

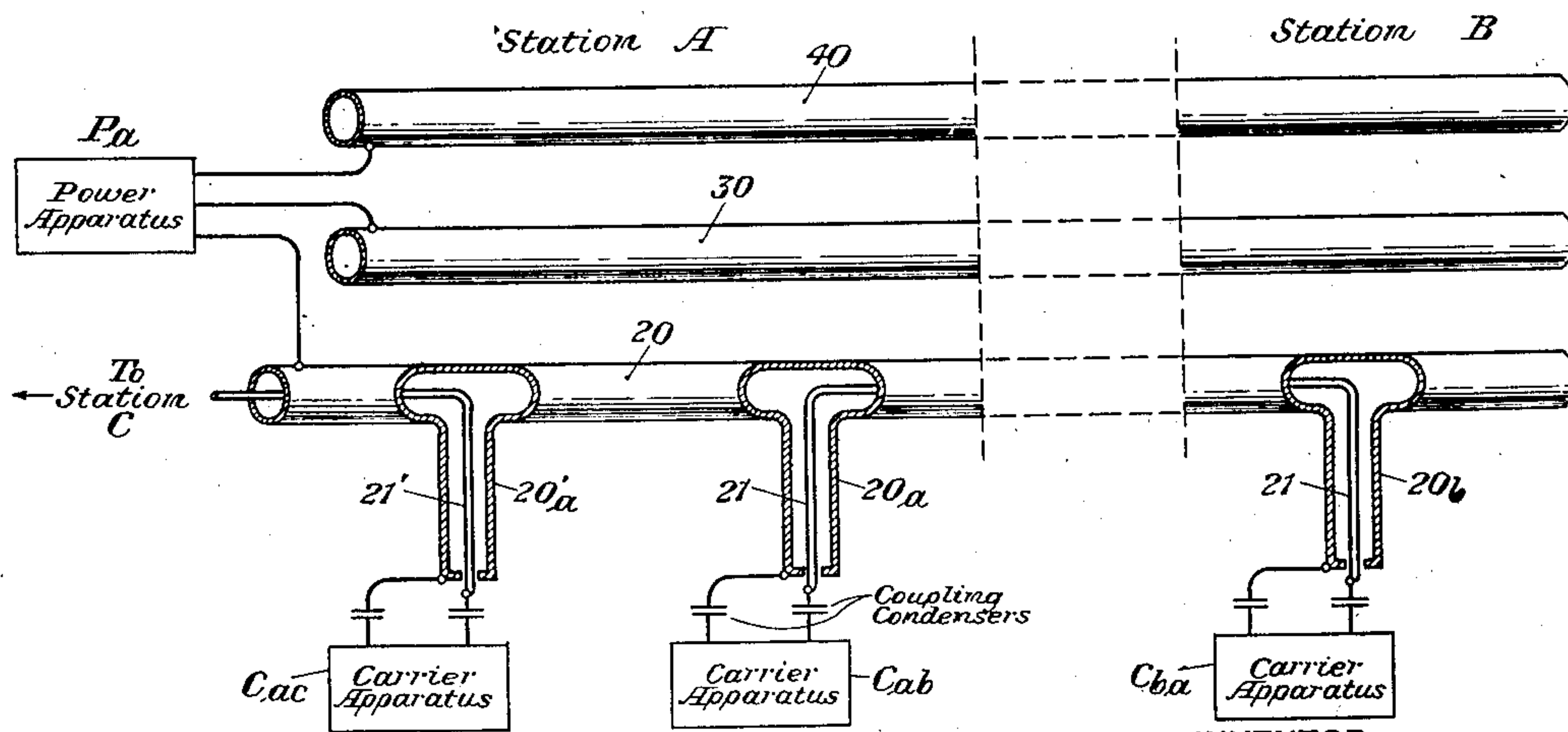
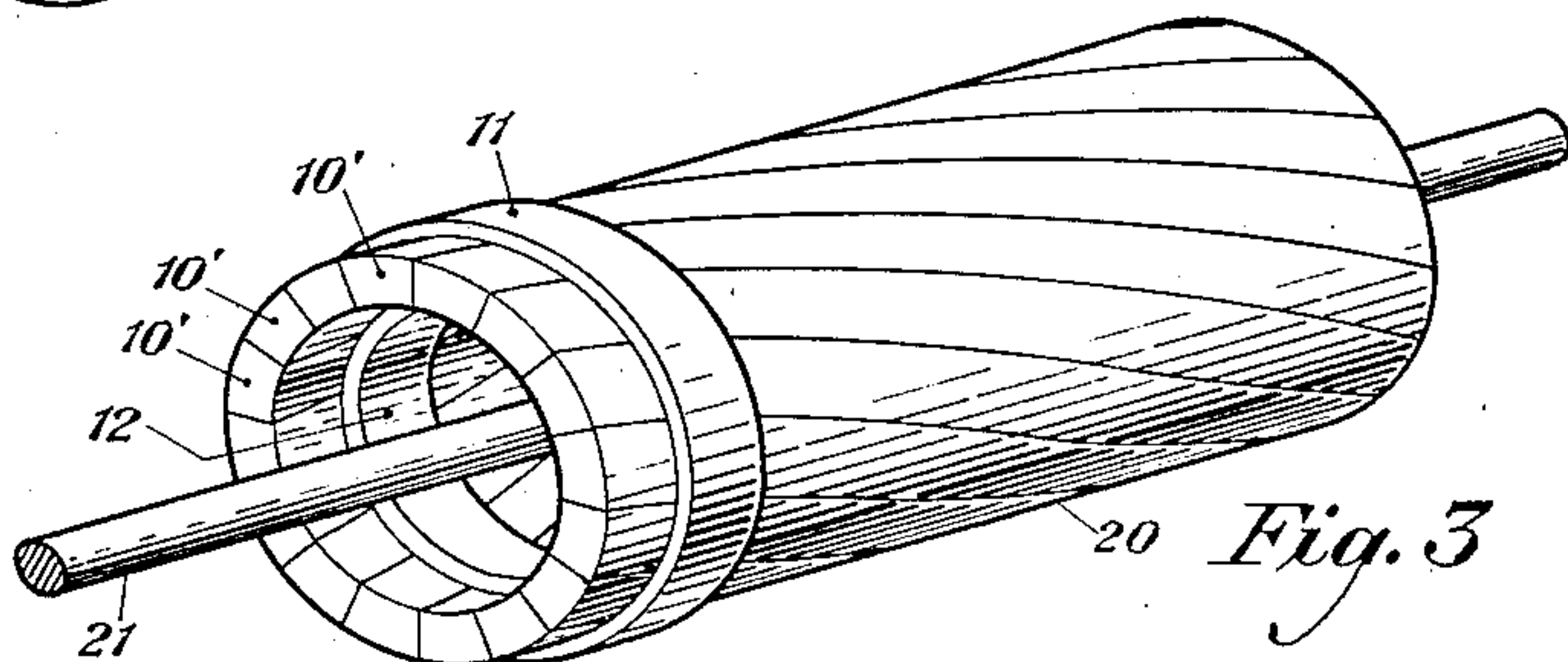
