

April 7, 1936.

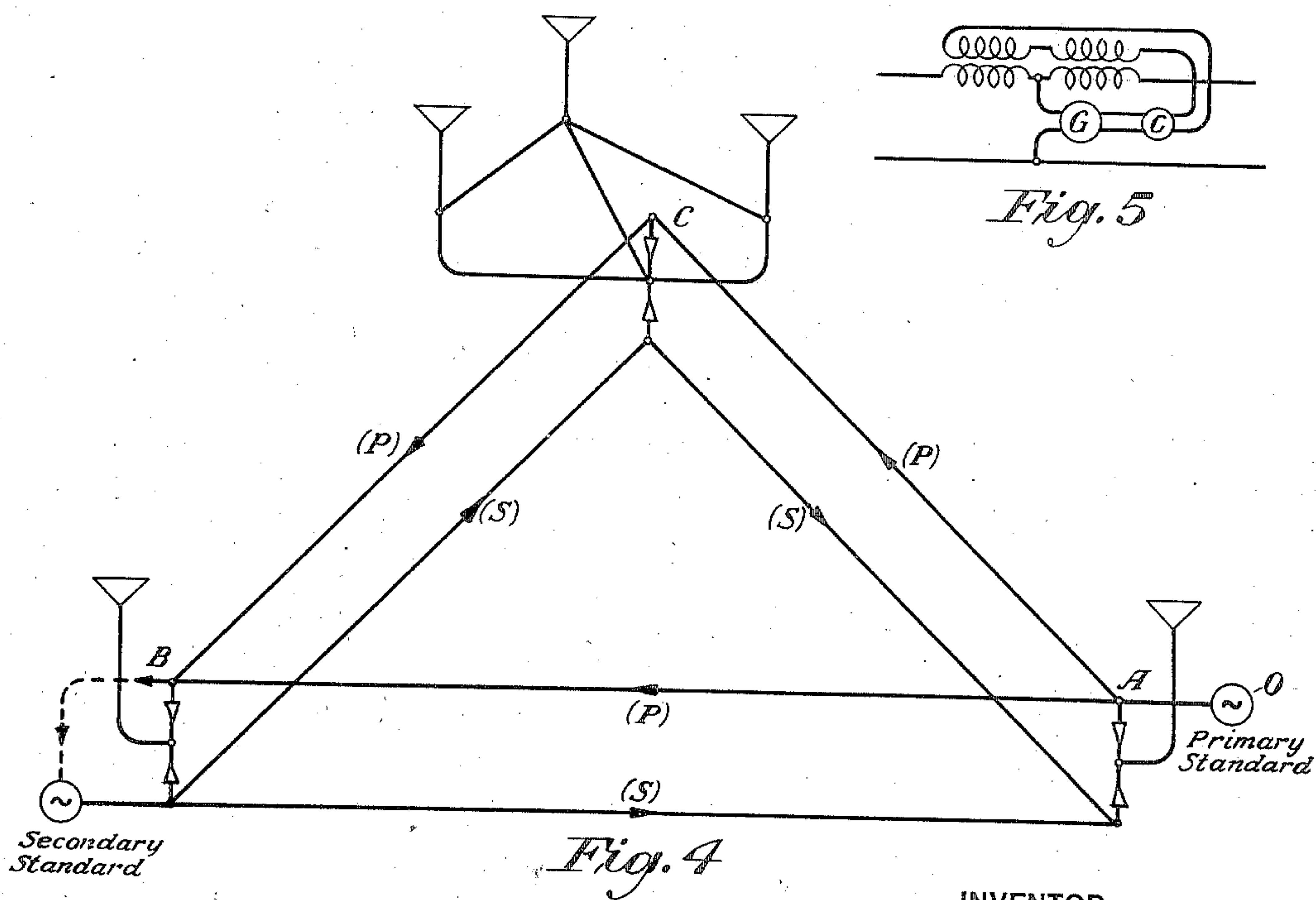
