

Aug. 11, 1942.

H. H. HAGLUND

2,292,783

ROTARY REGENERATIVE REPEATER

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2 Sheets-Sheet 1

FIG. 2

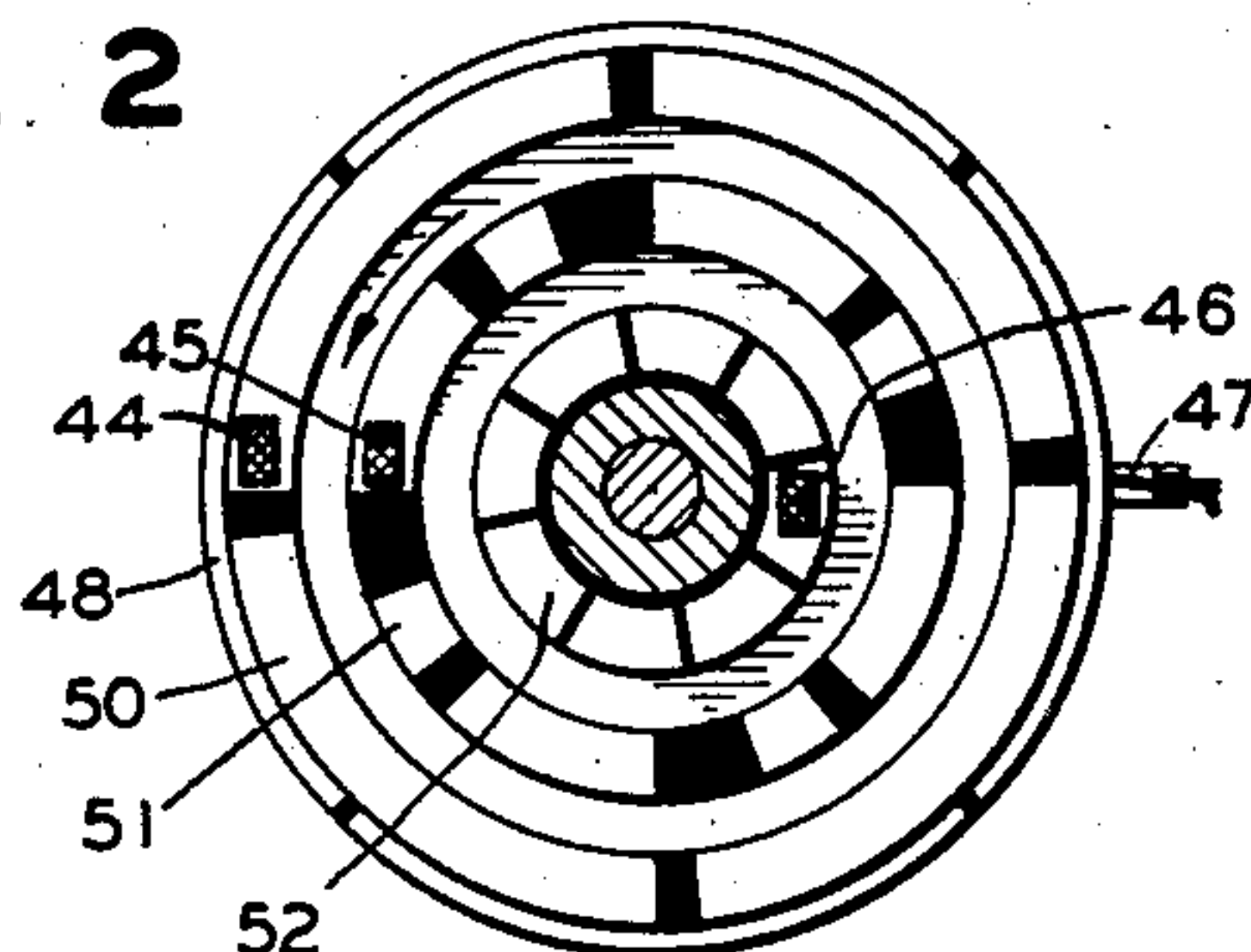
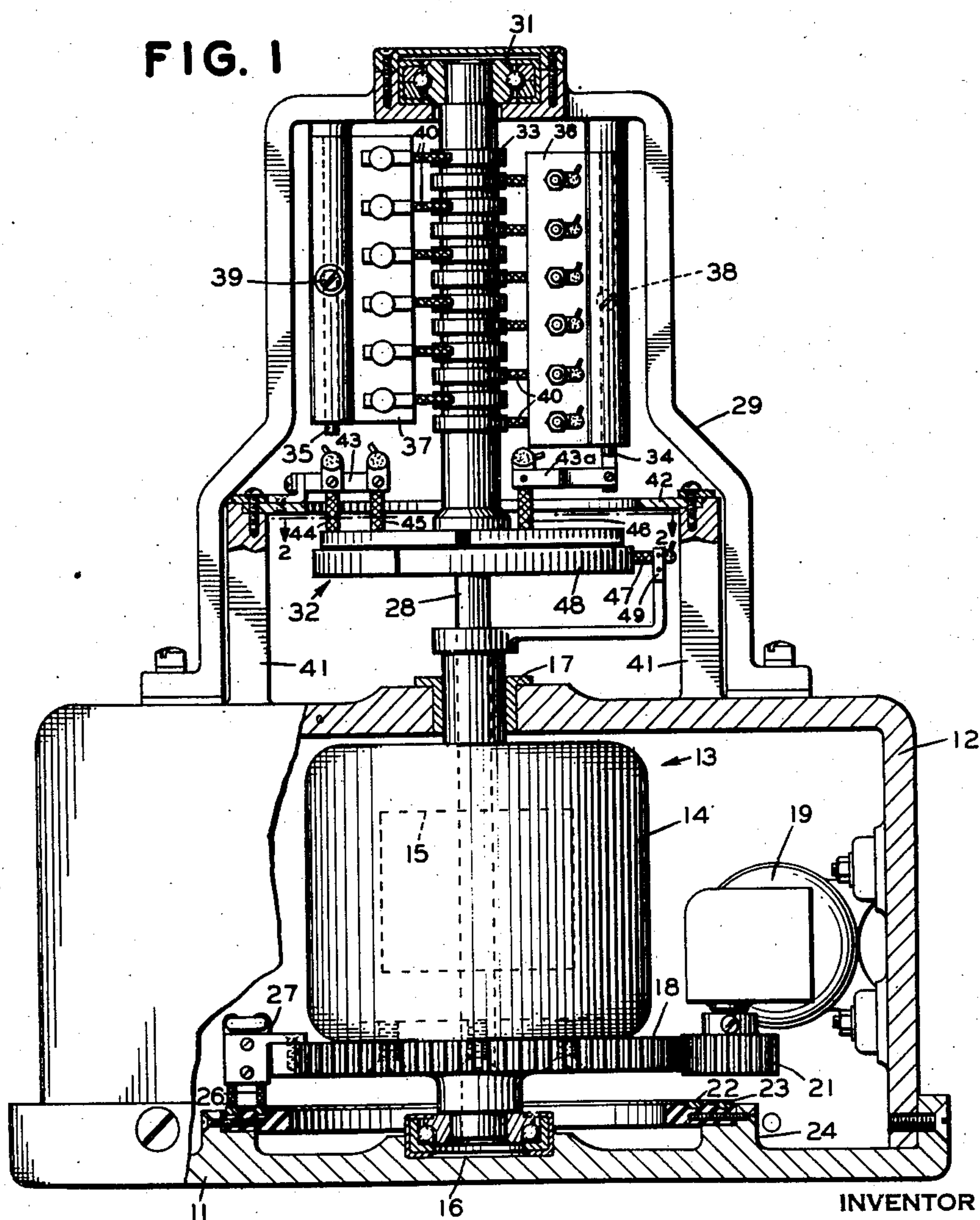


