

May 22, 1928.

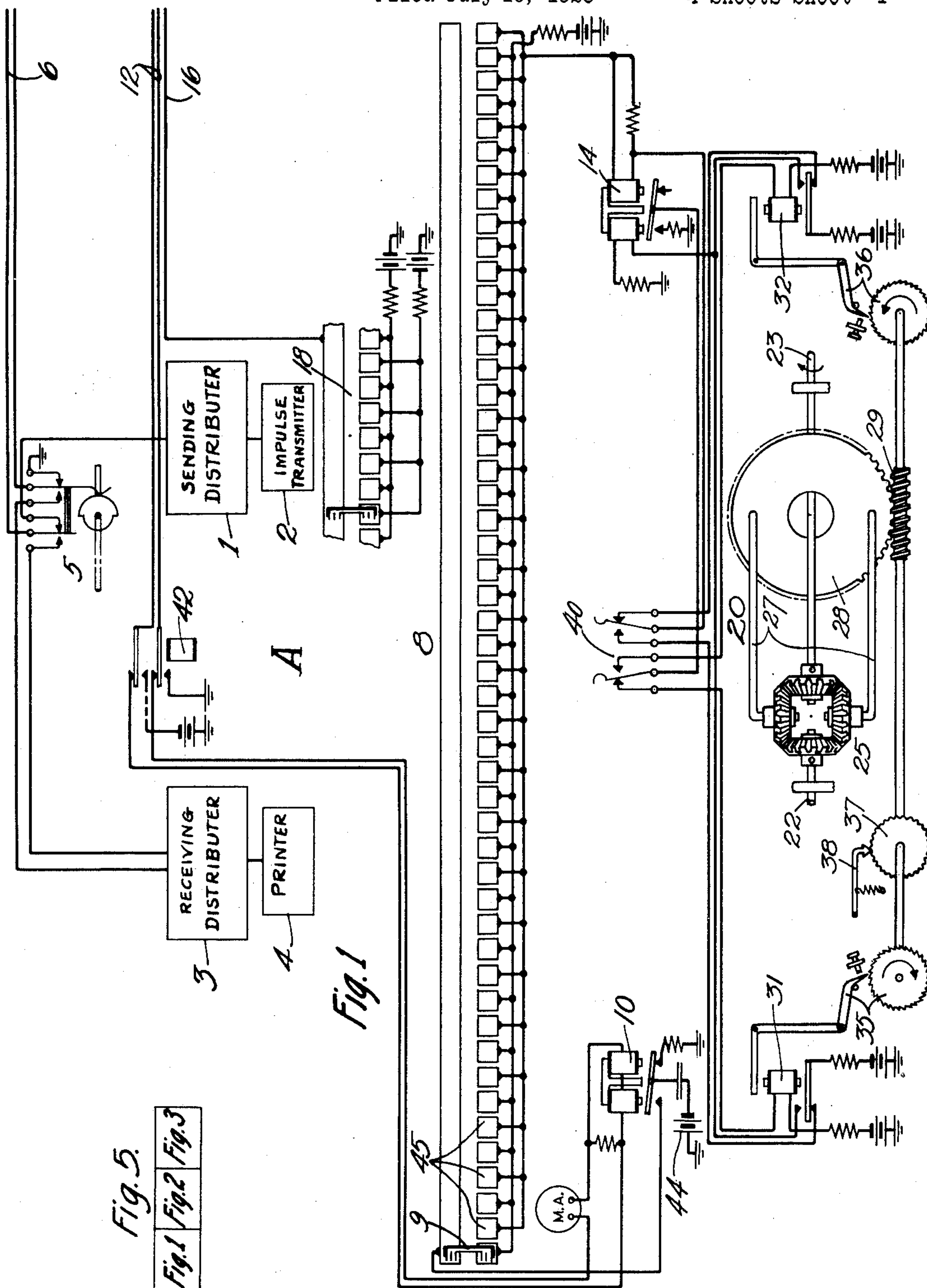
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G. A. LOCKE