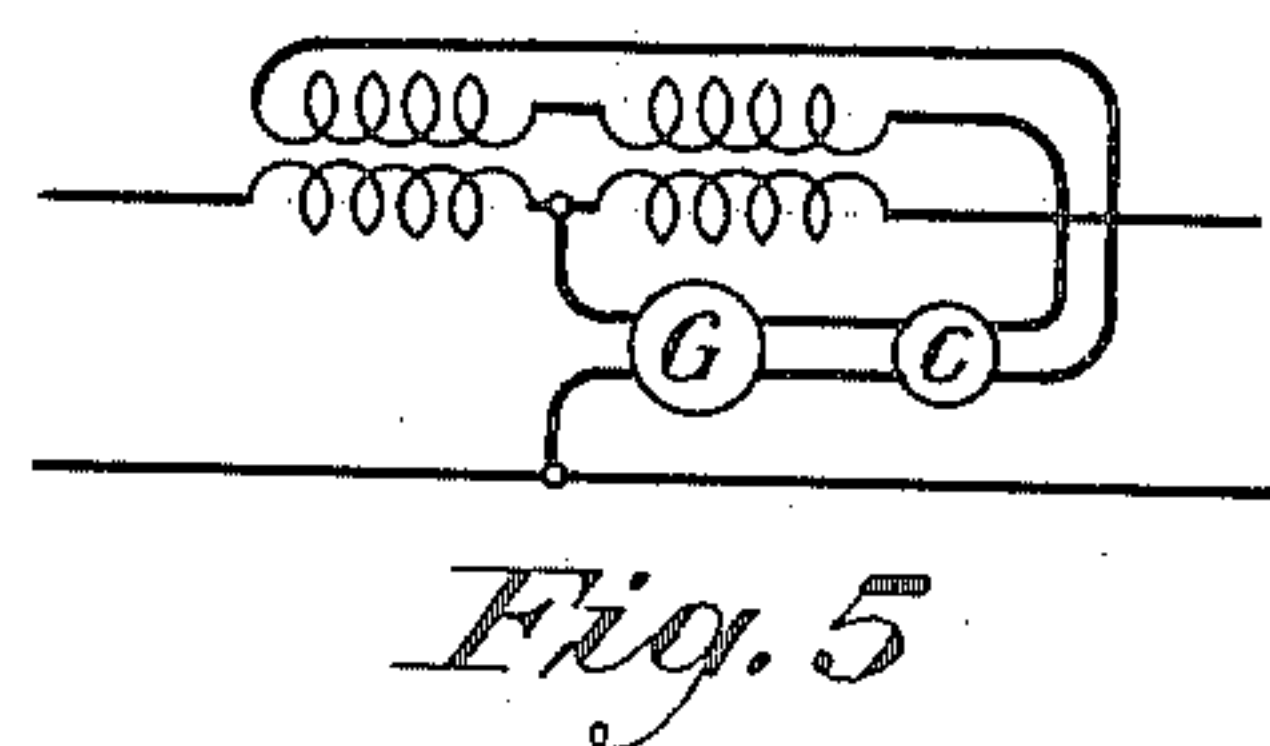
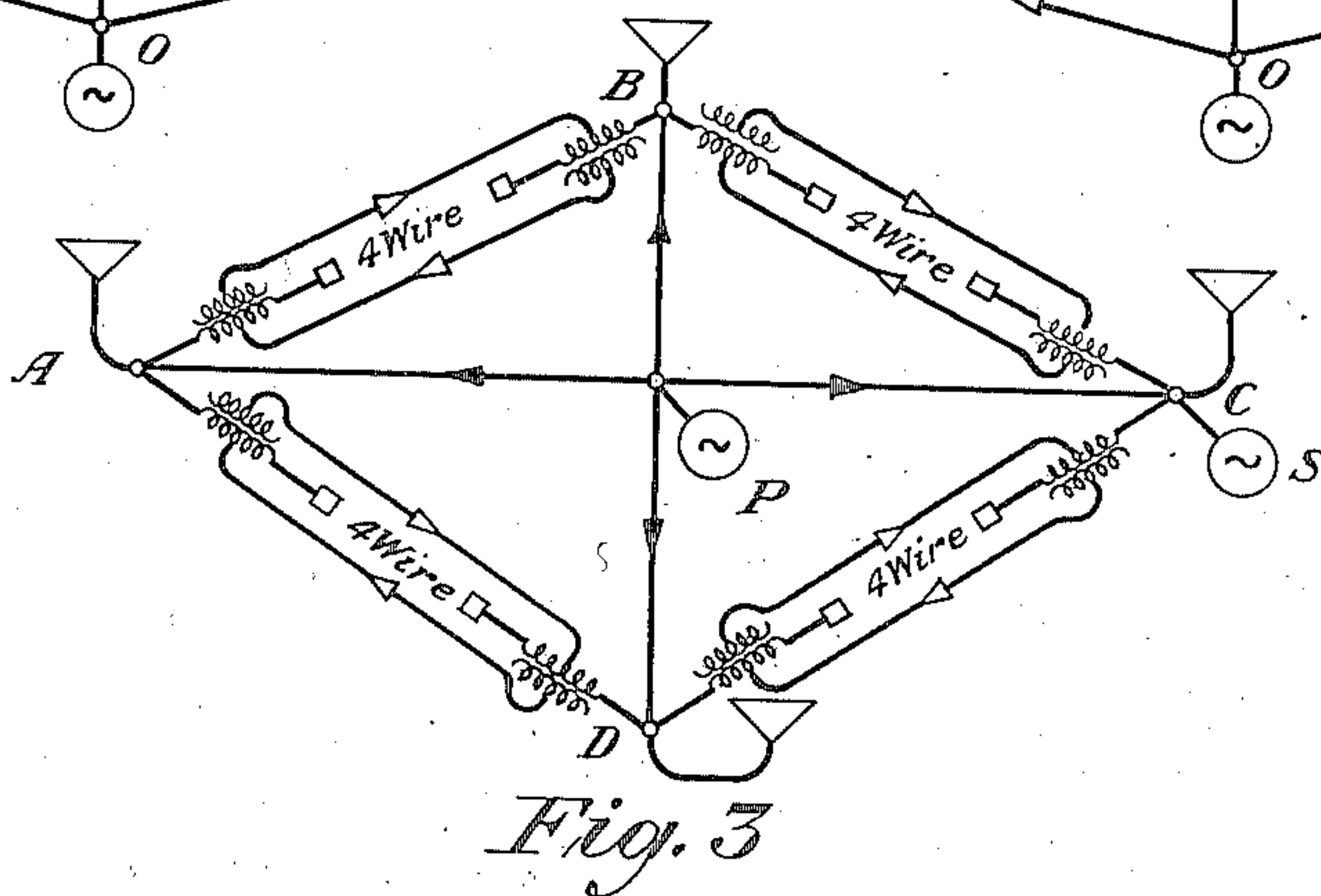