FIG. 1



INVENTOR
H. H. HAGLUND

BY *M. H. Sprague*
ATTORNEY

Aug. 11, 1942.

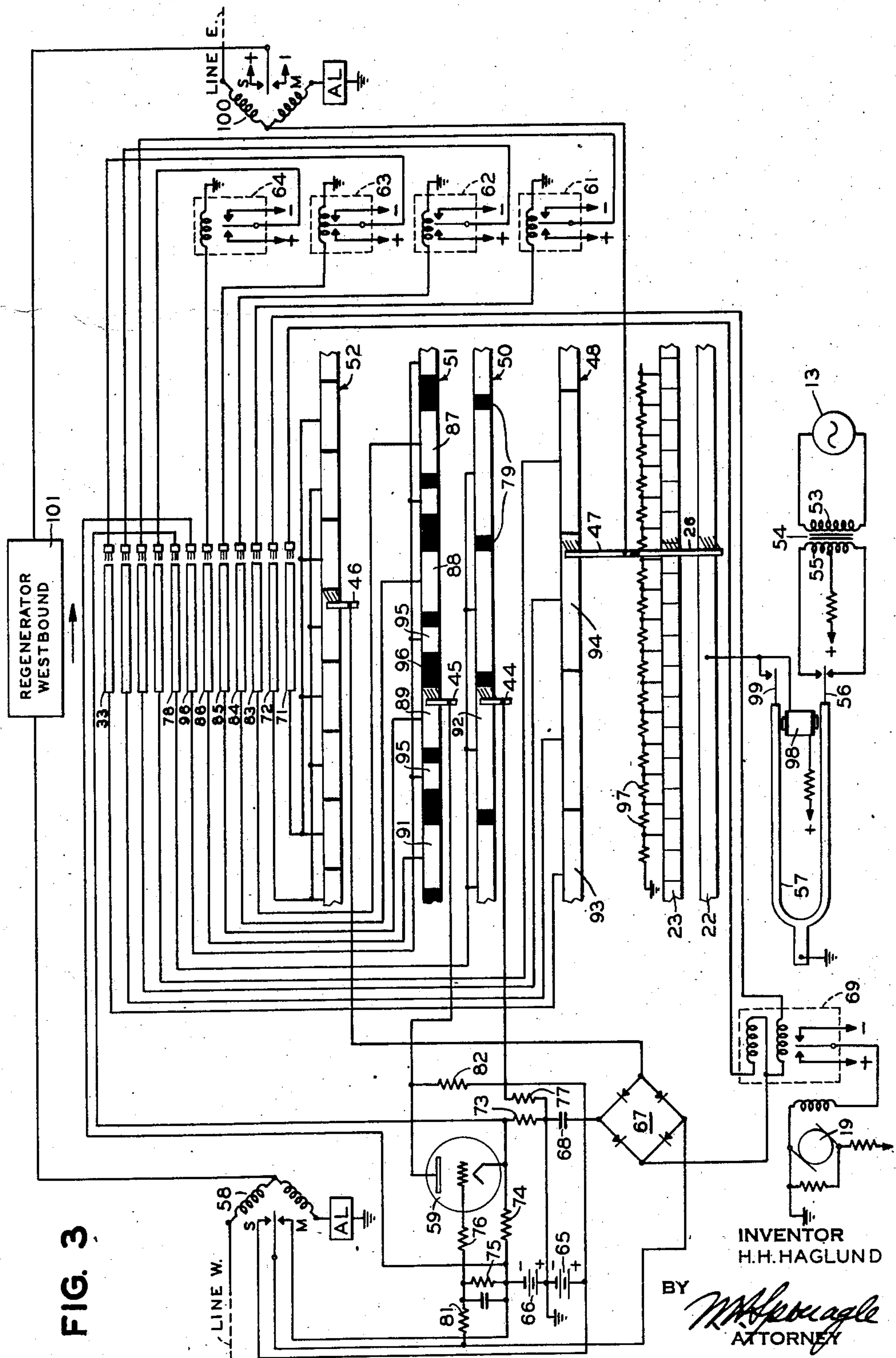
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2 Sheets-Sheet 2