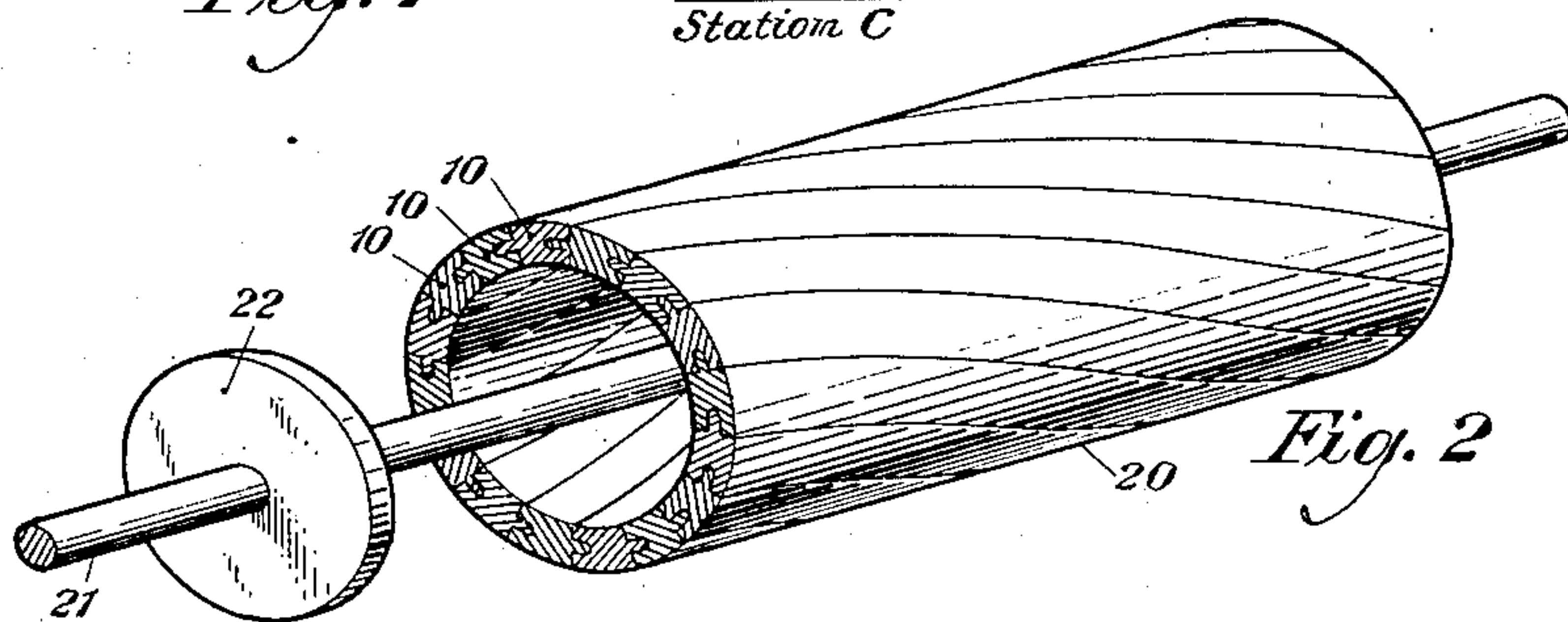
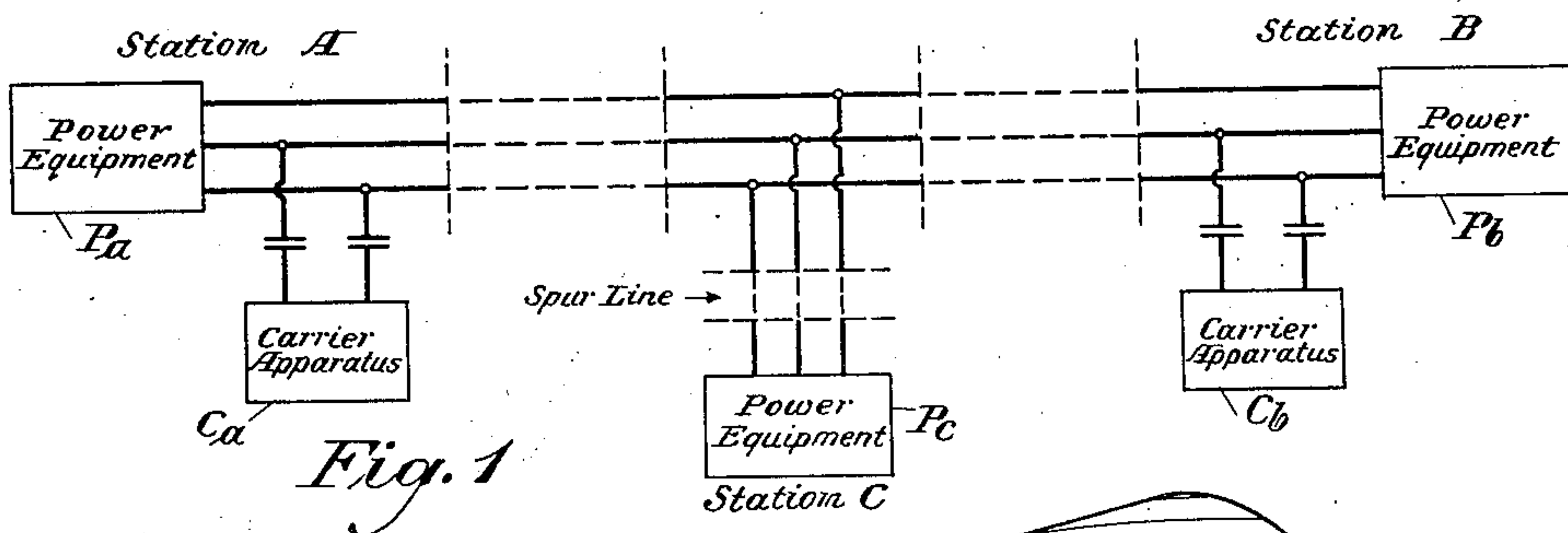
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COAXIAL CONSTRUCTION FOR POWER LINE CARRIER SYSTEMS