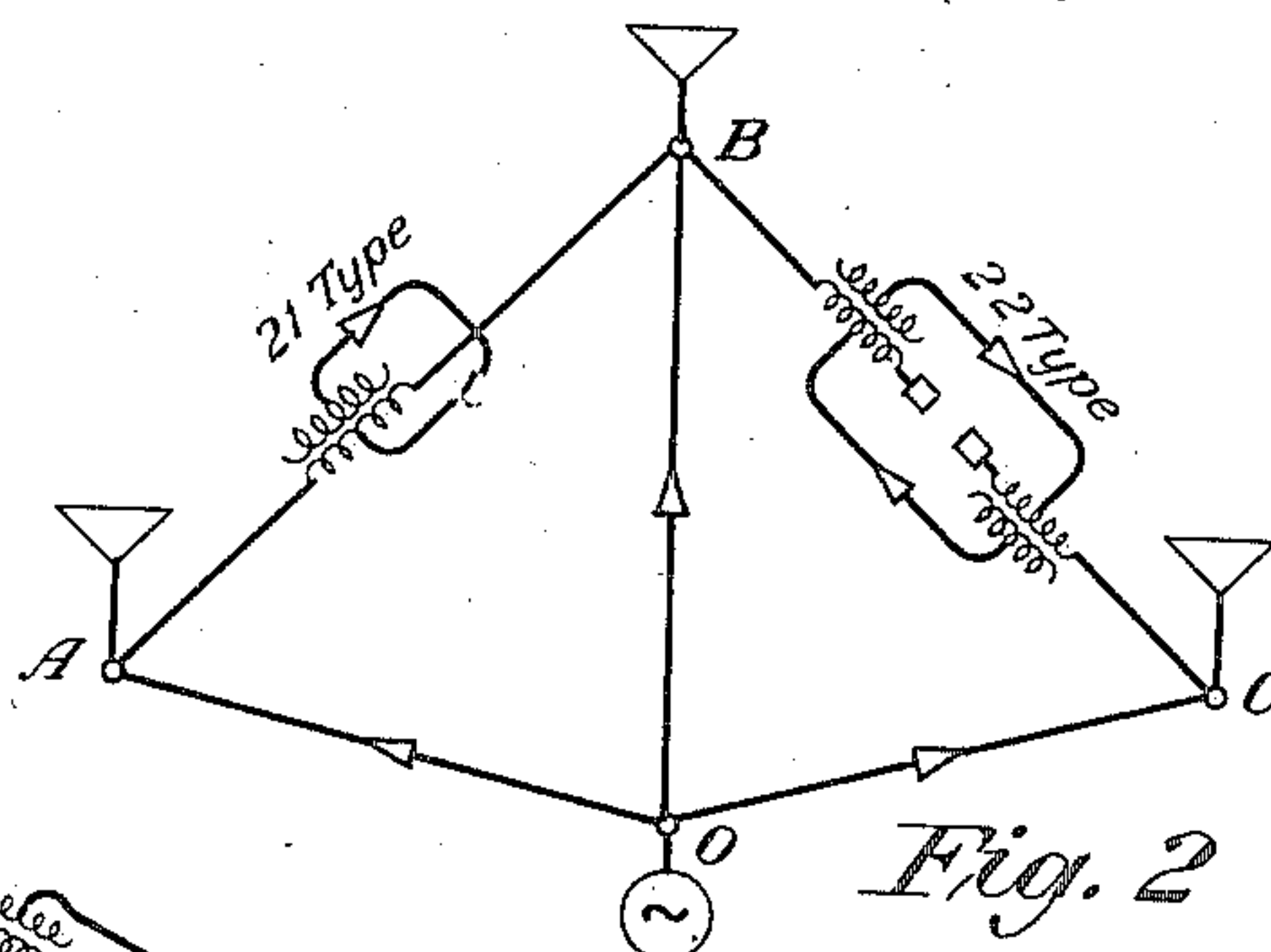
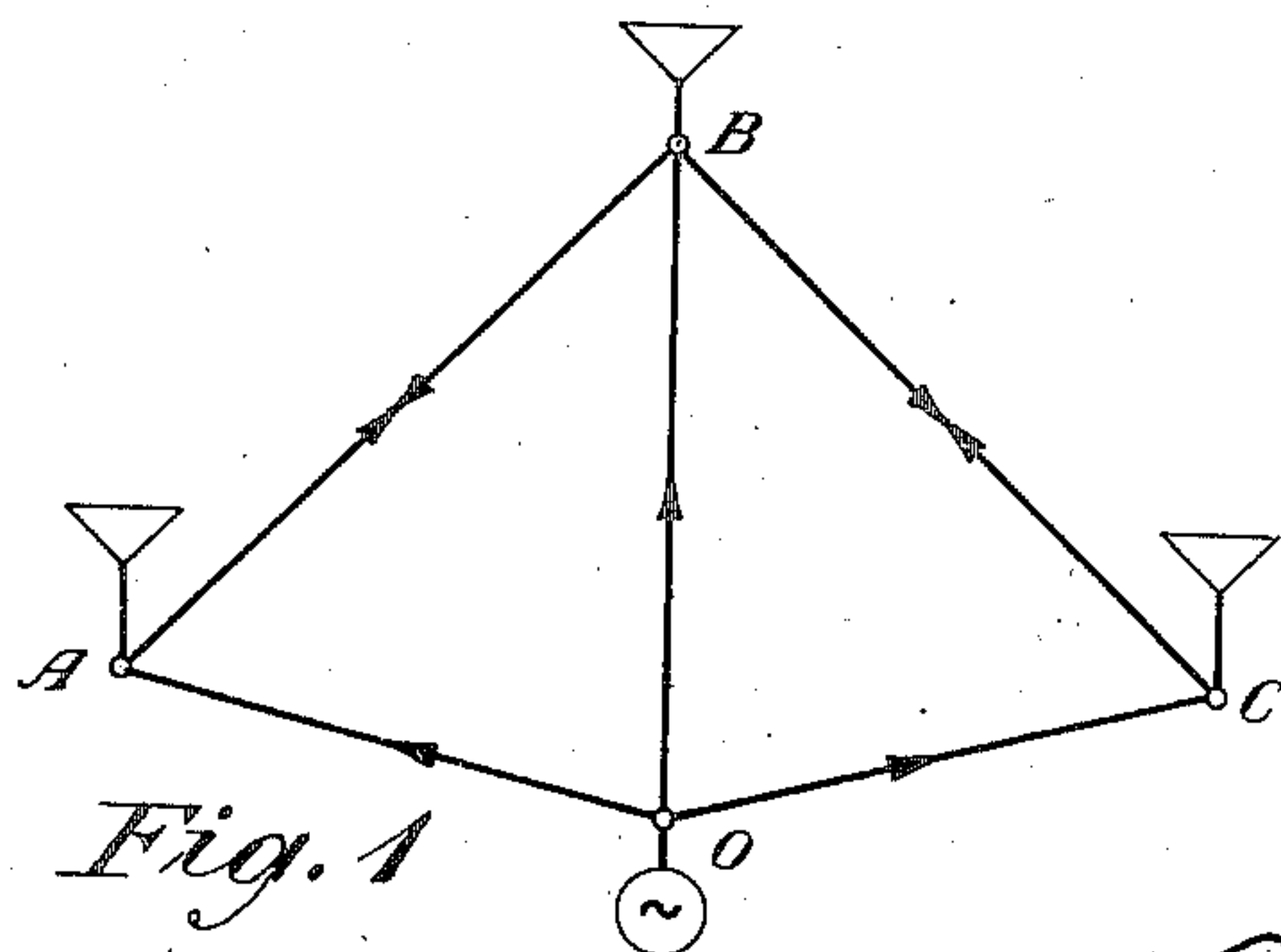
H. A. AFFEL