UNITED STATES PATENT OFFICE

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ROTARY REGENERATIVE REPEATER

Hakon H. Haglund, New York, N. Y., assignor to
The Western Union Telegraph Company, New
York, N. Y., a corporation of New York

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13 Claims. (Cl. 178—53)

This invention relates to synchronous telegraph systems and has particular reference to repeating apparatus employed to regenerate signals both as to amplitude and as to phase.

The commonly used synchronous telegraph systems, one form of which is known as multiplex, utilize distributors at the transmitting and receiving stations. Each of the distributors is driven by means of a synchronous motor which derives its energy from an alternating current source which is usually a vibrating fork. The two forks are adjusted to generate alternating current at substantially the same frequency. Even in cases where the transmitting and receiving forks can be adjusted with sufficient precision to effect the generation at both stations of exactly the same frequency, the phase relation existing between the individual signals transmitted is subject to considerable variation because of the effects of extraneous currents picked up along the telegraph wire. It is the function of any correcting mechanism employed at the receiving station to maintain synchronism between the received signals and the receiving apparatus. One correcting system for accomplishing this result which is in extensive use at present employs a small reversible direct current motor connected mechanically to the receiving apparatus.

The usual form of multiplex distributor comprises a plurality of segmented and solid rings which are traversed by a plurality of cooperating brushes. The receiving and transmitting brushes, together with the correcting and other local brushes in the conventional form of distributor, are mounted on a structure which is attached to the rotating shaft of the synchronous motor whereby all of the brushes are rotated as a unit. The reversible direct current motor is geared to the shaft of the synchronous motor so that the brush mounting may be shifted backward or forward with respect to the face plate rings while the apparatus is in operation, thereby effecting a change in the phase relation between the various brushes and their associated segmented rings. One form of such apparatus is disclosed in Patent No. 1,924,050, granted to O. E. Pierson on August 22, 1933, and entitled "Correcting mechanism for synchronous apparatus." The use of such apparatus permits a high degree of synchronism to be maintained between receiving apparatus and the signals received thereby.

When apparatus of the type disclosed by Pierson is used with the receiving mechanism of a repeater of the regenerative type, the action of the correcting motor is such that each phase shift

of the receiving apparatus produces a corresponding phase shift in the signals which are transmitted to the next line section, by reason of the fact that the transmitting and receiving brushes are both shifted in response to phase shifts of the received signals. Since the purpose of a regenerative repeater is to correct both for amplitude and phase distortion, it is desirable to transmit the signals from such a repeater with a minimum of phase distortion. It is apparent that this result cannot be obtained satisfactorily by means of any of the devices known to the prior art.

Hence, it is an object of the instant invention to provide simplified signal regenerating apparatus of the rotary type whereby the signals are regenerated more perfectly than heretofore.

It is another object of the invention to prevent the retransmission into the retransmitted signals of the corrector action of a rotary regenerative repeater, when such action is oscillatory in nature.

Another object of the invention is to provide rotary distributing apparatus wherein the receiving and transmitting elements may be adjusted independently.

In its general aspect the invention contemplates the separation of the receiving and retransmission functions of the rotary regenerator so that the retransmission shall be substantially independent of the receiving function. In its present form the invention contemplates the use in a rotary regenerative repeater of a synchronous motor, to the rotating shaft of which is attached a face plate comprising a plurality of segmented rings including the receiving and transmitting rings. A plurality of stationary brushes are mounted in fixed relation to one another and effect contact with certain ones of the segmented rings. Included in the aforementioned set of brushes is the receiving brush. The transmitting brush is attached to the stator of the synchronous motor. Also attached to the stator is a gear which is arranged to mesh with another gear carried by the shaft of a reversible direct current motor. The rotation of the segmented rings with respect to the stationary brushes causes a traversal of the segments by the respective brushes. Also, there is rotation of the segmented rings with respect to the transmitting brush. However, by suitably energizing the direct current reversible motor to rotate in one sense or the other, the stator of the synchronous motor may be rotated with respect to the stationary brushes. Since it is inherent in this type of

motor that any rotation of the stator effects a corresponding rotation of the motor, a change in the phase of the receiving elements of the distributor may be made to correspond to phase shifts of the received signals. At the same time there is no phase shift produced between the transmitting brush and its segmented ring since both are shifted with respect to the stationary brushes. Therefore, the apparatus functions to maintain synchronism between the receiving distributor and the received signals without producing any change in phase of the signals retransmitted by the transmitting distributor.

Means are provided for temporarily storing any predetermined number of signals between the receiving and the retransmitting distributors in order to secure the independent functioning of these distributors. But since any storage device is necessarily limited in accordance with the predetermination as to the number of signals that can be stored in the regenerative repeater, means are provided for automatically changing the speed of the synchronous motor if the correction of the receiving distributor is in the same sense for a sustained period.

