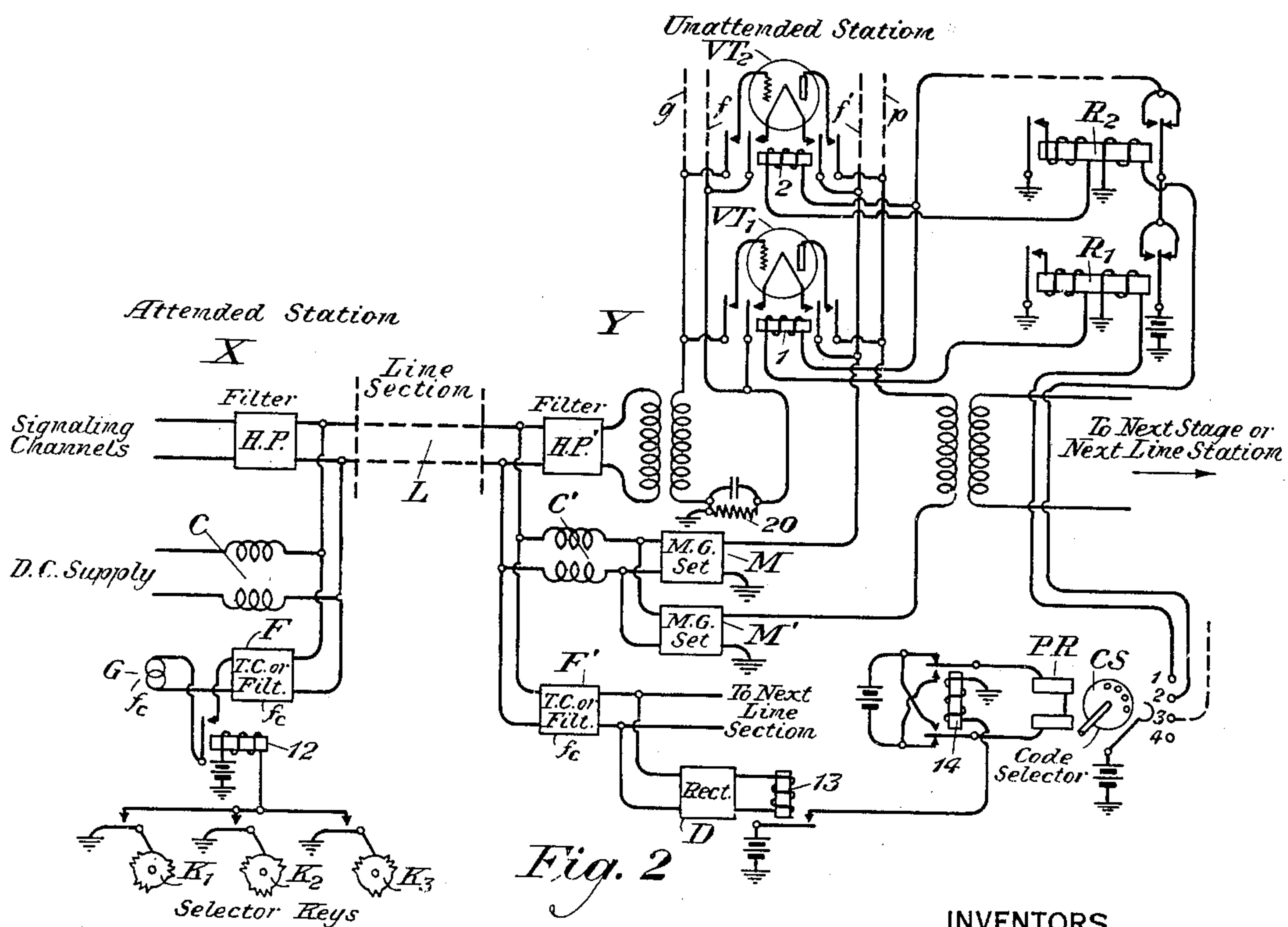
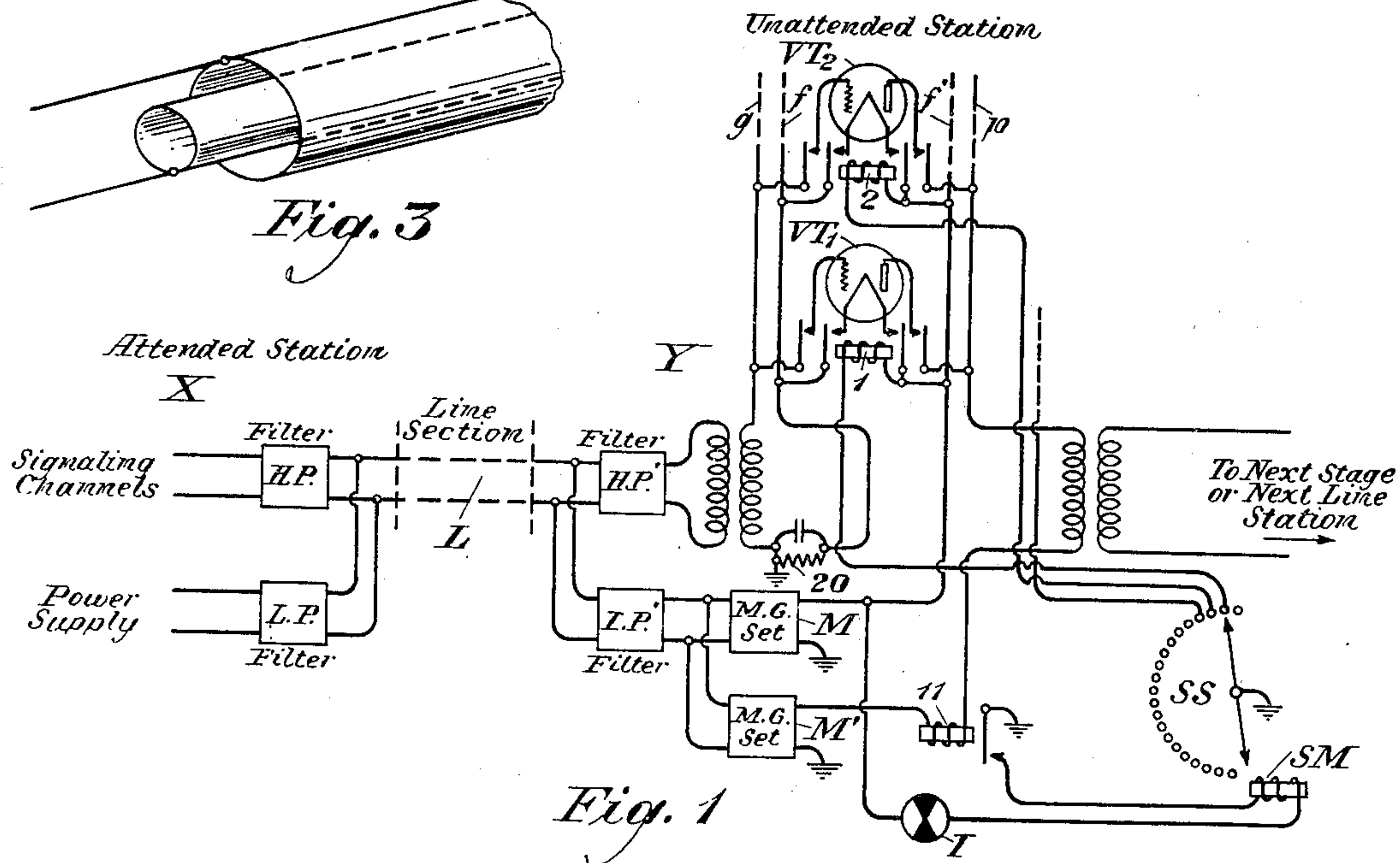