2,036,383

FREQUENCY CONTROL DISTRIBUTION

Filed Aug. 29, 1934

2 Sheets-Sheet 1



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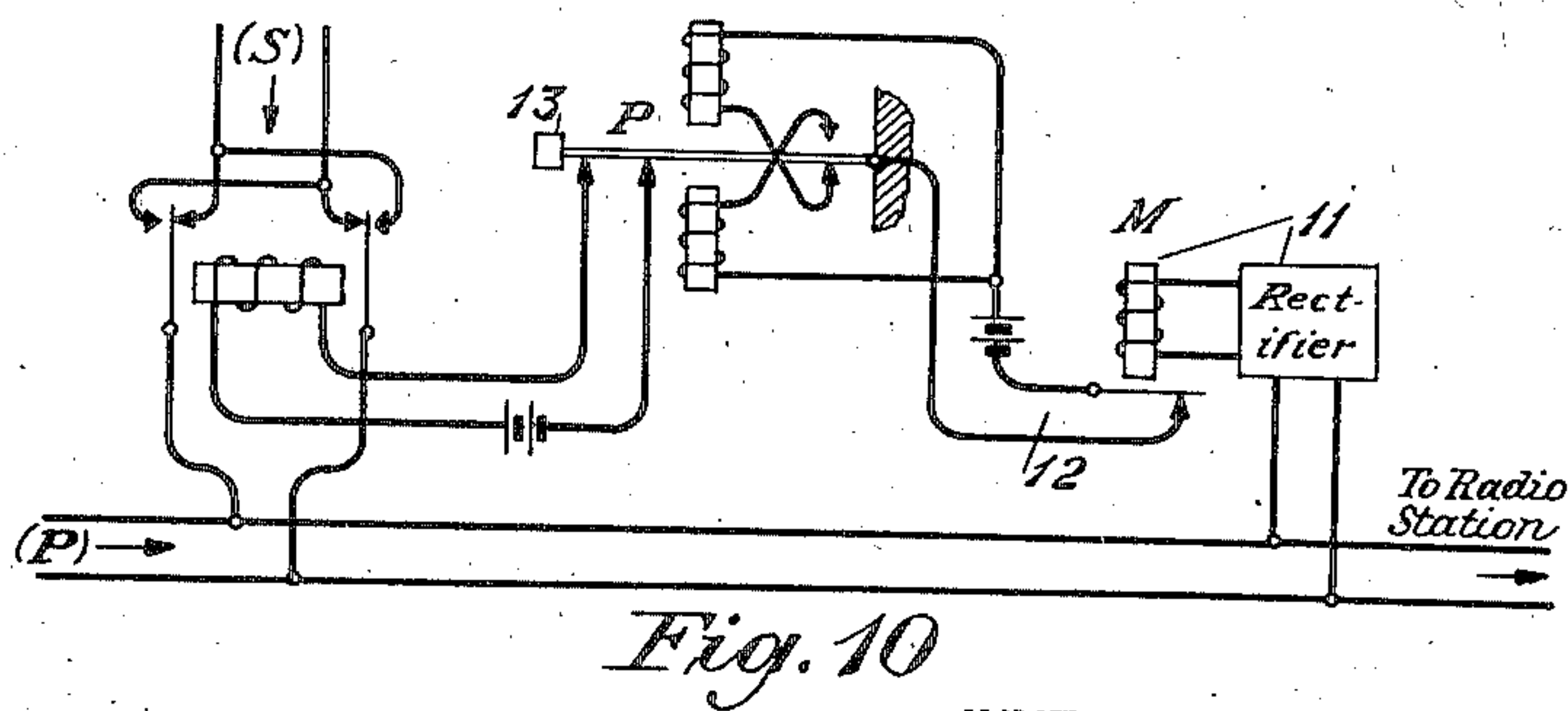