The method and means for carrying out the invention will be better understood by reference to the accompanying drawings, in which:

Fig. 1 is an elevational view, partly in section, of a distributor embodying one feature of the invention;

Fig. 2 is a sectional view taken on the line 2—2 of Fig. 1; and

Fig. 3 is a diagrammatic illustration of a regenerative repeater embodying the invention.

Reference will be made first to Figs. 1 and 2. The distributor is mounted on a base 11. A housing or casing 12 is attached to the base and extends upward therefrom. A synchronous motor 13 having a stator 14 and a rotor 15 is mounted in the housing 12, the stator being journaled at 16 in the base 11 and at 17 in the top of the casing. The purpose of mounting the motor in this manner is to provide for rotation of the stator with respect to the housing 12.

A gear 18 is rigidly attached to the lower end of the stator 14. A small reversible direct current motor 19 is attached to one side of the housing and carries on its shaft a small pinion gear 21 which is arranged to mesh with the motor gear 18. A pair of rings 22 and 23, one segmented and the other solid, are supported by a plurality of upstanding studs 24 formed in the base 11. These rings are arranged concentrically with the motor 13 and are engaged by a pair of brushes 26 which are strapped together and carried by a brush holder 27 attached to the motor gear 18. Thus, the stator 14 of the synchronous motor may be rotated by means of the direct current motor 19 and the gears 18 and 21. Rotation of the stator also moves the brushes 26 relative to the rings 22 and 23 for a purpose to be described. A few of the teeth are removed from the gear 18 on both sides of the brush holder 27 to prevent the rotation of the stator 14 beyond the two limits thus provided.

The shaft 28 of the synchronous motor rotor 15 is extended upward for a considerable distance beyond the stator 14. A supporting framework 29 is attached to the top of the housing 12 and may be provided with a bearing 31 which serves to journal the upper extremity of the distributing apparatus driven from the shaft 28. The distributing apparatus is fastened to the

shaft 28 and includes a face plate 32 comprising a plurality of segmented rings, the plan view of which is shown in Fig. 2, and a plurality of slip rings such as the ring 33 which are electrically connected to the various segments. These rings are fixed relative to one another and are insulated electrically from but secured to the shaft 28 so that they are rotated thereby. A pair of depending rods 34 and 35 are attached to the under side of the top portion of the bracket 29 and serve to support respectively insulating brush holders 36 and 37. The brush holders are adjustably attached to the supporting rods by means of set screws 38 and 39. Each of the brush holders 36 and 37 forms the mounting for a plurality of flexible brushes such as 40, each of which is adapted to engage one of the slip rings. Connections are made to suitable terminals connected to the respective brushes 40 whereby the various segments of the face plate may be connected in the circuits of the repeater in a manner to be described.

A plurality of supporting posts 41 extend upwardly from the top of the housing 12. These supports carry at their upper extremities a ring 42 which is clamped by means of suitable screws to the supporting posts. The preferred form of the ring 42 embodies, adjacent its periphery, arcuate notches whereby the ring may be adjusted about the shaft 28. The purpose of such an adjustment is to orient the distributor elements relative to the received signals in accordance with the practice well-known to those skilled in the multiplex art. A brush holder 43 is attached to the ring 42 and serves to support a pair of brushes 44 and 45 which are adapted to engage two of the segmented rings of the face plate 32. A third brush 46 engaging the inner segmented ring is attached to a brush holder 43a which may be fastened to the rod 34 as shown or to any other convenient stationary part of the device whereby it is not orientable with respect to the face plate 32 as is the brush holder 43.

Of the segmented rings of the face plate 32, one is located below the three which are carried at the top of the group. The brush 47 which is associated with the lower segmented ring 48 is carried by a brush holder 49 attached rigidly to the stator of the synchronous motor 13. As viewed in Fig. 2, the top outer ring 50 and its associated brush 44 are employed to scan the received signals. The top middle ring 51 and its brush 45 are used to transfer the scanned signals to a storage device. The top inner ring 52 and its brush 46 serve to control the operation of the corrector motor 19. The lower ring 48, shown also in Fig. 1, and its associated brush 47 are utilized to transmit the stored signals to the outgoing line section.

With the corrector motor 19 deenergized and the synchronous motor 13 energized by alternating current of the desired frequency, the face plate 32 is rotated relative to the respective brushes. However, the phase of the incoming signals is constantly being shifted about a mean position because of fortuitous line disturbances. These relatively rapid phase shifts are detected by means of the corrector ring 52 and its associated circuits and apparatus. The corrector circuits suitably energize the reversible direct current motor 19 in accordance with the detected phase shifts and effect rotation of the corrector motor 19 in one direction or the other and thereby rotate the stator 14 of the synchronous mo-

tor. These small rotative movements of the stator are transferred to the rotor 18 since it is an inherent characteristic of this type of motor that the phase relation between the stator and the rotor remains constant. Consequently, the group of segmented rings of the face plate 32 is shifted in phase relative to the brushes mounted on the ring 42. Thus, the receiving and correcting rings are kept substantially in phase with the received signals. It is important to note that there is no phase change made between the transmitting ring 48 and its associated brush 47, for the reason that there has been no phase change made between the stator and rotor of the synchronous motor 13. Therefore, it is seen that, while the receiving rotary apparatus is made to follow relatively rapidly any phase shifts of the incoming signals, the transmitting rotary apparatus remains unaffected, thereby producing no change in the phase of the outgoing signals.