SIGNALING SYSTEM

Filed July 19, 1926

4 Sheets-Sheet 1



Inventor:
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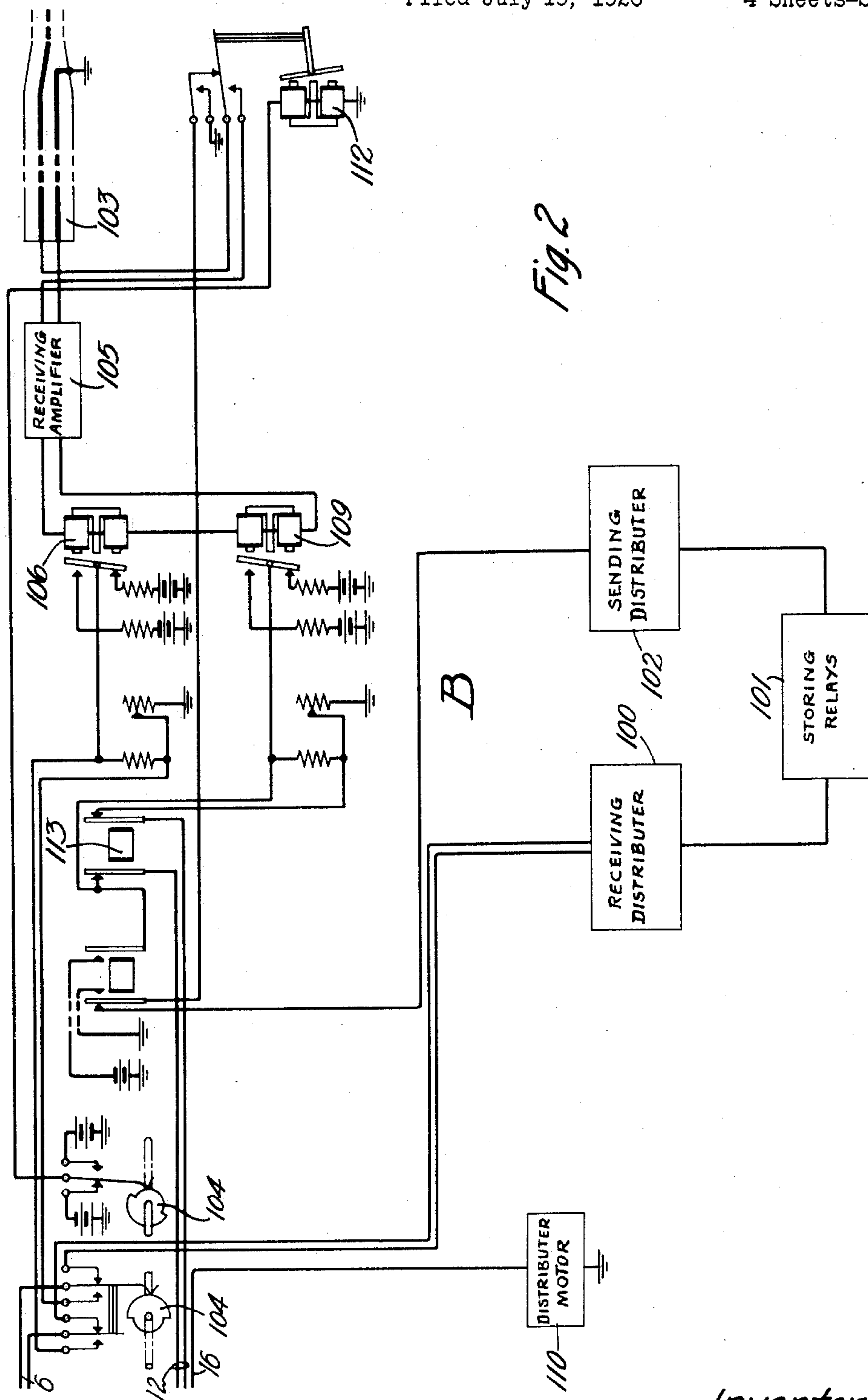
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4 Sheets-Sheet 2