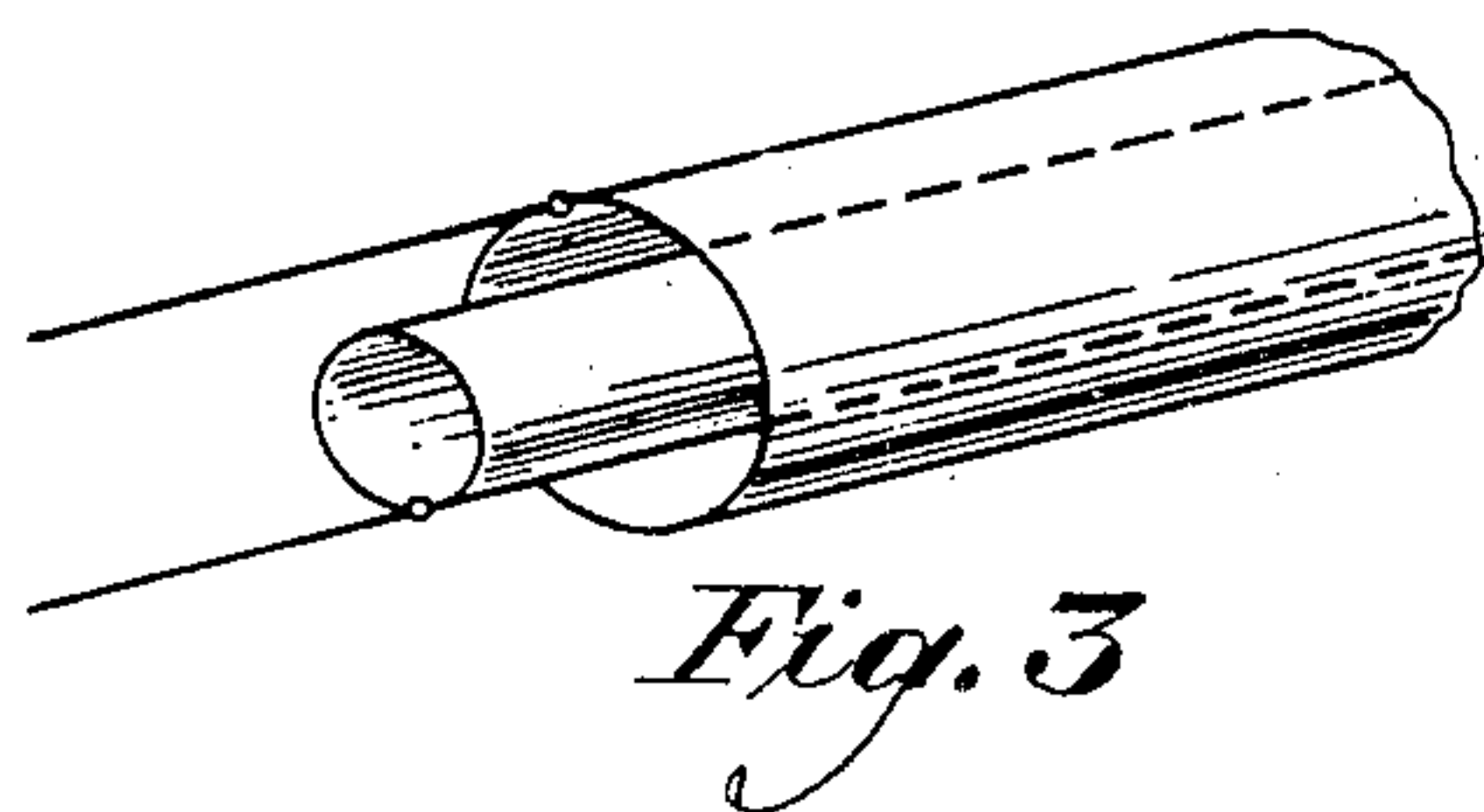
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AMPLIFIER CONTROL