So long as the speed of the apparatus controlling the transmission from the distant station to the repeater remains substantially constant with respect to the rotary apparatus controlled by the synchronous motor 13, the average phase shift of the incoming signals is zero, and therefore it is undesirable to produce any change in the speed of rotation of the synchronous motor 13. However, if the two rotary devices do not maintain substantially constant speed, facilities are provided herein to alter the speed of the synchronous motor 13 in order to restore the constant speed relation. The speed control mechanism for the synchronous motor responds to the movement of the brushes 26 attached to the motor gear 18 in a manner to be described. As long as the movements of the stator 14 are oscillatory about a mean position, the corresponding movements of the brushes 26 are ineffective, but should a sustained phase shift in one sense or the other from the average position occur, the movement of the brushes will produce a suitable change in the speed of the alternating current source supplying the synchronous motor 13. Consequently, a corresponding speed change is made in the rotation of the face plate 32 which will produce a desired frequency change in the outgoing signals transmitted from the ring 48. But this speed change is made gradually, thereby producing a relatively slow change in the frequency of the retransmitted signals.

Referring now to Fig. 3, a regenerative repeater embodying the invention is shown diagrammatically and includes the distributor previously described, of which the various rings of the face plate 32 are shown in a developed form. Similar reference characters are used in this figure to designate the corresponding parts of the distributor mechanism shown in detail in Figs. 1 and 2. The segmented rings 48, 50, 51 and 52 and the slip rings such as 33 are rotated in the direction of the arrow by means of the self-starting synchronous motor 13. This motor derives its energy from the secondary winding 53 of a transformer 54, the primary winding of which is energized from a contact 56 of a vibrating fork 57. In the preferred embodiment, the frequency of vibration of the driving fork 57 is adjusted to produce a speed of rotation of the motor 13 approximately equal to 1980 R. P. M. when the telegraph signaling frequency is equal to 66 cycles per second. Obviously, it is within the scope of the invention to drive the motor 13 at other speeds for other signaling frequencies.

The signals which are received from the line

W operate a line relay 58, the contacts of which are employed to control the corrector mechanism and also to condition a selector tube 59, whereby the signals may be transferred to one of the storage relays 61, 62, 63 or 64. Subsequently, the stored signals are transmitted by means of the transmitting ring 48 and its associated brush 47 to the outgoing line E.

The functioning of the corrector mechanism whereby the receiving apparatus is maintained in synchronism with the transmitting apparatus at the distant end of the line W is substantially the same as that of the corrector apparatus described in detail in the aforementioned Pierson patent. Briefly, at each signal reversal the tongue of the line relay 58 moves from one contact to the other. The spacing contact S of this relay is connected to the positive terminal of a battery 65, and the marking contact M is connected to the negative terminal of a battery 66. The other terminals of these two batteries are connected to ground. The armature of the relay 58 is connected to one of the input terminals of a full-wave rectifier 67. The other input terminal of the rectifier is connected in series with a condenser 68 to the grounded terminals of the batteries 65 and 66. One of the output terminals of the rectifier 67 is connected to one terminal of each of the windings of a corrector relay 69. The other output terminal of the rectifier is connected to the corrector brush 46. Alternate segments of the corrector ring 52 are connected together, and each group of segments is connected through the slip rings 71 and 72, respectively, to a terminal of each of the windings of the corrector relay 69. Consequently, as the armature of relay 58 moves from one contact to the other, at each signal reversal, one or the other of the windings of the corrector relay 69 is energized, depending upon the group of segments of the corrector ring 52 with which the brush 46 is engaged at the instant of reversal. The impulses thus transmitted to the corrector relay 69 are of relatively short duration, equal to the charging time of the condenser 68. The windings of the corrector relay are oppositely poled so that the armature of this relay is moved to one contact or the other depending upon the winding energized. The armature remains in contact with one of its contacts until moved to the other under the influence of the operating windings. Positive potential is connected to one of the corrector relay contacts and negative to the other, and the armature of this relay is connected to the corrector motor 19. Consequently, when the armature of the corrector relay is connected to positive battery the corrector motor tends to rotate in one direction, and when the armature is connected to negative battery the corrector motor tends to rotate in the opposite direction. In accordance with the teachings of the aforementioned Pierson patent, as long as the apparatus at the distant terminal and the repeating apparatus remain synchronous, there will be, on the average, as many reversals occurring while the corrector brush 46 is engaged with one group of segments as there are when the brush is engaged with the other group. Therefore, the armature of the corrector relay 69 will oscillate between its contacts rotating the corrector motor 19 first in one direction and then in the other, the average rotation being substantially zero.

The selector tube 59 which is employed to control the operation of the storage relays in conjunction with the distributor rings 50 and 51 is of

the gaseous conduction type. The input circuit of the tube is controlled by the contacts of the line relay 58 in conjunction with a biasing circuit. One branch of this biasing circuit includes a resistance 73 connected between the grounded terminals of the batteries 65 and 66 and the cathode of the selector tube 59, and a second resistance 74 which is connected between the cathode of the selector tube and the negative terminal of the battery 66. Another pair of resistors 75 and 76 are connected in series between the negative terminal of the battery 66 and the control grid of the tube 59, the former to communicate the bias potentials to the grid and the latter to prevent excessive grid current during the arc discharge of the tube. The values of the resistors 73 and 74 and of the battery 66 are such that the grid is made approximately 24 volts negative with respect to the cathode by this branch of the biasing circuit. Such a potential is well below the critical firing potential of the tube so that the tube does not become conductive when influenced by this branch of the circuit alone. Most of the time there is connected in parallel with the resistor 73 a second branch of the biasing circuit including a resistor 77. One terminal of this resistance is connected to ground and the other terminal is connected to the brush 44 associated with the pickup or scanning ring 50. The conducting segments of this ring are strapped together and connected through the slip ring 78 to the cathode of the tube 59 to complete the parallel connection of the resistors 73 and 77. Between the conducting segments of the scanning ring 50 are a plurality of insulating inserts 79, the engagement with which by the brush 44 opens the second branch of the biasing circuit through the resistance 77. While the brush 44 is engaged with the conducting portions of the scanning ring, the resistor 77 is connected in parallel with resistor 73 thereby further depressing the potential of the grid of the tube 59 to approximately 46 volts negative with respect to the cathode.