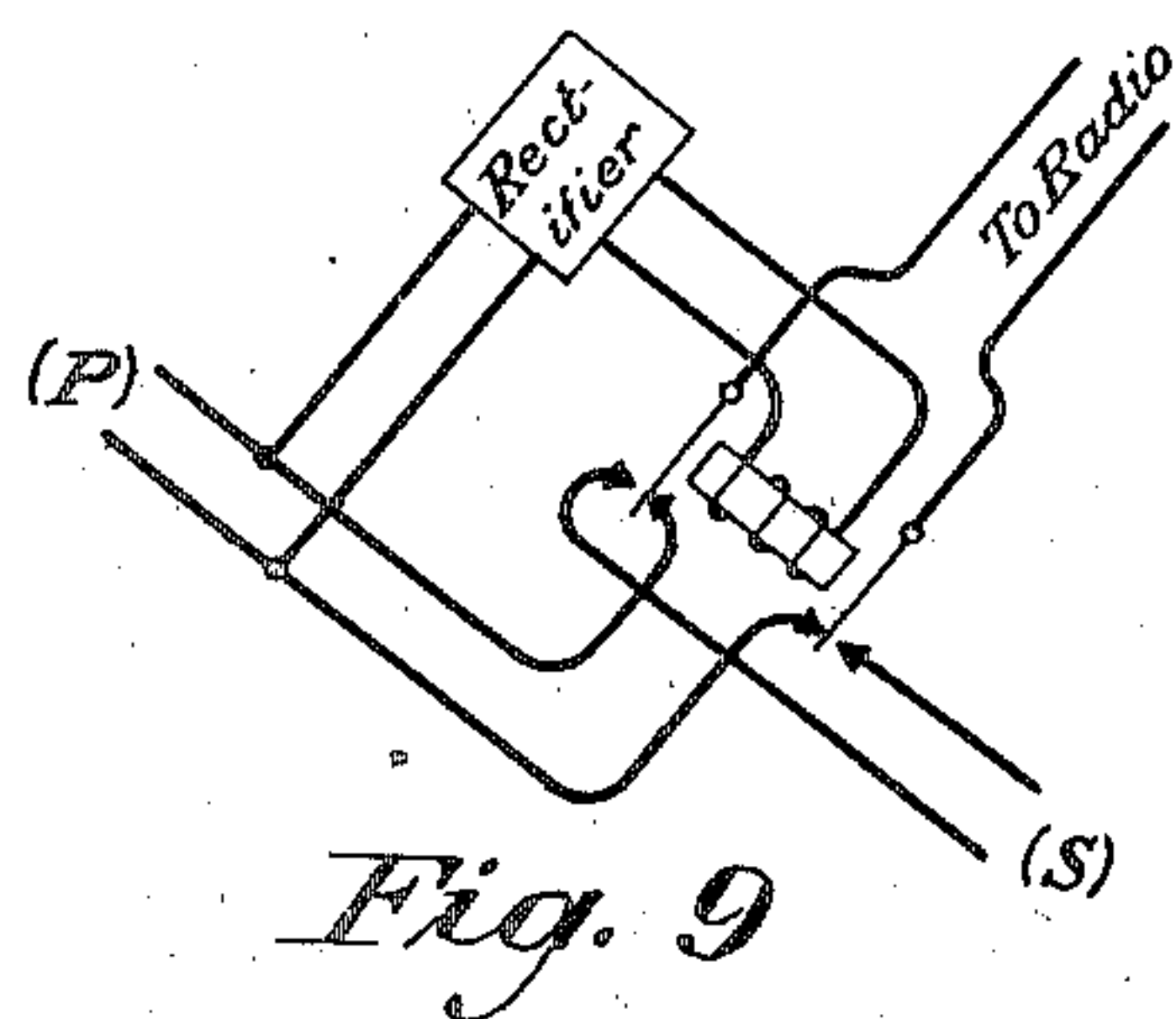
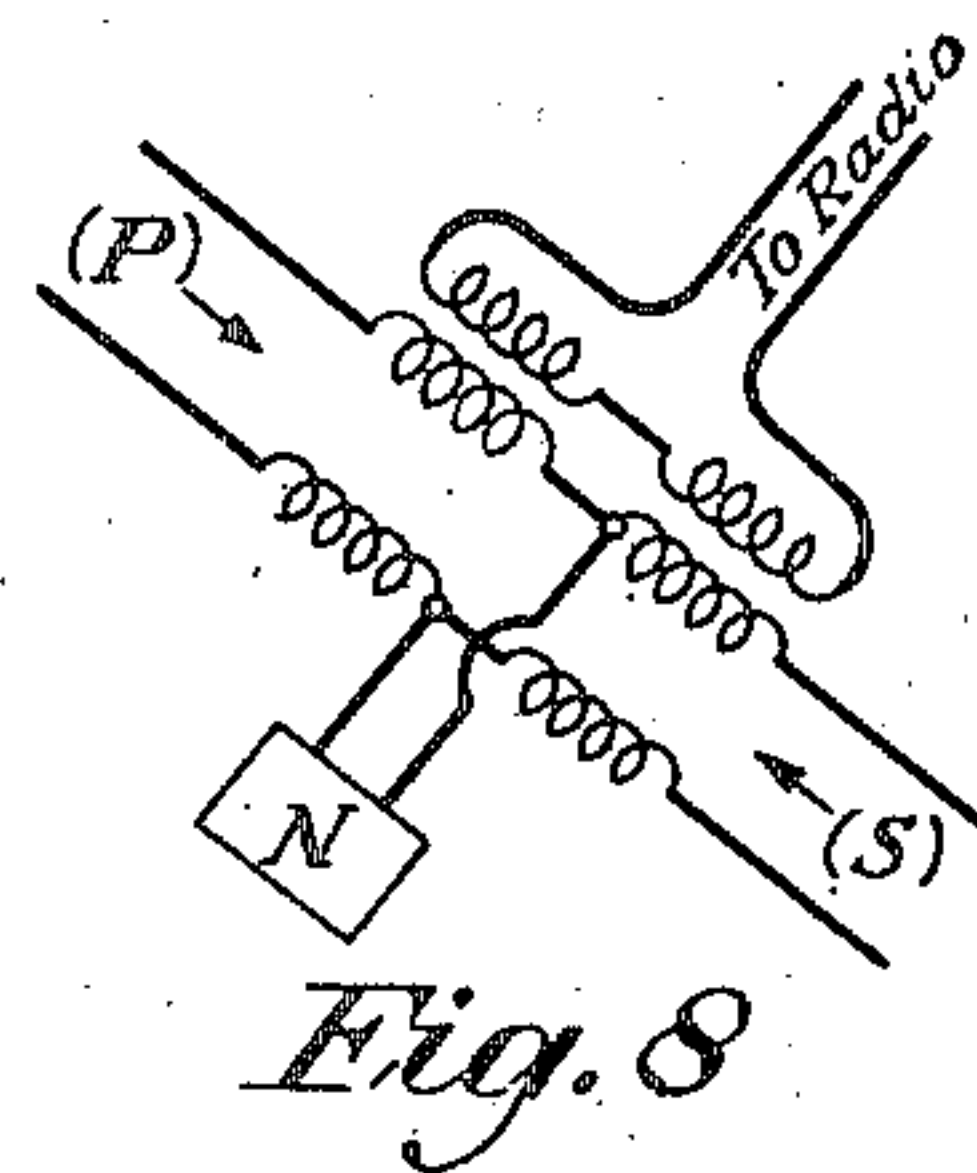
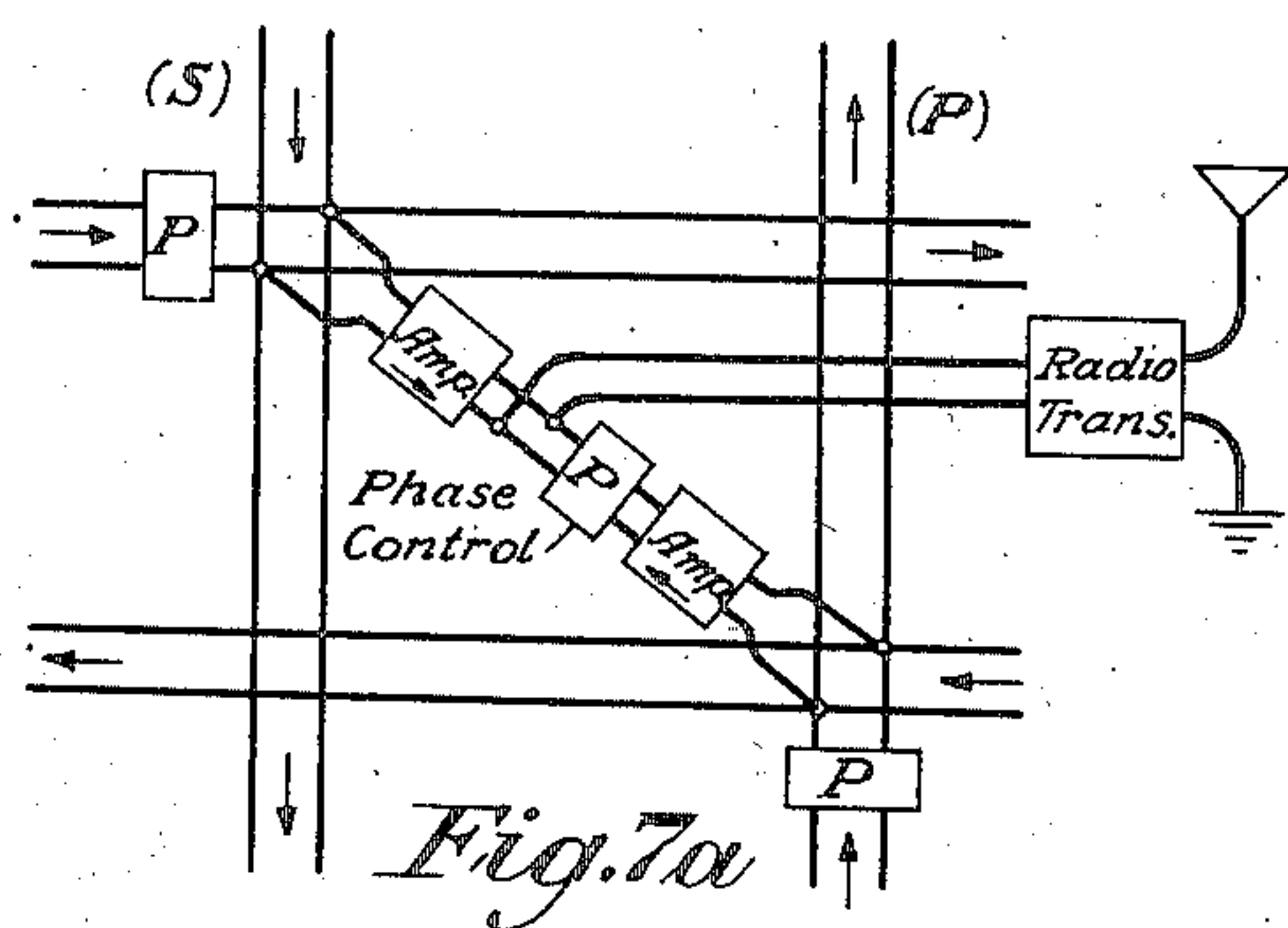