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1,946,607

AMPLIFIER CONTROL

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6 Claims. (Cl. 179—170)

This invention relates to transmission circuits, and more particularly to arrangements for controlling amplifiers and other vacuum tube equipment in such transmission circuits.

5 It has been found that the coaxial conductor type of construction furnishes a very useful transmission circuit. This type of conductor involves two cylindrical conductors of different sizes, concentrically arranged, and one connected
10 as a return for the other. The conductors will be maintained in properly spaced relationship by means of suitable insulating washers arranged at intervals along the conductors, but the principal dielectric medium between the conductors will be
15 air. Such a circuit has a very low attenuation over an exceedingly wide range of frequencies.

The coaxial conductor type of construction lends itself particularly well to the use of intermediate repeaters which are unattended and
20 whose power supply is furnished over the conductors used for the transmission of intelligence. This is due to several factors. In the first place, the cross-section of copper in the concentric conductor is sufficient to transmit very large amounts
25 of power. Furthermore, there is required at each repeater point only one amplifier for all of the transmission channels transmitting in a given direction. And finally, the coaxial construction is so well shielded from external disturbances that
30 the amplifiers employed need not have large carrying capacity, and therefore, can be operated with smaller power supply than is the case for the ordinary amplifier. However, it should be understood that the invention described is
35 not necessarily limited to this particular form of conductor.

Wherever an unattended repeater station occurs, it is desirable to have available some arrangement for providing alternative repeater
40 equipment if a given repeater should fail, and this is true whether the transmission circuit is of the concentric conductor type or of the ordinary type. The present invention provides means whereby, when a vacuum tube at an unattended repeater
45 station fails, it will be replaced by a spare tube either automatically or under the control of an attendant at a distant attended repeater station.

The invention will now be more fully understood from the following description, when read
50 in connection with the accompanying drawing, in which Figure 1 shows an arrangement for automatically substituting a spare vacuum tube for a vacuum tube which fails; Fig. 2 shows an arrangement in which the spare tube is switched into
55 circuit under the control of an attendant at a

distant station; and Fig. 3 shows schematically a concentric type of conductor system which may be employed as the transmission circuit in Figs. 1 and 2.

Referring to Fig. 1, a line section L is shown
60 extending between an attended repeater station X and an unattended repeater station Y. One or more signaling channels may be transmitted over the line section L by means well known in the art, and these channels will be amplified by
65 the amplifying apparatus located at station Y. The signaling channels are transmitted to the line section L at the attended repeater station X, through a high-pass filter HP, which passes the signaling channels but prevents lower fre-
70 quencies, such as power frequencies, from passing. The power supply, which in this case may be an alternating current source of power, is applied to the line section L through a low-pass filter LP, which prevents the higher frequency
75 signaling currents from entering the power supply circuit.

At the unattended repeater station Y the signaling frequencies are separated from the power current by means of high-pass filter HP', which
80 passes signal currents to the amplifier, and a low-pass filter LP', which passes the power currents to motor generator sets or other equipment for supplying direct operating currents to the vacuum tube or tubes of the amplifier.
85 In the case illustrated, the power received from the line section L is applied to motor generator sets M and M' of well known construction. The motor generator set M supplies direct current at a suitable voltage for energizing the filaments
90 of the vacuum tubes, and the motor generator set M' supplies a direct current at a suitable potential for energizing the plates of the tubes. In order to supply the usual C or grid potential, the filament current is caused to flow through
95 a suitable resistance 20 and the grids of the vacuum tubes are connected to such a point with respect to the resistance 20 that there will be a negative potential drop between the filament and the grid. This grid potential may be obtained
100 from plate circuit drop if desired.

In order that there may be no failure of the repeater at the unattended station because the repeater tube becomes disabled, the present invention provides two or more similar repeater
105 tubes together with suitable arrangements for connecting an alternative tube into circuit in case the operating tube fails. Such repeater tubes are shown at VT₁ and VT₂, it being understood that additional tubes will be connected to the
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grid, filament, and plate bus bars g , f , f' , and p . An automatic step-by-step switch SS is provided, having a wiper which may rest upon any one of several contacts leading to relays such as 1, 2, etc., for controlling the connection of the several tubes to the bus bars.