The tongue of the line relay 58 is connected through a resistor 81 to the grid terminal of the resistor 75. The engagement of the armature of the line relay with its negative marking contact M develops a negative voltage across the resistance 75, thereby rendering the grid of the selector tube even more negative with respect to its cathode. Thus, the selector tube is not operated in response to a received marking signal, when the brush 44 engages one of the inserts 79. However, when the armature of the line relay is engaged with its positive spacing contact S, a positive potential of approximately 37 volts is developed across the resistance 75. The 37 volts positive potential is added algebraically to the negative bias potential and the resultant voltage controls the operation of the selector tube. It will be seen that while the brush 44 is engaged with the conducting portions of the scanning ring 50, the effective grid-to-cathode voltage of the selector tube (algebraic sum of the 46 volts negative bias potential and 37 volts positive potential developed across the resistance 75) is approximately 9 volts negative which is below the critical firing potential of the tube. However, when the brush 44 crosses one of the inserts 79 and the negative bias is reduced to 24 volts, the algebraic sum of the bias potential and the 37 volts positive potential developed across the resistance 75 is 13 volts positive to which potential the grid of the selector tube is raised with respect to the

cathode. This voltage is well above the critical firing potential and the tube becomes conducting. Thus, it is seen that, in response to a marking signal, the selector tube is non-conducting, and, in response to a spacing signal, the selector tube is conducting.

Plate potential for the selector tube 59 is supplied by a connection from the positive terminal of the battery 65 through a resistance 82 to the anode of the tube. When the tube is non-conducting the plate is at a positive potential with respect to ground. However, when the tube is conducting, the resistance 82 is so proportioned with respect to the resistance 74 and the batteries 65 and 66 that the plate is at a negative potential with respect to ground. Connection is made between the plate of the selector tube and the distributor brush 45 whereby the plate potential may be communicated to the bank of storage relays. The storage relays 61, 62, 63 and 64 are connected respectively through the slip rings 83, 84, 85 and 86 to the respective segments 87, 88, 89 and 91 of the distributor ring 51. The brushes 44 and 45 are arranged with reference to the segments of rings 50 and 51 respectively so that as the brush 45 passes from one of the insulating inserts 79 onto one of the conducting segments, such as 92 for example, the brush 45 passes onto segment 89. Consequently, the polarity of the plate of the selector tube 59 with respect to ground is communicated through the segment 89 and the slip ring 85 to one terminal of the grounded winding of the storage relay 63. The armature of this relay is positioned in accordance with the polarity applied to the operating winding to place either positive or negative battery through the slip ring 33 onto segment 93 of the transmitting ring 48. At this time the transmitting brush 47 is engaged with segment 94 of the transmitting ring whereby the signal which is stored by the relay 61 is being transmitted to the line E. As the distributor rotates, the signal which is stored by the relay 63 is transmitted at a time which normally is substantially equal to two bauds after the scanning of the received signal. It is to be noted that this difference in the time of reception and transmission of the signals is the normal time required. This time may be increased or decreased substantially during the operation of the repeater due to the operation of the speed adjustment for the synchronous motor 13.

After the engagement of the brush 45 with the segment 89, it passes over an insulating segment and then onto one of a plurality of segments 95 which are all strapped together and connected through the slip ring 96 to the negative terminal of the battery 66. Thus, periodically after the delivery of the scanned signal to one of the storage relays the plate of the selector tube 59 is connected directly to negative battery, thereby rendering the plate approximately 46 volts negative with respect to the cathode and extinguishing the arc in the tube if one has been formed in response to a spacing received signal. It will be noted that while the brush 44 is engaged with one of the inserts 79 of the scanning ring 50, the brush 45 is engaged with one of a plurality of insulating inserts, such as 96, placed between each of the extinguishing segments 95 and each of the storage relay operating segments, such as 89. The purpose of such an arrangement is to isolate the output circuit of the selector tube 59 during the time that the tube is being conditioned in response to a received signal.

The corrector mechanism acts, in response to movements of the armature of the line relay 58 caused by reversals of the line current, to maintain certain predetermined relations between the received signals and the engagements of the receiving brushes with their respective segments. These relations are such that only the middle portions of the received signals are scanned. In other words, approximately one-half a baud after the time at which a reversal of the line current occurs, or would occur if the particular signal combination required it, the brush 44 engages one of the inserts 79 to read, in effect, the position of the armature of relay 58. Thus, since the middle portion of any received signal is the most reliable, the armature of relay 58 is given time to become firmly engaged with the desired contact and the chance of incorrectly reading the received signal is minimized.

For the consideration of the action of the corrector motor 19 to shift the phase of the receiving distributor apparatus in accordance with phase shifts of the received signals, it should be remembered that the brushes 44, 45 and 46 remain stationary in the relative positions shown. The rings 22 and 23 also are stationary. If the receiving apparatus is to be advanced to compensate for a corresponding phase shift of the received signals, the distributor rings 48, 50, 51, 52 and the transmitting brush 47 are moved to the right, as viewed in the drawings. Consequently, the brushes 44, 45 and 46 then become engaged with the segments of their respective rings earlier, thereby maintaining the receiving and correcting apparatus of the distributor in phase with the earlier arriving received signals. However, since the brush 47 is shifted in the same sense and magnitude as the transmitting ring 48, there is no change made in the timing of the retransmitted signals.