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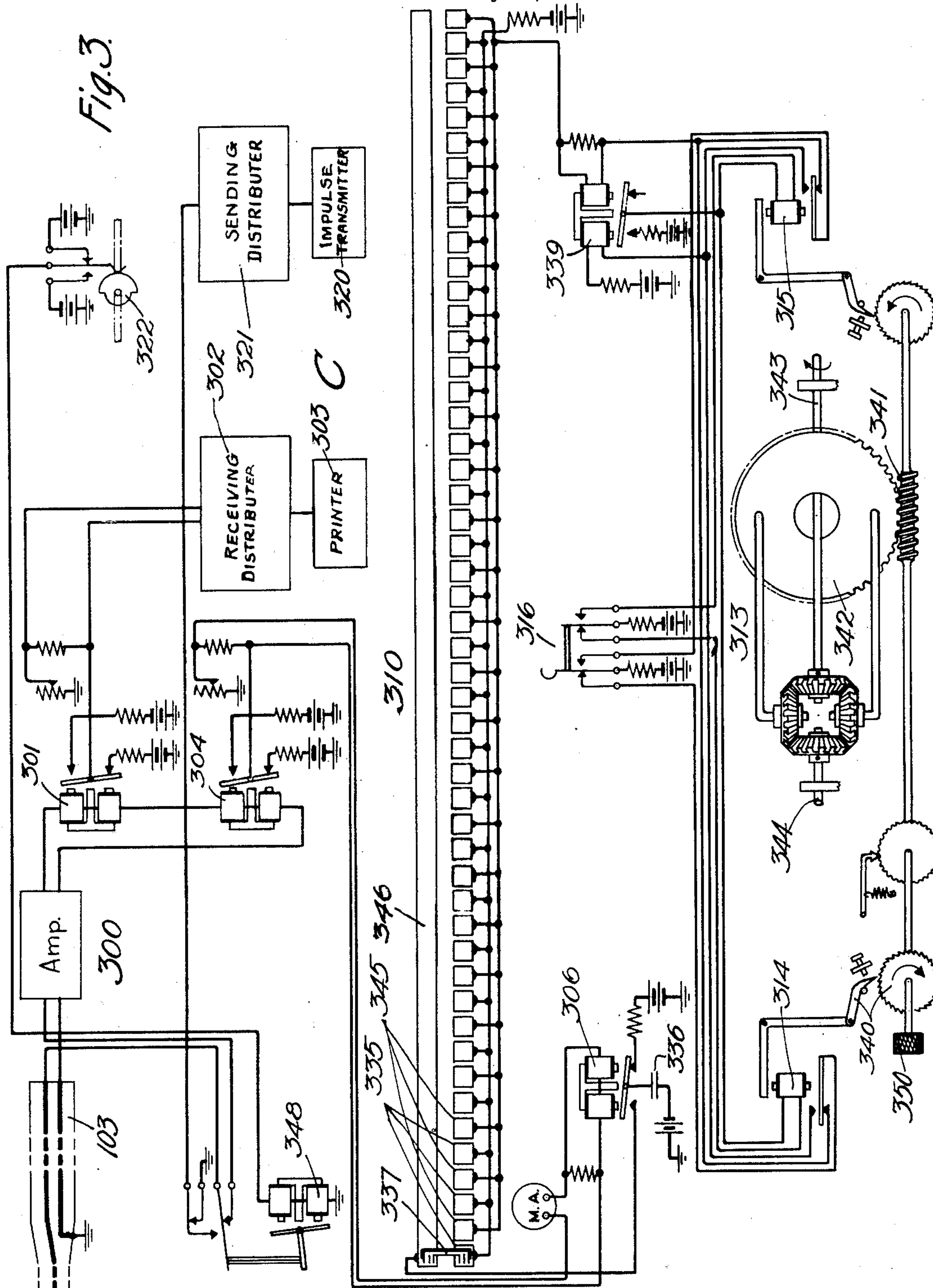
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SIGNALING SYSTEM

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4 Sheets-Sheet 3



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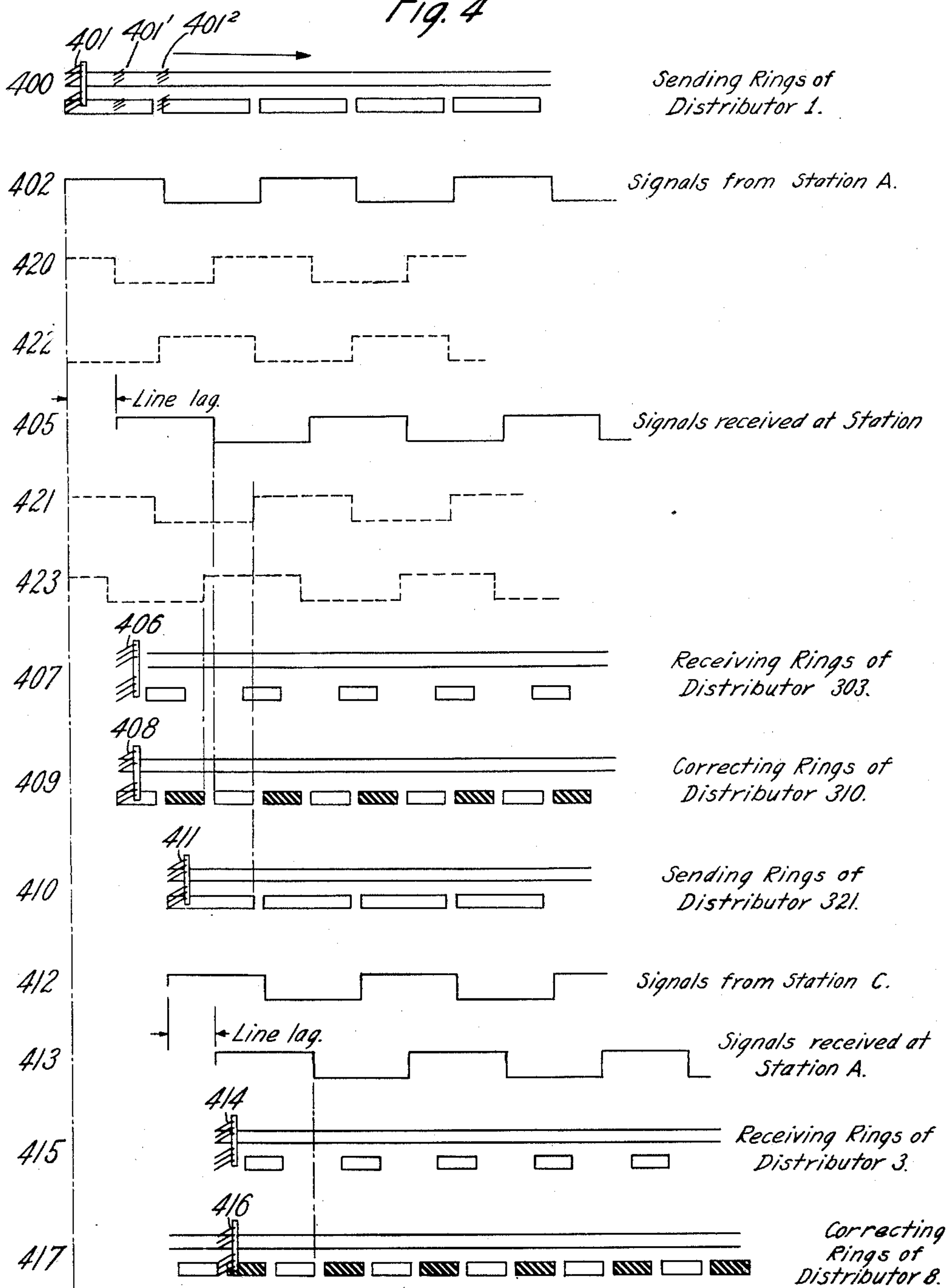
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SIGNALING SYSTEM