Let us assume that the tube VT₁ is connected in circuit. Relay 1 will be energized by a connection from ground over the arm and first contact of the switch SS, through the relay 1, and through the direct current generator winding of the motor generator set M to ground. The filament circuit of the tube VT₁ will be completed from ground through the resistance 20, through the closed inner contacts of the relay 1, through the generator of the motor generator set M to ground. The grid potential will be supplied from the negative side of the resistance 20 over the left-hand contact of the relay 1. The plate circuit will extend from the grounded filament of the tube VT₁ to the plate, and thence over the right-hand contact of relay 1 and through the common relay 11 to the generator of the motor generator set M' and thence to ground.

If, now, the filament of the tube VT₁ should burn out or for any other cause the plate current should cease to flow, the relay 11 which is normally energized will release its armature and complete a circuit from ground over its back contact through the stepping magnet SM of the switch SS, through the interrupter I and thence through the generator winding of the motor generator set M to ground. As soon as the interrupter completes the circuit of the stepping magnet SM, the switch SS is stepped to the second contact and a circuit will be completed from ground over said second contact through the winding of the relay 2 and through the generator of the motor generator set M to ground. The relay 1 is released at the same time that the wiper of the switch SS passes to the second contact, and the relay 2 is energized to connect the tube VT₂ to the bus bars in the same manner as the tube VT₁ was previously connected. If the tube VT₂ is operative, plate current will, of course, flow through the relay 11 and said relay will open the circuit of the stepping magnet SM before the interrupter I has an opportunity to close the circuit of said stepping magnet again and the switch SS will remain with its wiper resting on its second contact. The vacuum tube VT₂ now serves as the operating vacuum tube of the repeater.

If it should happen that when the wiper of the switch SS passes to the second contact the vacuum tube VT₂ is also disabled, as, for example, because its filament has burned out, no current would flow from its plate through the relay 11 and its armature would remain resting on its back contact. Consequently, as soon as the interrupter I again closes its circuit, the stepping magnet SM will be energized to step the switch to a third contact, and this operation will continue until the wiper is stepped to the contact of an operative tube, whereupon the plate current will flow through the relay 11 and stop further stepping of the switch SS.

While the arrangement above described is applicable to any type of transmission line, it is particularly desirable where the line sections are of the concentric conductor type shown schematically in Fig. 3. The concentric conductor type of system is one in which two cylindrical conductors are arranged one within the other on the same axis, the one conductor acting as a return for the other. As is well known in the art, the two

conductors may be maintained in proper spatial relation by means of insulating washers or equivalent devices which are arranged along the circuit at suitable intervals. The principal dielectric between the two conductors is, however, air or other gas which has a dielectric constant of about unity, so that there is substantially no attenuation loss due to leakage between the conductors.

The coaxial conductor type of construction lends itself particularly well to the use of intermediate repeaters which are unattended and whose power supply is furnished over the conductors used for the transmission of intelligence. In the ordinary type of transmission circuit the line wires are so small and their construction is such that they are not capable of transmitting efficiently the amount of power required for a vacuum tube repeater. In the case of a group of telephone circuits such as, for example, an open wire lead or a cable, there is a considerable amount of copper in the total cross-section of all the line conductors involved. This factor is completely negated, however, by the fact that a large number of repeaters must be supplied with power at each repeater station, there being at least one repeater for each line conductor. Hence, the large number of circuits does not simplify the problem but rather complicates it because of the difficulty in assuring uninterrupted operation of so many repeaters without attendants.

In the coaxial type of circuit, however, we have a combination which is admirably adapted to the operation of automatic repeaters supplied with power over the transmission circuit. In the first place, there is a large cross-section of copper. For example, if a construction were employed in which the outer copper pipe had an outer diameter of 2½ inches and a thickness of .065 inches, with an inner conductor of ¾ inch outer diameter and .109 inch thickness, the direct current resistance of the circuit would be about .5 ohm per mile, which would permit the transmission of power over considerable distances. In the second place, only one repeater is required at each repeater point for transmission in a given direction. Finally, the coaxial construction is so well shielded from external disturbances that the amplifiers used need not have a large carrying capacity, and hence, may employ tubes which require a relatively small power supply.