Because of the fixed mechanical relation of the transmitting brush 47 and the speed control brush 26, the latter brush is also moved to the right, thereby effecting a change in the engagement of this brush with the stationary segmented ring 23. Associated with this ring is a series connection of a plurality of resistances 97 from which connections are made to the individual segments of the ring 23 as shown. One end of the series connection of resistances is connected to ground. The ring 22 is connected to one terminal of the driving magnet 98 of the vibratory fork 57. The other terminal of this winding is connected to battery so that there is a circuit from battery through the winding of the driving magnet, through the ring 22, the brush 26 and one of the segments of the ring 23, through a portion of the speed control rheostat made up of the resistances 97 to ground. One tine of the fork 57 carries a contact 99 which periodically short circuits the speed control rheostat and produces a pulsating current component to drive the fork in a well-known manner.

As the brush 26 is shifted to the right or to the left, as viewed in the drawings, in accordance with the operation of the corrector motor 19, more or less resistance is connected in the speed control rheostat. The adjustment of the speed control rheostat determines the magnitude of the constant current component flowing through the fork driving magnet 98. If the brush 26 is moved to the right in accordance with an advance in the phase of the receiving apparatus, more resistance is inserted by the rheostat to reduce the constant current component of the fork driving magnet

98. Therefore, the average position of the fork tines moves away from the pole pieces. Consequently, the pulsating driving coil current is reduced, which decreases the amplitude of vibration of the fork tines and increases the frequency of vibration thereof.

However, the great ratio between the mass of the vibratory fork and its energy losses produces a very slow response to the adjustment of the speed control rheostat. Therefore, so long as the distributor at the remote station and the distributor at the repeater maintain substantially constant speeds the corrector action of the repeater causes the speed control rheostat to oscillate about a mean position and there is, therefore, no appreciable change made in the frequency of vibration of the fork 57. Hence, the speed of rotation of the synchronous motor 13 remains substantially constant and no change is made in the phase of the retransmitting apparatus.

However, if the terminal and repeater apparatus deviate in speed, the brush 26 will move from its average position, the fork driving mechanism will respond to the speed control rheostat, change the frequency of vibration of the fork, and thereby correspondingly change the frequency of the retransmitted signals.

It should be obvious that when the receiving distributor apparatus and the brush 26 are moved to the left, as viewed in the drawing, to compensate for a phase shift of the received signals requiring the retarding of the repeater apparatus, the resistance of the speed control rheostat is decreased, thereby increasing the constant component of the current drawn by the fork driving magnet 98. Consequently, the fork tines tend to assume new average positions closer to the pole pieces of the driving magnet, thereby tending to increase the amplitude of vibration and tending to decrease the frequency. Such a state, if maintained for a long enough period, will reduce the speed of rotation of the synchronous motor 13, and thereby effect the transmission of signals to the line E at a slightly lower frequency.

As stated previously, there are normally stored in the bank of storage relays two signals. The signals, as received, are stored sequentially in these storing relays while, at the same time, successive signals are being transmitted from these relays. The normal time relation existing between the received signals and the retransmitted signals is one whereby each signal is retransmitted approximately two bauds later than the corresponding received signal, the time delay being effected by the storage relays and the relation of the receiving and retransmitting distributors. The sequence of these receiving and retransmitting operations is as follows: Signal No. 1 is transmitted from relay 61 at the time that signal No. 3 is being stored by relay 63; signal No. 2 is transmitted from relay 62 while signal No. 4 is being stored by relay 64; signal No. 3 is transmitted from relay 63 while signal No. 5 is being stored by relay 61; and signal No. 4 is transmitted from relay 64 while signal No. 6 is being stored by relay 62. Thus, it is seen that the process of receiving, storing and subsequently retransmitting each of the signals sent over the line W is continuous. Also, it is apparent that the storage time of the signals is not necessarily fixed. With the apparatus herein provided, this storage time may be decreased to slightly less than one baud or increased to nearly three bauds, depending upon the angular posi-

tion of the transmitting brush 47. It is because of the flexibility of the storage facilities and the provision of means for adjusting the phase of the receiving apparatus independently of the transmitting apparatus that it is possible to retransmit the signals without introducing an appreciable loss due to phase variations of the receiving apparatus. Consequently, a considerable adjustment may be made in the receiving apparatus before it becomes necessary to make a corresponding change in the transmitting apparatus. Obviously, if additional storage facilities are provided, this time may be greatly increased. However, it has been found that good results may be obtained with the storage facilities as shown herein.

The repeater is arranged for duplex operation so that the signals which are transmitted over the line E from a distant station are received by the line relay 100 and by which they may be relayed to a regenerative repeater 101 and thence to the line W. The westbound repeater 101 may be in all respects a duplication of the eastbound repeater shown in detail in the drawings.

The nature of the invention may be ascertained from the foregoing description of an illustrative embodiment, it being understood that changes in the invention herein disclosed may be made within the scope of what is claimed without departing from the spirit of the invention.

What is claimed is:

1. In a device for receiving and retransmitting telegraph signals, rotary receiving and retransmitting apparatus, means responsive to phase deviations of said received signals to advance or retard said receiving apparatus, and means responsive to the average frequency of said received signals to accelerate or decelerate said retransmitting apparatus.