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4 Sheets-Sheet 4

Fig. 4



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UNITED STATES PATENT OFFICE.

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SIGNALING SYSTEM.

Application filed July 19, 1926. Serial No. 123,328.

This invention relates to signaling systems and more particularly to printing telegraph systems employing long submarine cables.

Its principal object is to improve the method and means for synchronizing the transmitting and receiving mechanisms in systems of this type.

In multiplex operation of printing telegraph systems, as at present employed, mechanisms are used that enable a number of separate printing telegraph systems at both ends of the line or cable to be connected in rotation so that each circuit at one end is momentarily connected over a cable to its corresponding circuit at the other end. In submarine cable operation the cable may be operated simplex, that is, messages are transmitted in one direction only during a given interval of time and the direction of transmission is reversed automatically at stated intervals in order to handle traffic in both directions over one cable. This reversal of direction of transmission in present types of systems is generally effected by direction control apparatus operated automatically after having been once set to the desired proportions of time.

It is well known in the art how the mechanisms for transmitting and receiving may consist of so-called distributors comprising transmitting rings, receiving rings, and correcting rings. The correcting rings at each station being used for maintaining synchronism between the distributor at that end of the cable and the signals transmitted from the opposite end of the cable.

The present invention is applicable to systems of this general character and comprises means including the correcting ring of the distributor at one end of the cable orientable in relation to the associated transmitting ring whereby the system may be adjusted, before the actual transmission of messages begins, to maintain synchronism during successive reversals of the direction of transmission. By this means different amounts of time lag due to the transmission characteristic of the cable may be compensated for and the tendency on the part of the sending and receiving distributors to fall out of synchronism, during the intervals when the reversals of direction of transmission take place, is overcome.

This invention has been illustrated in the accompanying drawings in connection with

a multiplex printing telegraph system which includes a terminal station, a land line, a repeater station, a submarine cable, and another terminal station in series. Fig. 1 represents one terminal station with its transmitting and receiving equipment indicated in a schematic form and the speed correcting mechanism shown in detail. Fig. 2 represents the repeater station connected to the land line from the station shown in Fig. 1 and to the submarine cable leading to the terminal station shown in Fig. 3. Fig. 3 shows in schematic form the transmitting and receiving equipment at the terminal station connected to the submarine cable incoming from the repeater station. The correcting mechanism in this figure is shown in detail.

As the invention relates principally to a method and means for synchronizing the operations of the distributors at the various stations, such parts of the system as are not directly concerned with this problem have been shown in a highly schematic form. On the other hand, the speed correcting or synchronizing means at the terminal stations have been shown in considerable detail.

The various parts of the system are arranged as follows: At the terminal station A, a transmitting distributor 1 with its associated impulse transmitting device 2 and a receiving distributor 3 with its printing devices 4, are shown connected to contacts actuated by cam 5 which, under the control of a direction control apparatus (not shown) is adapted to alternately connect said distributors to a land line 6. Corrector distributor rings 8 for station A are shown with their associated brush 9, a corrector line relay 10 controlled by impulses from station B over line 12, and an auxiliary corrector relay 14 controlled from the corrector rings 8. The corrector mechanism 20 is for producing angular shifts of the brushes traveling over the faces of the correcting, transmitting and receiving distributor rings. This corrector mechanism is located between the motor for driving the distributors and the distributors themselves. The motor has not been shown. The shaft 22 is driven by the motor and the shaft 23 drives the arms on which the brushes, such as 9, for the distributors are mounted. These arms are arranged to drive the brushes over the various distributor faces in a manner well known in