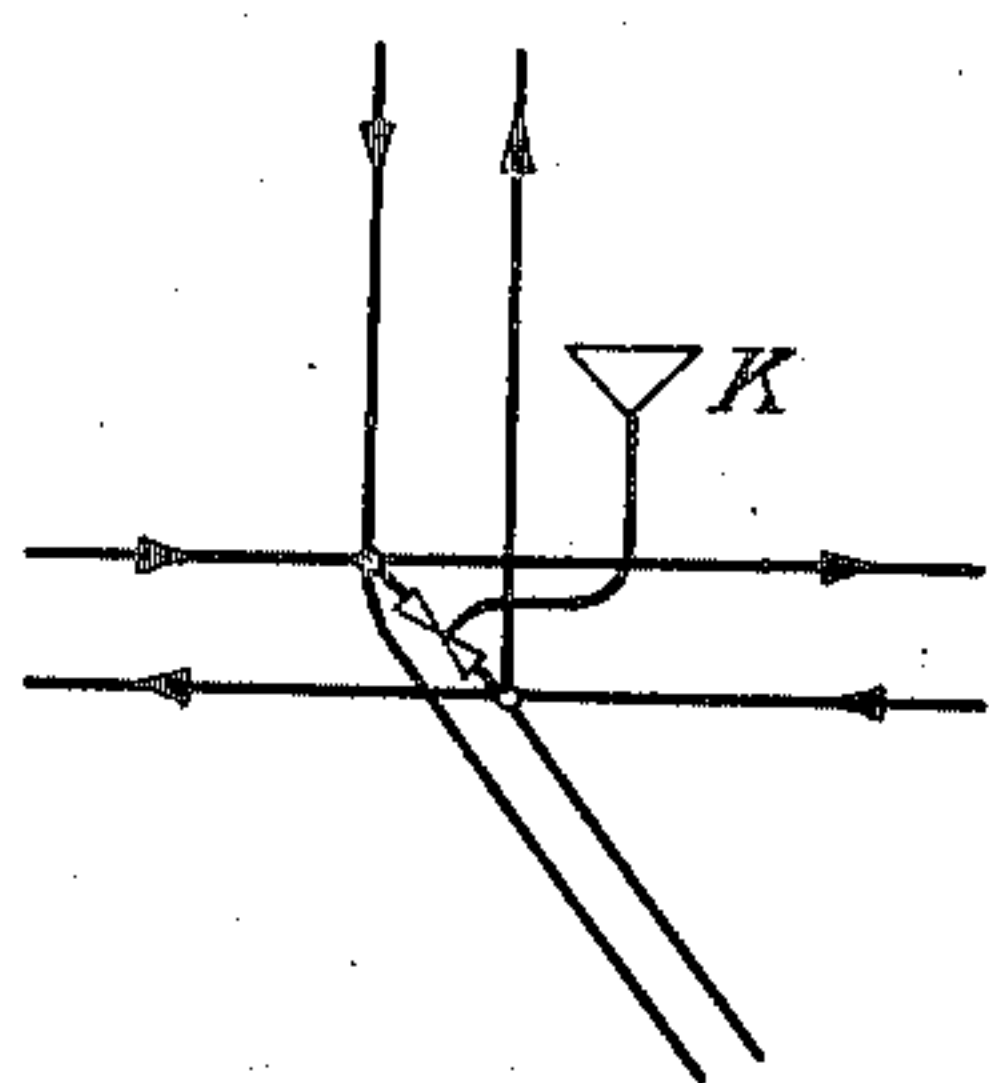
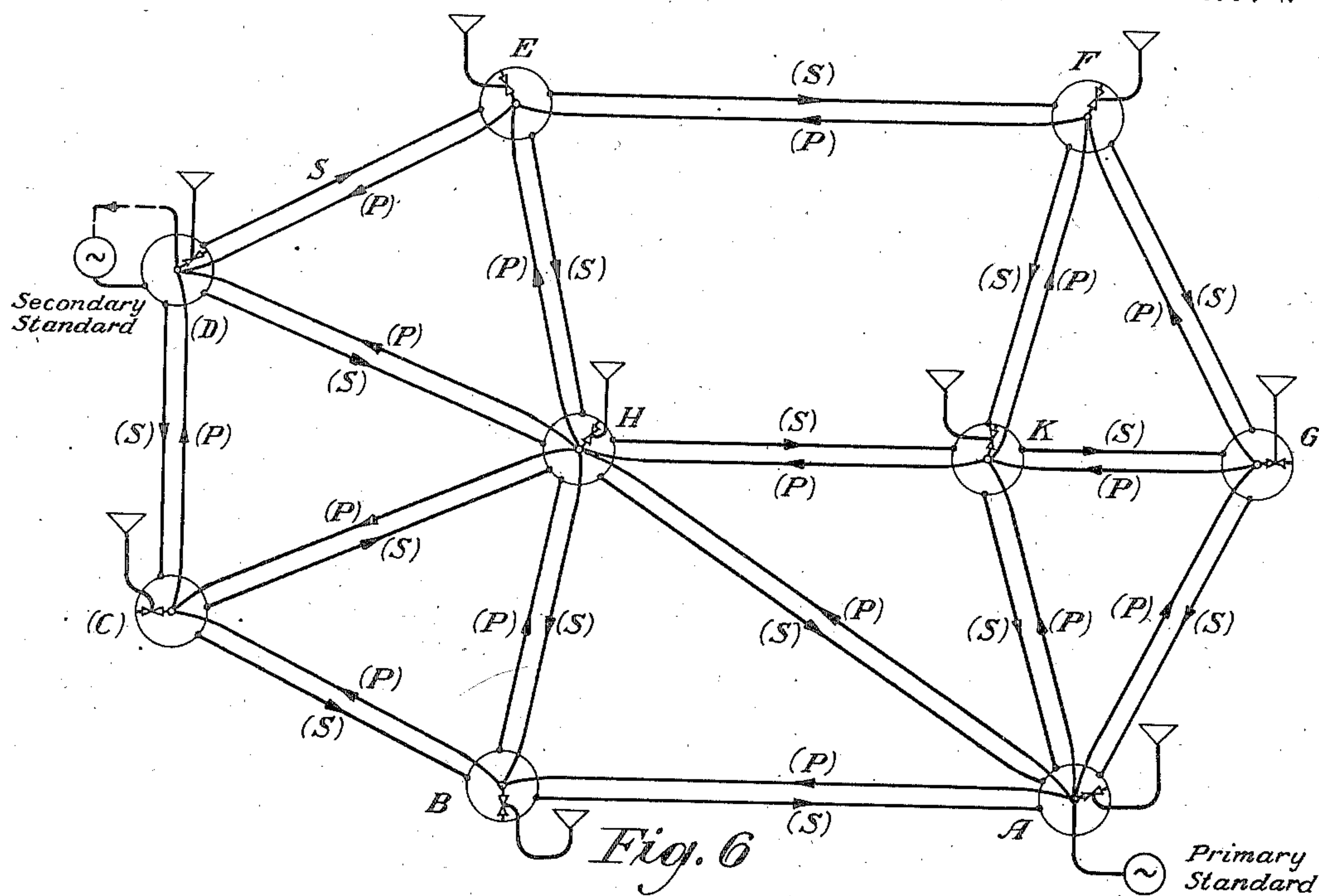
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FREQUENCY CONTROL DISTRIBUTION