In the case of a coaxial conductor system, the repeaters might be supplied with power at relatively low voltages over substantial distances. Moreover, the construction is such that a higher voltage may readily be employed, if this is desired, in order to secure greater power or transmission over longer distances. The adaptability of the coaxial circuit to high voltages results from the fact that the inner and outer conductors are spaced a substantial distance apart by means of high grade insulators, the circuit being protected from weather effects due to the inherently water-tight nature of the outer conductor, and the hollow construction generally resembling mechanically that of a power cable.

Accordingly, it is extremely feasible in the case of a coaxial circuit to provide unattended intermediate repeater stations whose power is supplied from an attended office and whose amplifier tubes may be automatically or otherwise replaced by spare tubes in case a given tube fails. Obviously, these unattended repeaters might be alternated between regular attended repeaters or

a whole series of unattended repeaters might be employed.

An alternative arrangement is illustrated in Fig. 2. In this case the power supply for operating the vacuum tubes at the unattended station is transmitted over the line section L in the form of direct current. The power current is applied to the line through a choke coil C at the attended station and is taken off at the unattended station by means of a choke coil C' instead of by means of a low-pass filter, as the choke coil is cheaper and discriminates sufficiently against the signaling frequencies while efficiently permitting the transmission of direct current energy. As in the case of Fig. 1, the power received from the line L is used to operate motor generator sets M and M' for supplying the filament and plate potentials, respectively.

In Fig. 2, the substitution of a spare tube for a disabled tube is under the control of the operator at the attended station and for this purpose an auxiliary control channel is provided by supplying an alternating current of frequency f_c from a suitable generator G at the attended station, its frequency being transmitted to the line section L from a filter or tuned circuit F. Such carrier can be used as a pilot of transmission level and for performing other functions at the same time. The frequency of the auxiliary channel is taken off at the unattended station from a similar filter or tuned circuit F', and the selected frequency is then applied to a rectifier D which supplies rectified operating current for a relay 13.

In order to select any particular tube, a code selector and key arrangement of the type disclosed in U. S. patent to J. C. Field, No. 1,343,256, are employed. The selector keys K₁, K₂ and K₃ are disks which send various combinations of groups of impulses through a controlling relay 12 which interrupts the alternating control current supplied to the line L, thereby causing an intermittent operation of the receiving relay 13 at the unattended station in a manner similar to the operation of the relay 12 at the sending station. The relay 13 opens and closes the circuit of a relay 14 which, in turn, reverses the polarity of the current supplied to the polar relay PR of the receiving element of the code selector. Under the control of the polar relay PR the code selector CS is operated to a selected position, depending upon which one of the selector keys was operated at the attended station. If the code selector CS is operated to complete a circuit from battery over the first contact of the code selector, the right-hand winding of the relay R₁ will be energized and the left-hand winding of said relay will be locked up over its left-hand contact through said left-hand winding, through the winding of the relay 1, over the right-hand back contacts of relays such as R₂, and over the front right-hand contact of relay R₁ to battery. Relay 1 is now energized over this locking circuit and connects the vacuum tube VT₁ to the grid, filament and plate bus-bars, over the front contacts of said relay 1. Filament and plate currents are now supplied to the tube from the motor generator sets M and M', respectively, the grid potential being derived from the resistance 20 as in the case of Fig. 1.