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COAXIAL CONSTRUCTION FOR POWER LINE CARRIER SYSTEMS

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This invention relates to carrier transmission systems, and more particularly to carrier transmission systems which are superposed upon power networks.

5 In the use of carrier systems on power lines, considerable difficulty arises from the fact that the power circuit is generally part of a network of interconnecting lines, with frequent radiating spurs, paralleling circuits, etc. The high-frequency carrier system derived from a power line is therefore markedly different from a telephone line carrier circuit which proceeds directly from one terminal to another without intermediate connections.

15 The complex nature of the power connections introduces undesirable impedance irregularities and reflection effects, and makes the characteristics of the carrier transmission circuit extremely erratic. For example, if it is desired to provide carrier transmission between two stations and at an intermediate point in the power line connecting the stations there is a spur connection leading to another power station, the carrier frequency impedance presented by the spur line at the junction with the main line will vary widely with frequency. At certain frequencies it may practically approach a short-circuiting condition, thereby preventing satisfactory transmission between the stations.

25 The power network is also unsatisfactory for carrier use because a particular carrier frequency which is applied to one part of the network is apt to spread over the entire system. Hence, a given frequency band can ordinarily be used only once in the entire power network. Efforts have been made to obviate this difficulty by inserting in the power wires blocking high frequency impedances in the form of anti-resonant circuits or "chokes". Such expedients, however, have a detrimental effect upon the power circuit and, hence, have not been widely used.

40 Again, carrier transmission over power wires suffers some limitation by reason of the interference which may be produced in telephone line carrier systems. Large amounts of power are required for the power line carrier system and owing to the unbal-

anced nature of the power circuit at high frequencies, the high frequency induction into adjacent telephone circuits is naturally large. Up to the present time this difficulty has largely been avoided by employing different frequency ranges for the power line carrier systems and for telephone line carrier systems. With increasing use of both types of systems, however, this arrangement may not continue to be possible.

60 A further limitation in the use of power line carrier is the high frequency noise which results when the same circuit is employed for both power and carrier transmission. The interfering effect upon the carrier circuit of such phenomena as corona discharge, arcing at defective insulators, etc., is particularly marked.

70 The purpose of the present invention is to provide means for surmounting the difficulties above noted by using coaxial conductors for power lines. As is well known, the modern tendency toward higher and higher voltages for power transmission has made the avoidance of corona discharge a very serious problem. Special power conductors are being designed to increase the corona limit, these ordinarily taking the form of a hollow conductor of large diameter and smooth surface. It is therefore proposed in accordance with the present invention to insert within these hollow conductors wires which are supported coaxially with respect to the power conductor by means of annular or disk-shaped insulators. Thus, there will be derived at the nominal cost of a wire and some insulators, a coaxial circuit of a type which has been found extremely advantageous for high frequency transmission.

90 The invention will now be more fully understood from the following description, when read in connection with the accompanying drawings, in which Figure 1 illustrates certain difficulties involved in superposing a carrier system upon a power network; Figs. 2 and 3 show how the concentric conductor arrangement may be applied to two forms of hollow or cylindrical power conductors which it has been proposed to use in order to overcome the effects of corona dis-

charge, etc., and Fig. 4 shows how one or more carrier systems may be applied to the concentric conductor transmission medium afforded by conductor systems of the type shown in Figs. 2 and 3.