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2 Sheets-Sheet 2



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2,036,383

FREQUENCY CONTROL DISTRIBUTION

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13 Claims. (Cl. 250—17)

This invention relates to frequency control distribution, and its purpose is to insure adequate reliability in the transmittal of standard frequencies over lines and their use for the synchronizing of radio stations, or for other purposes.

In present day communication it is becoming increasingly important to have available at certain places an alternating current of a very precise and constant frequency which may be used directly for communication or which may be used as the control for frequency changers, such as harmonic generators, from which may be obtained other particular frequencies desired.

One field of use of such standard frequencies is in connection with broadcasting a program from a plurality of radio stations which are to be operated in synchronism. Other important uses are in connection with numerous applications in telephony and in telegraphy and in comparison or standardization of timepieces.

The difficulty of maintaining a standard source of frequency of the requisite precision and stability is sufficiently great so that it is advantageous to have one such master source maintained as a primary source from which its frequency or related frequencies may be transmitted to numerous outlying stations. Occasionally secondary standards may be advantageously located at a few outlying points, these secondary standards being normally controlled by the frequency from the primary source and serving in turn smaller areas if called upon to do so. Having received the standard frequency at any station, the actual desired frequency may then be obtained in any desired manner such, for example, as that disclosed in patent to Marrison No. 1,931,873, October 24, 1933, or in application of Gannett, Serial No. 739,989, filed August 15, 1934.

In this invention, the purpose is to so relate a primary source with outlying stations and with secondary sources located at appropriate points as to insure, by suitable wire networks, the greatest reliability of service possible. The invention will be better understood by reference to the following specification and accompanying drawings, in which Figure 1 illustrates by conventionalized circuits the application of my invention to three outlying stations; Fig. 2 shows the same arrangement in somewhat greater detail; Fig. 3 shows the application of the invention to four points and shows also the use of a secondary source; Figs. 4 and 6 show further details of the invention, first in connection with a three-point system and then a nine-point system; Fig. 5 illus-

trates one manner of associating the secondary standard to the system; Figs. 7 and 7a give details of the connections for any one point of such a circuit as that of Fig. 6; and Figs. 8, 9 and 10 illustrate alternative means for preventing undesirable cross-connections between various circuits.

It will be appreciated that a complete frequency distribution network has increased reliability to the extent that there are many sub-standards provided and also to the degree with which emergency or alternative routes are included in the line circuits. The latter feature is illustrated, for example, in Fig. 1, in which it is the desire to distribute a standard frequency from a point O to three stations, A, B and C, which are here shown as radio stations. A desirable line system would include not only lines radiating from O to A, B and C, respectively, but also cross-connections such as A—B and B—C, so that in the case of failure of such a line as O—A, radio station A would still receive its frequency over route O—B—A. Even though two of the lines such as O—A and O—B are interrupted, all three stations would still receive frequency over the circuit O—C—B—A.

For the distribution of standard frequencies in certain districts where the line circuit will ordinarily be non-loaded cable pairs, such a permanently connected network as illustrated in Fig. 1 could be readily provided. With stations further apart, however, amplification would frequently be required in the wire connecting circuits. Such a system is shown in Fig. 2, in which amplifiers are shown in a conventionalized manner by a triangle, the amplifiers being unilateral in action and the direction of transmission being indicated by the apex of the triangle. Thus, in Fig. 2, the lines radiating from the primary source A include one-way repeaters. However, in the case of the cross-connecting emergency links, transmission would ordinarily be required in either direction on the occasion of a break in the circuit. For this reason the amplifiers in the cross-connecting lines should be two-way in their operation and might well consist of the 21-type repeater or the 22-type repeater, both of which are now well known to those acquainted with the art of communication, and these repeaters are shown in highly conventionalized form in Fig. 2. In some cases it would be desirable to use complete four-wire circuits in the cross-connecting emergency links, as shown in Fig. 3.

This Fig. 3 incidentally shows four radio stations, and illustrates the situation where many

radio stations are located at important cities throughout the country and in which there are radiating wire circuits from the central source and there are provided also cross-connection emergency circuits. It should be pointed out, however, that in setting up such a network certain difficulties arise. For example, with the general use of repeaters or amplifiers, there would be a natural desire to make the gain over these circuits as large as feasible, and there would result the danger of singing being set up, particularly in the loop combinations of the two-way circuits between any two stations. Also, there would be phase difficulties where the power is received at a point from several sources or over several routes. Then, again, in an extensive system, the points will be sufficiently remote and the number of stations frequently great so as to justify the employment of secondary standards at various points in order to insure continuance of service in case of complete failure of the primary standard or the lines radiating directly therefrom.

One way of meeting these difficulties is illustrated in the circuit of Fig. 4 which, among other things, shows the general use of four-wire circuits interconnecting all the points involved, and also shows the employment of at least one secondary standard which will be available at all times for service and is synchronized with the primary standard, at the same time continuing to supply approximately correct frequency if the primary standard source is removed. In this figure there is shown a primary standard at a point O from which the desired frequency current is to be supplied to radio stations A, B and C. The two directional paths of each four-wire circuit interconnecting the radio stations will independently form what may be termed the primary and secondary networks, indicated by the letters (P) at (S), is respectively. Each radio station will be fed its frequency simultaneously from the two networks through balancing devices or one-way amplifiers, as illustrated, which will effectively prevent current from one network reaching the other except through the secondary standard shown as located at the station B, and which it is understood is to be controlled from the primary network. This means that each secondary standard is available not only to feed the radio station in the immediate vicinity of this standard itself, but also to serve as a source of standard frequency for the network as a whole, even though the primary standard were completely isolated by failure of all of the interconnecting wires.