the art. The corrector mechanism 20 consists of differential beveled gear arrangement 25 interposed between the motor shaft 22 and the brush shaft 23 and the gears that link these two shafts together are mounted on a supporting frame 27 secured to a worm pinion 28 that meshes with a worm 29. Any change in the angular position of the worm pinion 28 changes the angular position of the linking gears and this in turn changes the angular position of the brush shaft 23 with respect to the motor shaft 22. The worm 29 is rotatable to shift the angular position of the worm pinion a small angle by means of corrector magnets 31 and 32 in one direction or the other. The ratchet wheel and pawl mechanisms 35 and 36, respectively, are operated by these magnets so that on the operation of either one of the magnets, an angular shift of the distributor brushes in one direction or the other is effective. In order to hold the worm 29 firmly while the magnets are not rotating it, a separate ratchet wheel 37 and a pawl 38 is provided. This wheel and pawl also limits the movement of the worm 29 to one step each time a corrector magnet operates. The automatic corrector mechanism 20 is therefore capable of shifting the brushes of the distributors in a forward or in a backward direction; magnet 31 being provided for shifting it in a forward direction and magnet 32 for shifting it in a backward direction. By forward is meant a shift in the same direction as the rotation of the brushes; by backward is meant a shift opposite to the direction of the rotation of the brushes. It is seen, therefore, that by this mechanism, corrections in either direction can be effected while the distributor brushes are being rotated by the motor and hence synchronizing effects may be produced between the brushes of the distributors at different stations as will be hereinafter more fully explained. A correction direction key 40 is provided to connect one corrector magnet or the other with the circuit controlled by the auxiliary corrector relay 14 which in turn is under control of the corrector rings 8 and brush 9.

The equipment at the repeater station B comprises a receiving distributor 100 and its associated storing relays 101 from which the signals are retransmitted through the transmitting distributor 102 to the submarine cable 103 leading to the terminal station C. Of the direction control apparatus at this station only the cams 104, for controlling contacts to switch from reception to transmission and vice versa, have been shown. At this station signals received from line 6 are repeated to cable 103 through the receiving distributor 100, storing relays 101, transmitting distributor 102, while the signals from the submarine cable 103 are

amplified through the amplifying device 105 to actuate line relay 106, which directly controls the transmission of signals to the land line 6 through the contacts actuated by cams 104. In series with the line relay 106 is another relay 109 called a corrector control relay since it is used for repeating correcting signals received from cable 103 to land line 12 for actuating the corrector line relay 10. The distributors at station B are driven in synchronism with the distributors at station A by means of a distributor arrangement 18 at station A whereby impulses are sent over a separate line 16 between these stations to the driving motor arrangement 110 at station B.

The submarine cable 103 terminates at station C at which the equipment for receiving signals consists of the amplifier apparatus 300, line relay 301, receiving distributor 302 and the printing apparatus 303. The correction control relay 304 is in series with the line relay 301 to control the corrector line relay 306 which in turn controls the application of correcting impulses through the corrector rings 310 for the actuation of the correcting mechanism 313 to correct the distributors at this station forward during reception of signals at this station. This mechanism 313 is identical with the corresponding mechanism 20 at station A and the magnet 314 is provided for forward correction while the magnet 315 is provided for backward correction. The direction correction key is marked 316. Transmission from the station C is directed from the impulse transmitting devices 320 through the transmitting distributor 321 to the submarine cable 103 and the direction control cam 322 causes the shifting of the cable 103 from the receiving to the transmitting apparatus and vice versa.

In operation the distributor at station B is at all times maintained in synchronism with the distributor at station A by means of synchronizing impulses continuously transmitted from the distributor segments 18 in Fig. 1 over the separate synchronizing line 16 to the distributor motor 110 at station B. Therefore stations A and B may be regarded as a unit and station C as a separate unit between which units synchronism must be maintained by means of signals transmitted over the cable 103.

The knurled handle 350 is provided on the shaft 341 for manually adjusting the system in order to set it to a synchronous condition.

Assuming that the initial synchronous condition has been achieved and that transmission is from stations A and B to station C, signal impulses received over the cable 103 at station C are amplified in the amplifier 300 and applied to a receiving relay 301 and a synchronizing relay 304. Relay 304 responds to each reversal of the signal cur-