Referring to Fig. 1, a typical power circuit network is shown comprising a three-wire transmission line extending between stations A and B, at which stations power equipment is provided as shown at P_a and P_b . At an intermediate point a branch or spur power line of three conductors runs to another station C at which power equipment P_c is provided. Suppose, now, we have the problem of setting up a signaling circuit such as a telephone circuit between stations A and B, and we attempt to solve this problem by connecting carrier terminal apparatus such as shown at C_a and C_b to two of the power conductors through the usual coupling condensers so that one of the power conductors acts as a return for the other with regard to the carrier transmission system. At once the difficulty is presented that the carrier frequency impedance which the spur line presents at the junction with the main line will vary widely with frequency and at certain carrier frequencies will resemble a short circuit, thereby preventing satisfactory transmission between stations A and B. Such a carrier transmission system will also be subject to the various other difficulties which have already been outlined.

Accordingly, it is proposed to use coaxial power conductor arrangements for transmitting the carrier frequencies. Two types of conductors which may be employed in power lines for the purpose of increasing the corona discharge limit are shown in Figs. 2 and 3 respectively. These conductors may be of copper or other suitable material. In Fig. 2 the outer conductor consists of a number of specially shaped wires 10—10—10 which interlock by means of tongue and groove arrangements to form what is practically a solid tube 20. This conductor may be used for power purposes without internal support. In Fig. 3 the outer or power conductor is composed of wires 10'—10'—10' which are wedge-shaped or cuneiform in section, these wires being bound together by outside bands arranged at suitable intervals as shown at 11. This type of conductor may also require some sort of internal support such as, for example, metal rings arranged at intervals as illustrated at 12.

In accordance with the present invention it is proposed to obtain a coaxial conductor system from conductors of this type by supporting a second conductor such as 21 in a concentric position within the outer conductor 20. The inner conductor 21 may be either a solid wire or a tube. It will be supported in its concentric position by means of insulating spacers 22 which may assume various

forms, but as here illustrated are in the shape of disks, these disks being strung along the inner conductor at such intervals as are necessary to maintain proper spacial relationship. These spacing washers should be of some dielectric material of the lowest possible dielectric constant and power factor consistent with the necessary mechanical strength. However, since these insulators only occur at intervals, the principal dielectric intervening between the conductors will be air or other suitable gas whose dielectric constant is approximately unity, so that there is substantially no power loss between the conductors. In the case of Fig. 3, the insulating spacers 22 may be used either instead of or in addition to the internal supporting rings 12 required for the outer wires.

By constructing the power conductors in this manner there is obtained a power line circuit which contains within itself a coaxial circuit for high frequency carrier transmission. This coaxial circuit may be terminated at any point merely by terminating the inner conductor as is shown, for example, in Fig. 4. Here the power circuit is made up of three hollow conductors 20, 30 and 40, connected in three-wire form to power apparatus which may be branched off as shown at P_a . The power conductors which are shown as extending to stations A and B may also be considered to extend to a third station C at the left (not shown). For communication between stations A and B, outer tubular members 20_a and 20_b may be associated with the conductor 20 as shown and the inner conductor 21 brought out at the two stations through these tubular outlets. The terminal carrier apparatus C_{ab} at stations A and similar apparatus C_{ba} at station B, which is to be used for communication between stations A and B can then be connected to the conductors 21 and 20 through coupling condensers so that a concentric conductor system comprising conductors 20 and 21 is used for high-frequency transmission. Similarly, an inner concentric conductor may be brought out through the outlet 20'_a as shown at 21' and terminal carrier apparatus C_{ac} connected thereto for communication between stations A and C. The additional high-frequency system thus formed is quite independent from a transmission standpoint of the one used for communication between stations A and B and they can employ the same carrier frequencies without interference.

By using this arrangement the power line connections will have no effect upon the characteristics of the high frequency circuit and the carrier frequencies will be limited to the section to which they are applied. Difficulties of interference at carrier frequencies in neighboring telephone circuits will be eliminated, as in the concentric type of conductor system the outer conductor acts as a shield

to prevent interference. Noise in the carrier circuit resulting from high frequency components of the power frequencies would be very substantially reduced, owing to the fact that the power circuit and the carrier circuit would be, to a considerable extent, distinct from one another. As is well known, the high frequency waves employed for carrier transmission tend to concentrate along the outer surface of the inner conductor and the inner surface of the outer conductor, whereas the low frequency power currents will spread more or less throughout the cross-sectional area of the copper forming the outer conductor. So far as skin effect applies to the power currents, it tends to concentrate the power waves at the outer surface of the outer conductor. The effects of corona discharge and other high frequency disturbances, so far as these are present, also tend to be concentrated at the outer surface of the outer conductor and consequently are shielded from the internal carrier transmission path.