This secondary standard would be of any suitable form, preferably quite similar to the primary standard, and might very well take on the form of the so-called crystal-control oscillator. In any event, it would be so designed that it is kept in step with the input frequency from the primary, but if the latter is interrupted, then it will continue to generate independently a constant frequency. A suitable connection for this purpose is illustrated in Fig. 5, in which the secondary source is introduced into a 21-type circuit where it is available to receive controlling frequency from the primary and is available also to feed out frequency in either direction, as indicated in Fig. 5.

The general arrangement of Fig. 4 is shown more extensively applied in Fig. 6 in which nine points instead of three are involved. In this case each radio or other station is served by

at least three general sources of frequency, transmitting in both directions. For the middle station H, for example, six sources are involved, and it will be apparent that a complete failure of the frequency supplied to this station would require failure of an extremely large number of pairs of wires in the system as a whole.

The method of connection to the take-off points is shown in Fig. 7 for the station K, and the exact connections for this station are shown in greater detail in Fig. 7a which is drawn to indicate completely the two wires comprising a pair instead of a single line, as has been used in the conventionalized circuits of the previous figures. The boxes P indicate phase controllers for the purpose of properly relating the phases of the frequency supplied over the different circuits. Amplifiers are used partly for the purpose of controlling the magnitude of the impulses over any one line, but still more because of the unilateral characteristics of these amplifiers which insure that there is no direct cross-connection between the primary (P) and secondary (S) supply circuits which might otherwise introduce singing difficulties in the network as a whole.

The matter of avoiding such singing conditions is of prime importance and may be brought about in a number of different ways. One is that illustrated in Fig. 7a, in which unilateral amplifiers are used, as already indicated. A second method would be that shown in Fig. 8, which makes use of a hybrid coil arrangement which electrically separates the (P) and the (S) circuits. Still another arrangement would be that shown in Fig. 9, where an amplifier relay arrangement controlled by oscillations coming over the (P) circuit normally maintains the transmission to the radio station from the primary source, but on failure of this source the relay automatically switches the connections to the secondary source. This arrangement has the advantage that it avoids the phase difficulties which might otherwise arise if the radio transmitters or other synchronizing devices received current continuously from two or more sources.

Still a further alternative is shown in Fig. 10, in which case it is desired to insure that the frequency supplied from two sources simultaneously will combine in phase favorably and not result in a balancing out of the currents received from two sources. This figure shows an amplifier relay arrangement 11 which normally keeps a circuit 12 open, but on failure of the frequency to appear in sufficient amplitude, the relay M closes a contact for circuit 12 and starts a low-period pendulum 13 into oscillation, thus alternately reversing the polarity of the incoming frequency over the (S) circuit. If the low amplitude of the standard frequency arriving at 11 resulted from the dephasing of the two incoming sources, then a 180° shift in the one incoming source would cause the two sources to add rather than subtract, at which time the relay M opens the circuit 12 and the periodical reversals cease. This device has the added advantage that in the event of the complete failure of both sources, the continued periodic action of the reversing device would act as an alarm.

The invention has been described in a very general way, and it is to be understood that many variations and modifications may be introduced without departing from the spirit of the invention.

What is claimed is:

1. In a frequency control distribution system, a

source of standard frequency and a plurality of stations to be supplied with the standard frequency, the method of maintaining the supply of standard frequency to each station which consists in transmitting standard frequency to each station separately and in relaying this frequency both ways between each station and each of the other stations whereby each station may receive standard frequency over a plurality of paths.

2. The combination of claim 1 characterized by the fact that the phase of arrival of the current over each path is adjusted so that all components come together in substantially the same phase.

3. In a frequency control distribution system, a source of standard frequency, a plurality of stations, transmission lines from the source to each station for transmitting standard frequency current, means for relaying the received current from each station to each other station, and means for bringing the frequency currents from the various directions into phase.

4. In a frequency control distribution system, a source of standard frequency and a plurality of stations, transmission lines from the source to some of the plurality of stations, and a plurality of opposite two-way cross-connections between the stations whereby each station receives frequency current from a plurality of directions.

5. In a frequency control distribution system, a source of standard frequency and a plurality of stations, transmission lines from the source to some of the plurality of stations, a plurality of cross-connections between the stations whereby each station receives frequency current from a plurality of directions, and means at each station for bringing the frequency currents from the various directions into phase.

6. In a frequency control distribution system, a source of standard frequency and a plurality of stations, transmission lines from the source to some of the plurality of stations, and connections from each station to each of a plurality of the stations, each connection consisting of two unilateral oppositely directed connections whereby each station receives and sends out frequency current over independent paths to each of a plurality of stations.

7. In a frequency control distribution system, a source of standard frequency and a plurality of stations, transmission lines from the source to some of the plurality of stations, and four-wire circuit connections from each station to each of a plurality of the stations whereby each station receives and sends out frequency current over independent paths to each of a plurality of stations.

8. The combination of claim 6 characterized by the fact that certain of the incoming circuit connections to a station have phase shifting de-

vices to bring the resultant incoming current to a station to a desired value and phase.

9. In combination, a plurality of transmitting stations, two sources of standard frequency A and B, connections therefrom to said transmitting stations, further connections between the said transmitting stations, all those connections forming a network, and means at source B to keep it adjusted to the frequency of source A as that frequency is received through the network from source A, said sources A and B each being operable independently of each other so that source B continues its operation to supply the approximate standard frequency to the networks whenever source A ceases operation.

10. In the operation of a network of connected transmitting stations with two independently operable sources of standard frequency A and B connected through the network to the transmitting stations, the method which consists in supplying a standard frequency to the network by feeding the standard frequency from each of the two standard frequency sources A and B into the network at different places, applying the frequency transmitted from the source A through the network to maintain the frequency of the source B adjusted thereto, and continuing the operation of the source B to supply approximately that frequency of the network whenever source A ceases operation.

11. In a frequency control distribution system, a source of standard frequency and a plurality of stations, transmission lines from the source to some of the plurality of stations and connections from each station to each of a plurality of stations, each connection consisting of two unilateral oppositely directed connections whereby each station receives and sends out primary standard frequency current over independent paths to each of a plurality of stations, and secondary sources of standard frequency, and means whereby they serve any part of the system which may be cut off from the primary source.

12. In combination, a plurality of transmitting stations, a central source of standard frequency, connections therefrom to said transmitting stations, further connections between transmitting stations, and at each station phase adjusters in all the connections thereto, except one, by which the currents of standard frequency to each station may be adjusted to be in the same phase for each station.

13. In combination, a plurality of transmitting stations, a source of standard frequency, connections therefrom to said stations, and further four-wire connections between stations whereby each station may get its current directly from the source or indirectly by way of other stations.

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