rent to reverse the position of its armature which reverses the current in a second synchronizing relay 306. Relay 306 also reverses the position of its armature in response to each reversal of current in its winding and successively charges condenser 336, from a source of positive potential shown, and discharges it through the main ring 346 on a distributor 310, a brush 337 to segments 335 or 345 associated therewith. As long as the distributor at station C is in proper phase relation with respect to the received signals the brush 337 will be on one of the segments 345 at the time relay 306 reverses the position of its armature and the condenser 336 will be discharged through the negative battery shown connected to segments 335 and no correction will be produced. The distributor at station C, however, is set to run at a speed slightly lower than that of the distributor at station A. Therefore the brush 337 will be constantly shifting back and eventually will be resting on one of the segments 345 at the time relay 346 reverses the position of its armature. As a result of this the charge from condenser 336 will be applied through the brush 337 and a segment 345 to the right hand winding of relay 339 and through the back contact and armature of magnet 314 to negative battery at key 316. This causes the armature of relay 339 to shift to the position opposite that shown in the drawing which applies positive battery over the armature of relay 339 through the winding of magnet 314 to negative battery at key 316. This causes magnet 314 to operate and shift the distributor brushes forward through the differential gear mechanism comprising ratchet wheel 340, worm 341, and worm wheel 342. A correction takes place whenever brush 337 drops back far enough to contact with a segment 345 at the time a signal reversal occurs and therefore acts to maintain the distributor at station C at all times in phase with the received signals from stations A and B.

When transmission from A and B to C has continued for a predetermined period, the direction of transmission is reversed.

To switch the connections so that sending can take place from station C to station A, the direction control cams 5, 104 and 322 are actuated by a timing device (not shown). This timing device is merely a means for actuating the above mentioned cams at certain intervals to make them perform this desired switching of the circuits at predetermined intervals. The mechanism for controlling the operation of these cams is not a part of this invention and is therefore not shown. It is sufficient to mention that the cams at all three stations are controlled to perform their switching operations substantially simultaneously with due regard to lag

in transmission. Cam 5 causes the contacts to open the connections between the sending distributor 1 and the line 6 and to close a connection between the receiving distributor 3 and the line 6. Similarly the cam 104 opens the connection to the receiving distributor 100 from line 6 and closes a connection from line 6 to the armature of line relay 106. One of the cams 104 also closes a circuit for the operation of relay 112 to open the connection between the submarine cable 103 and the sending distributor 102 and close a connection between this cable and the amplifying device 105. Signals incoming over cable 103 will therefore now pass as previously stated through the amplifying device 105, line relay 106 and correction control relay 109. The operation of cam 322 closes a circuit for the operation of relay 348 to cause this relay to actuate its armature to a position opposite to that shown in the drawing. Hence, the connection between the cable 103 and the amplifying device 300 will be opened and a connection between the cable and the sending distributor 321 and transmitting device 320 closed.

When the operations of the aforementioned cams are completed, signals will be transmitted from the sending distributor 321 at station C over the cable 103 through the receiving amplifier 105 at station B and through the signal receiving relay 106 and the synchronizing relay 109. Relay 109 thereupon repeats current reversals through the back contacts and armatures of relay 113 over the conductors 12, the armatures and back contacts of relay 42 of station A to relay 10 which functions in the same manner as relay 306 at station C to apply synchronizing impulses from a condenser to a synchronizing distributor 8. Since the distributor at station A normally runs slightly faster than the distributor at station C, the brushes at station A must be corrected backward, this being the converse of the operation at station C, and therefore switch 40 is set to actuate the backward correcting magnet 32. Relay 10 in operating closes a circuit for the operation of auxiliary corrector relay 14 through brush 9, provided brush 9 has advanced out of synchronism with the brushes of the sending distributor 321. If this is the case circuits will be completed from one side of the condenser 44, which previously has been charged through the circuit completed at the right-hand contact and armature of relay 10, through negative battery to ground and from the other side of the condenser 44 through the armature and left-hand contact of relay 10, the upper ring of the corrector rings 8, brush 9 and a segment of the lower ring of those marked 45, through the right-hand winding of auxiliary corrector relay 14, right-hand closed contacts of direction key 40, back contact and arma-

ture of magnet 32 through negative battery to ground. This latter circuit causes the auxiliary corrector relay 14 to actuate its armature to a position opposite to that shown in the drawing. A circuit is thereby completed as follows: from battery, through the winding of magnet 32, left-hand closed contacts of direction key 40, armature and contact of the auxiliary corrector relay 14 to ground. Magnet 32 in operating actuates the pawl and ratchet mechanism 36 to shift through the corrector mechanism 20 the shaft 23 for a small angular distance in a backward direction in relation to the rotation of the shafts 22 and 23. On the operation of magnet 32 the circuit through the right-hand winding of auxiliary corrector relay 14 is opened at the armature and back contact of magnet 32 and a circuit for the left-hand winding of relay 14 is closed from battery at the armature and front contact of magnet 32 through the left-hand winding of relay 14 to ground. This circuit restores the auxiliary corrector magnet 14 to its normal position and consequently the circuit for the stepping magnet 32 is opened so that this magnet returns its armature to normal condition. Corrections of this kind will occur until the brushes of the receiving distributor 3 are in perfect synchronism with the brushes of the sending distributor 321.

Although the apparatus, the operation of which is set forth above, is capable of maintaining synchronism between stations A and C during transmission in one direction, it has been found that the stations may fall out of synchronism during the reversal of the direction of transmission and the reason for this can best be explained with reference to Fig. 4 of the drawings in which a diagrammatic presentation has been made of various distributor segments and impulse curves and their inter-relations in order that an exact understanding of the effect of the phasing and orienting operations relating to this final adjustment may be had from this diagram.