If, with the circuit in this condition the attendant at station X should discover that the repeater VT₁ has failed, or if for any other reason he wishes to substitute some other vacuum tube, he will operate one of the selector keys at the attended station, which corresponds to such

other tube, thereby transmitting a different code combination to the code selector CS. If the tube which is now to be connected in circuit is the tube VT₂, the code selector CS will be stepped by the operation of the proper key to its second contact, thereby completing a circuit through the right-hand winding of the relay R₂. The right-hand contact of the relay R₂ is now shifted from its back to its front contact, thereby momentarily opening the locking circuit through the left-hand winding of the relay R₁ and causing the release of the relay 1. This disconnects the vacuum tube VT₁ from the bus-bars. A circuit is now completed over the left-hand contact of relay R₂ and through its locking winding and thence through the winding of the relay 2 over the back right-hand contacts of any relays beyond the relay R₂, over the front right-hand contact of the relay R₂ and over the back right-hand contact of the relay R₁ to battery. Relay 2 upon being energized connects the grid, filament and plate leads of the vacuum tube VT₂ to the bus-bars so that the vacuum tube VT₂ now functions as the amplifier at the unattended station.

It will be understood, of course, that other unattended repeater stations may be connected in the transmission circuit at various points, in which case the frequency f_c will be transmitted over the line and through all intermediate repeater stations to the terminal. At each unattended repeater station, apparatus similar to that shown at station Y will be provided and code selector keys will be provided at the attended station for selecting the various tubes at each of the other unattended stations. In this case, the code combinations which operate to connect tubes at such other unattended stations will be so chosen in accordance with the principles of the Field patent, already referred to, that the code selector CS at the unattended station Y (and at any other station where it is not desired to switch the amplifying tubes) will not complete a circuit over any of its contacts which are connected to switching relays such as R₁ and R₂.

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 transmission system, a transmission line, a vacuum tube repeater at a repeater station associated with said line, means to transmit signaling currents over said line to be amplified by said repeater, means to transmit power current from a distant station over said line to energize said repeater, a step-by-step selective switch for selecting any one of several spare repeater tubes to replace a repeater tube which has failed, and means to energize said spare tubes from the same power current when so selected.

2. In a transmission system, a transmission line, a vacuum tube repeater at a repeater station associated with said line, means to transmit signaling currents over said line to be amplified by said repeater, means to transmit power current from a distant station over said line to energize the filament and plate circuits of said repeater by the same power current, a step-by-step selective switch for selecting any one of several spare repeater tubes to replace a repeater tube which has failed, and means to energize said spare tubes from the same power current when so selected.

3. In a transmission system, a transmission

- line, a vacuum tube repeater at a repeater station associated with said line, means to transmit signaling currents over said line to be amplified by said repeater, means to transmit power current from a distant station over said line to said repeater station, means at said repeater station to translate said power current into direct currents of such potentials as to energize the filament and plate circuits of said repeater, a step-by-step selective switch for selecting any one of several spare repeater tubes to replace a repeater tube which has failed, and means to energize said spare tubes from the same power current when so selected.
4. In a transmission system, a transmission line, a vacuum tube repeater at a repeater station associated with said line, means to transmit signaling currents over said line to be amplified by said repeater, means to transmit power current from a distant station over said line to energize said repeater, a selective switch for selecting any one of several spare repeater tubes to replace a repeater tube which has failed, means to enable an attendant at a distant station to directively control said switch over said line, and means to energize said spare tubes from the same power current when so selected.
5. In a transmission system, a transmission line, a vacuum tube repeater at a repeater station associated with said line, means to transmit signaling currents over said line to be amplified by said repeater, means to transmit power current from a distant station over said line to said repeater station, means at said repeater station to translate said power current into direct currents of such potentials as to energize the filament and plate circuits of said repeater, a selective switch for selecting any one of several spare repeater tubes to replace a repeater tube which has failed, means to enable an attendant at a distant station to directively control said switch over said line, and means to energize said spare tubes from the same power currents when so selected.
6. In a transmission system, a transmission line, a vacuum tube repeater at a repeater station associated with said line, means to transmit signaling currents over said line to be amplified by said repeater, means to transmit power current from a distant station over said line to said repeater station, means at said repeater station to translate said power current into direct currents of such potentials as to energize the filament and plate circuits of said repeater, a selective switch for selecting any one of several spare repeater tubes to replace a repeater tube which has failed, means to enable an attendant at a distant station to directively control said switch over said line, and means to energize said spare tubes from the same power currents when so selected.
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