Obviously, each of the three hollow power conductors shown in Fig. 4 may be used for a different high frequency carrier circuit. Also, if desired, carrier circuits might be derived from the power conductors in the usual way illustrated in Fig. 1 in addition to the carrier circuits afforded by the concentric conductor arrangements. The carrier currents for the circuit applied in accordance with the arrangements of Fig. 1 would flow on the outside of the power conductors while the carrier currents of the coaxial circuit would flow on the inside of these conductors and, hence, the two carrier systems would be effectively shielded from each other.

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, hollow cylindrical conductors connected to form a transmission path for power currents, and an inner conductor arranged concentrically in at least one of said hollow conductors and connected to terminal carrier apparatus so that high frequency carrier currents may be transmitted, the inner conductor acting as a return for the outer at carrier frequencies.

2. In a transmission system, hollow cylindrical conductors connected to form a transmission path for power currents between a number of stations greater than two, an inner conductor arranged concentrically in one of said conductors and having its ends brought out at two of said stations, carrier apparatus at each station connected to said hollow conductor and to said inner conductor, a second inner conductor concentrically arranged in the

same hollow conductor and extending between one of said stations and a third station, and carrier apparatus at each of said stations connected between the ends of said second concentric conductor and said hollow conductor.

3. In a transmission system, hollow cylindrical conductors connected to form a transmission path for power currents, an inner conductor arranged concentrically in at least one of said hollow conductors, insulating spacing material arranged along said inner conductor to maintain it in proper spacial relation with respect to said hollow conductor, and terminal carrier apparatus so connected to said inner conductor and said outer hollow conductor that the one acts as a return for the other in the transmission of high frequency carrier currents.

4. In a transmission system, hollow cylindrical conductors connected to form a transmission path for power currents between a number of stations greater than two, an inner conductor arranged concentrically in one of said conductors and having its ends brought out at two of said stations, insulating spacing members arranged along said inner conductor to maintain it in proper spacial relationship with respect to said outer conductor, carrier apparatus at each station connected to said hollow conductor and to said inner conductor so that the one conductor acts as a return for the other for carrier transmission between the stations, a second inner conductor concentrically arranged in the same hollow conductor and extending between one of said stations and a third station, insulating spacing members arranged along said inner conductor to maintain it in proper spacial relationship with respect to said outer conductor, and carrier apparatus at each of said stations connected between the ends of said second concentric conductor and said hollow conductor so that the one conductor acts as a return for the other.

5. In a transmission system, hollow cylindrical conductors connected to form a transmission path for power currents, said conductors comprising a plurality of conductive strands so shaped that when arranged side by side and helically wound, their adjacent sides will fit each other to form a complete cylindrical structure, an inner conductor arranged concentrically in at least one of said hollow conductors, insulating spacers arranged along said insulating conductor for maintaining it in proper spacial relationship to said hollow conductor, and terminal carrier apparatus so connected to said hollow conductor and said inner conductor that the one conductor acts as a return for the other at carrier frequencies.

6. In a transmission system, hollow cylindrical conductors connected to form a transmission path for power currents between a number of stations greater than two, each

cylindrical conductor comprising a plurality of conductive strands so shaped that when arranged side by side and helically wound, their adjacent sides will fit each other to form
5 a complete cylindrical structure, an inner conductor arranged concentrically in one of said conductors and having its ends brought out at two of said stations, insulating spacers arranged along said inner conductor for
10 maintaining it in proper spacial relationship to said hollow conductor, carrier apparatus at each station connected to said hollow conductor and to said inner conductor so that the one acts as a return for the other for
15 carrier transmission between said stations, a second inner conductor concentrically arranged in the same hollow conductor and extending between one of said stations and a third station, insulating spacers arranged
20 along said second inner conductor for maintaining it in proper spacial relationship to said outer conductor, and carrier apparatus at each of said last mentioned stations connected to said second inner conductor and
25 said outer conductor so that the one conductor acts as a return for the other for carrier transmission.

In testimony whereof, I have signed my name to this specification this 20th day of
30 April, 1931.

ESTILL I. GREEN.

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