First, it will be assumed that the motors at stations A and C are running at exactly the same speed. Therefore, so far as the motor speed is concerned no corrections will be required after synchronism has once been obtained. This assumption can, of course, not be attained in actual practice and is, therefore, only justifiable on the ground that it simplifies the following descriptions relating to the necessity for the orientability of the correcting ring 8. In this diagram it has been assumed that the brushes travel from left to right as indicated by the arrow. As previously stated a correction can only take place at the instant a new impulse or signal is actuating a corrector control relay, such as 304 or 109, and then only if the impulse occurs when a brush, such as 337,

is on a correcting segment, for example 345 and the new impulse is of the opposite polarity to that of the preceding one. The correcting segments in Fig. 4 are hereafter called "black segments."

If the condition of sending from station A is considered, reference may now be had to the sending segments of the sending distributor 1 shown at 400. The sending brush 401 sweeps from left to right over the sending segments 400 and impulses, such as 402, will therefore be sent to station C. These impulses are for the sake of convenience assumed to consist of successive impulses of opposite polarity, although in actual practice they may consist of a plurality of impulses of one polarity followed by a plurality of impulses of the opposite polarity. An impulse interval is represented as occupying space or time, that is, a segment swept over by the brush 401 or the time required for such movement.

At station C the received impulses 405 come in later in time due to the lag in transmission. As is well known this lag is due to the transmission characteristics of the several circuit elements, such for example, as the line 6, submarine cable 103, amplifier 300, relay 301, etc. It is assumed that the system has already been phased or "lined up" to compensate for this lag. Hence it follows that when brush 401 is at the center of the sending segment as shown at 401', brush 406 has not yet reached the center of the receiving segment, but will reach it at a time later (equal to the line lag) when the center of the signal impulse arrives. The receiving segments are made shorter than the sending segments in order that the central portion of the received signal will be effective for operating the printing relay. Corrector brush 408 is shown in line with receiving brush 406, but in practice it should be understood that the receiving brush may be oriented without disturbing the corrector brush. As stated above, the receiving segments 407 have been phased to receive approximately the middle of the signal impulses 405 and the corrector rings 409 have such a relation to the point of the beginning of the impulses 405 that no corrections will occur as these impulses begin because the corrector brush 408 is on the left hand end of a non-correcting segment of the group 409. The non-correcting segments are hereinafter called "white segments."

When the direction of transmission changes to transmit from station C to station A the sending rings 410 of distributor 321 come into play. As far as the transmission of impulses is concerned the sending rings 410 may at this time have any relationship whatever to the receiving and correcting rings 407 and 409. As the send-

ing brush 411 sweeps over the sending segments 410 impulses such as 412 are sent out over the cable to station A.

The received impulses 413 come in at station A with an assumed line lag of half the distance between the beginning of two succeeding impulses sent out from station C. Since it is assumed that the system is also already phased or "lined up" for reception of impulses in this direction, it follows that when the brush 411 travels from the beginning of a sending segment of ring 410 as shown in the drawing the receiving brush 414 will arrive at the positions shown in the drawing when the impulse 413 arrives. Here also the receiving segments 415 are shortened and phased to receive only the middle portion of the impulses. The corrector brush 416, (same as corrector brush 9 in Fig. 1) and the corrector rings 417 (same as corrector rings 8 in Fig. 1), if they are properly oriented with respect to the sending ring 400 and sending brush 401, will have such relation to the beginning of impulses 413 that no correction will occur as the beginning of impulses take place because brush 416 will be at the right hand end of a white segment.

Assuming now that another reversal of direction of transmission occurs so that station A again transmits to station C, the relative relationship between correcting segments 417 and the sending segments 400 is of importance. If, as we have assumed, the correcting segments 417 are properly set, no correction resulted at station A when the direction of transmission was first reversed. Hence, the distributors at both stations are in their original relative positions and when the direction of transmission is next reversed and station A again sends to station C, the distributors at the two stations are still in proper phase relation.

But suppose that, following the first reversal, the correcting segments 417 were not properly set with respect to the sending segments 400. Suppose that the correcting brush 416 were on the right end of a black or correcting segment instead of the right end of a white segment where it should have been. The correcting mechanism at station A was thereupon actuated to correct all the brushes at station A backward the width of a correcting segment (which is half the width of a sending segment). This displaced the sending brush 401 to the position 401' (assuming that it was formerly at position 401²). Therefore, when station A again transmits, the first impulse will be transmitted from station A and received at station C at a corresponding portion of time later than the previous time. That is, the position of the impulses from station A in their relation in time to impulses 402 is indicated with a dotted impulse curve

420 and the arrival of the impulses at station C in this relation in time to impulses 405 is indicated by dotted impulse curve 421. Under these new conditions the first impulse would be received on the first receiving segment of ring 407 and the second impulse would also come on the first receiving segment and the system would be out of line. It will be noted that the system would remain out of line as the beginning of the impulses would take place while the correcting brush 408 travels over a white segment of ring 409. This may be verified by the dotted vertical line projected from the beginning of an impulse 421 to a white segment of ring 409.