2. In apparatus for receiving from one line telegraph signals distorted as to phase and retransmitting to a second line telegraph signals substantially undistorted as to phase, rotary receiving apparatus associated with said one line, rotary transmitting apparatus associated with said second line, means for controlling said receiving apparatus to maintain substantial synchronism between said received signals and said receiving apparatus, and means for controlling the fundamental speed of said transmitting apparatus in accordance with the average frequency of said received signals.

3. In a regenerative repeater for telegraph signals, rotary receiving and transmitting apparatus, means connected between said receiving apparatus and said transmitting apparatus for simultaneously storing a plurality of said signals, means including said receiving apparatus for relaying said signals to said storing means at variable rates substantially equal to the individual signal periodicity, and means including said transmitting apparatus for retransmitting said signals from said storing means at a uniform rate substantially equal to the average signal periodicity.

4. In a telegraph system, a source of signals, a repeater having rotary receiving and transmitting apparatus, driving means operating substantially at the average speed of said signals to control said receiving and transmitting apparatus, means responsive to phase differences of said signals with respect to said receiving apparatus to adjust the phase of said receiving apparatus relative to said signals without directly changing

the speed of said transmitting apparatus, and means responsive to the average phase adjustments of said receiving apparatus to correspondingly vary the speed of said transmitting apparatus.

5. In a telegraph system, a source of signals, a repeater having rotary receiving and transmitting apparatus, each including a segmented ring and an associated brush, an electric motor operating in substantial synchronism with said received signals, means including said synchronous motor for driving said rotary apparatus, a reversible electric motor, means including said reversible motor for advancing or retarding said receiving apparatus independently of said transmitting apparatus, and means responsive to the average speed of said receiving apparatus for varying the speed of said synchronous motor.

6. In a communication system, a first telegraph circuit, a second telegraph circuit, and regenerative repeating apparatus to relay signals from said first circuit to said second circuit comprising, a rotary device including a receiving element associated with said first circuit and a transmitting element associated with said second circuit, a synchronous electric motor, means including said motor for driving said rotary device, means to control said motor in a manner to vary the phase of only said receiving element relative to the signals of said first circuit, and means to control said motor in a manner to vary the phase of both the receiving and transmitting elements relative to the signals of said first circuit.

7. In a regenerative repeater for telegraph signals, an electric motor operating in substantial synchronism with said signals, rotary receiving and transmitting apparatus driven by said synchronous motor, a stationary brush associated with said receiving apparatus, a movable brush associated with said transmitting apparatus, a reversible electric motor mechanically connected to said synchronous motor in a manner to advance or retard said rotary apparatus and said movable brush with respect to said stationary brush, means responsive to phase deviations of said signals relative to said receiving apparatus for actuating said reversible motor to correct rapidly said phase deviations, and means responsive to the average rotation of said reversible motor to vary the speed of rotation of said synchronous motor.

8. In a telegraph system, a source of signals, a synchronous electric motor having a stator and a rotor and operating in substantial synchronism with said signals, rotary apparatus comprising a receiving ring and a transmitting ring attached to said rotor, a fixed receiving brush associated with said receiving ring, a transmitting brush attached to said stator and associated with said transmitting ring, a reversible direct current motor geared to said stator to alter the phase relation of said receiving ring with respect to said receiving brush without altering the phase relation of said transmitting ring with respect to said transmitting brush, means responsive to phase shifts of said signals with respect to said receiving ring to correctively operate said reversible motor, speed control apparatus for said synchronous motor, and means including said speed control apparatus responding to average movements of said stator to correspondingly alter the speed of said synchronous motor.

9. In a synchronous telegraph system, a distributor comprising, a synchronous electric motor having a stator rotatable with respect to a

stationary structure and a rotor rotatable with respect to said stator, a first sequential contacting device including two relatively movable members, means for linking one of the members of said first contacting device to said rotor to effect relative movement between both members thereof, a second sequential contacting device including two relatively movable members, and means for linking one of the members of said second device to said rotor and the other member of said second device to said stator to produce relative movement between both members thereof.

10. In a synchronous telegraph system, a distributor comprising, a synchronous electric motor having a stator rotatable with respect to a stationary structure and a rotor rotatable with respect to said stator, a pair of cooperating signal receiving distributing elements, one of said receiving elements being fixed in position and the other mechanically linked to said rotor in a manner to be rotated by said rotor, and a pair of cooperating signal transmitting distributor elements, one of said transmitting elements being attached to said stator and the other mechanically linked to said rotor in a manner to be rotated by said rotor.

11. In a synchronous telegraph system, a distributor comprising, a synchronous electric motor having a stator rotatable with respect to a stationary structure and a rotor rotatable with respect to said stator, a pair of cooperating signal receiving distributor elements, one of said receiv-

ing elements being fixed in position and the other attached to said rotor, and a pair of cooperating signal transmitting distributor elements, one of said transmitting elements being attached to said stator and the other attached to said rotor.

12. In a synchronous telegraph system, a distributor comprising, a synchronous electric motor having a stator rotatable with respect to a stationary structure and a rotor rotatable with respect to said stator, signal receiving and signal transmitting segmented rings attached to said rotor, a receiving brush fixedly mounted to cooperate with said receiving ring, and a transmitting brush attached to said stator to cooperate with said transmitting ring.

13. In a synchronous telegraph repeater for receiving signals from a first line, regenerating and retransmitting said signals to a second line, a receiving distributor associated with said first line, means for maintaining synchronism between said receiving distributor and said received signals, means for temporarily storing said received signals, a transmitting distributor associated with said second line, means including said transmitting distributor for retransmitting said stored signals into said second line without fixed phase relationship to said received signals, and means responsive to a difference between the frequency of the retransmitted signals and the average frequency of the received signals for adjusting the speed of the transmitting distributor.

HAKON H. HAGLUND.