We have considered above the result of the correcting brush being displaced the width of the correcting segment in one direction. Obviously, if the displacement is greater in the same direction or less than a segment and in the opposite direction, the brush 416 will fall on a non-correcting or white segment and no correction will result. This would do no harm in our hypothetical case with the distributors at stations A and B running at the same speed, but in practice, with the distributors running at different speeds, they would soon drift apart.

From the foregoing considerations it can be seen that the system may get out of synchronism even though the motors at the two stations are running at exactly the same speed. In the actual system of correction employed the motor at station A is running faster than the motor at station C. This requires a forward correction of the brushes at station C in the manner previously described to maintain synchronism while station A is sending, and a backward correction of the brushes at station A when station C is sending. Therefore, during the change over or switching period when no impulses are transmitted over the cable and consequently no correction can take place the brushes at station A gain in speed and the brushes at station C lose in speed so that when transmission again begins a few correcting steps are normally required to bring the system back into synchronism.

In the practical operation of the system the proper orientation of the ring 417 may be determined by observing the number of corrections that take place to bring the system toward synchronism at the receiving station after a reversal of direction of transmission has occurred. If the number of steps which occur are just the number required to correct for gain or loss of brush 401 during a changeover interval, then the orientation of the ring segments 417 is correct. If it is different, the proper orientation change can be determined, from the amount of the difference, from the fact that

the number is greater or less than it should be and from the further fact that the distributors do or do not get out of phase on successive transmissions in the same direction. It is evident then that as previously explained the synchronizing of the brushes at the two stations is dependent on the proper orientation of the corrector rings 417, taking into account the difference in speed of the motors at the two stations, the fact that no correction takes place during the changeover period and the relationship of the sending ring 400 to the corrector ring 417.

Since alternate segments of the corrector rings are similar and are connected together as shown at 8 in Fig. 1 and at 310 in Fig. 3, it is unnecessary to make the correcting ring adjustable through a circumferential distance greater than that between successive correcting segments.

What is claimed is:

1. In a synchronous telegraph system, a plurality of stations, distributors at said stations, a transmission line connecting said stations, means for automatically reversing the direction of transmission from time to time, synchronizing means for said distributors controlled by the distributors at the station which is sending, means for changing the relative positions of the sending segments and the correcting segments at one of said stations whereby the system may be adjusted to maintain synchronism during successive reversals of the direction of transmission.

2. In a synchronous telegraph system, a plurality of stations, sending and receiving distributors at each station, a correcting distributor at each station, a transmission line connecting said stations, means for automatically reversing the direction of transmission from time to time, synchronizing means for said distributors comprising means at each station for synchronizing distributors at the station receiving with a distributor at the station sending including the correcting distributor at the station receiving, and means for changing the relative positions of the sending distributor and the correcting distributor at one station to maintain synchronism between the distributor at said stations during successive reversals of the direction of transmission.

3. In a synchronous telegraph system, a

plurality of stations, sending and receiving distributors at each station, a correcting distributor at each station, a transmission line connecting said stations, means for automatically reversing the direction of transmission from time to time, synchronizing means for said distributors comprising means at each station for synchronizing distributors at the station receiving with a distributor at the station sending including the correcting distributor at the station receiving, and means for changing the position of the correcting distributor with relation to the sending distributor at one station by at least the distance of one sending segment for maintaining synchronism between the distributors of said station during successive reversals of the direction of transmission.

4. In a synchronous telegraph system, two stations, sending, receiving and correcting distributors at each station, a transmission line connecting said stations, means for automatically reversing the direction of transmission at predetermined regular intervals, synchronizing means for the brushes on said distributor comprising automatic means for synchronizing the brushes of one station with a speed at the other station characterized in this, that the speed of the brushes of the distributors of the receiving station is synchronized to the speed of the brushes of the distributors of the sending station in a system where the normal speed of the brushes of one station is faster than the normal speed of the brushes at the other station, and means for orientating the distributor at one station to a certain relation to the position of the sending distributor at this station whereby the synchronizing means is controlled to reestablish synchronism between the brushes of the distributors at the two stations if the brushes get out of synchronism during the successive reversals of direction of transmission due to the difference in speed of the brushes at the two stations and to correct the tendency of the brushes to get out of synchronism during the successive reversals of direction of transmission due to certain relationship of the brushes of the sending and correcting distributors and the brushes of the receiving distributor of said other station.

In witness whereof, I hereunto subscribe my name that 25th day of June, A. D., 1926.

GEORGE A. LOCKE.