

Aug. 22, 1933.

O. E. PIERSON

1,924,050

CORRECTING MECHANISM FOR SYNCHRONOUS APPARATUS

Filed May 15, 1931

4 Sheets-Sheet 1

FIG. 1

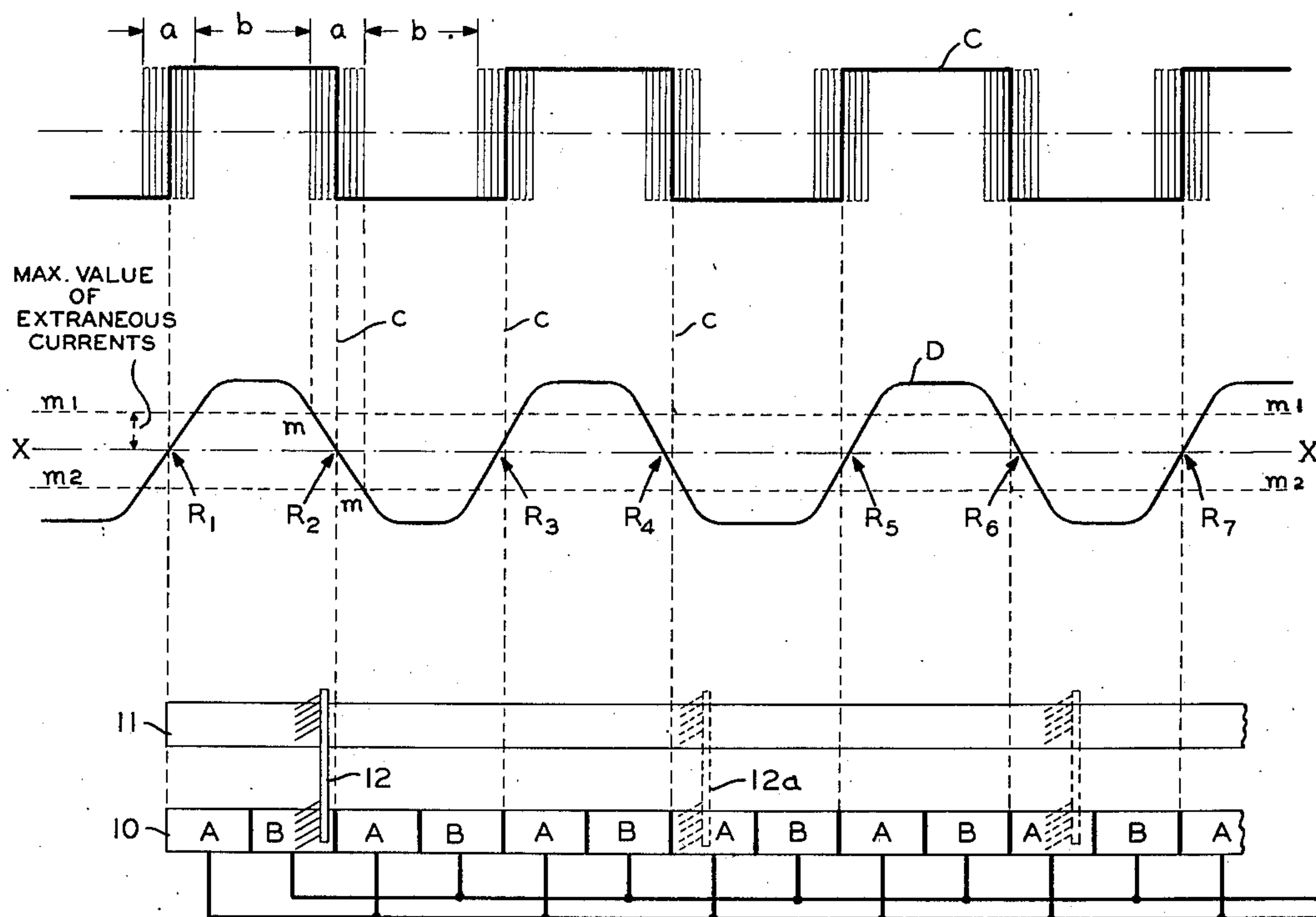


FIG. 3

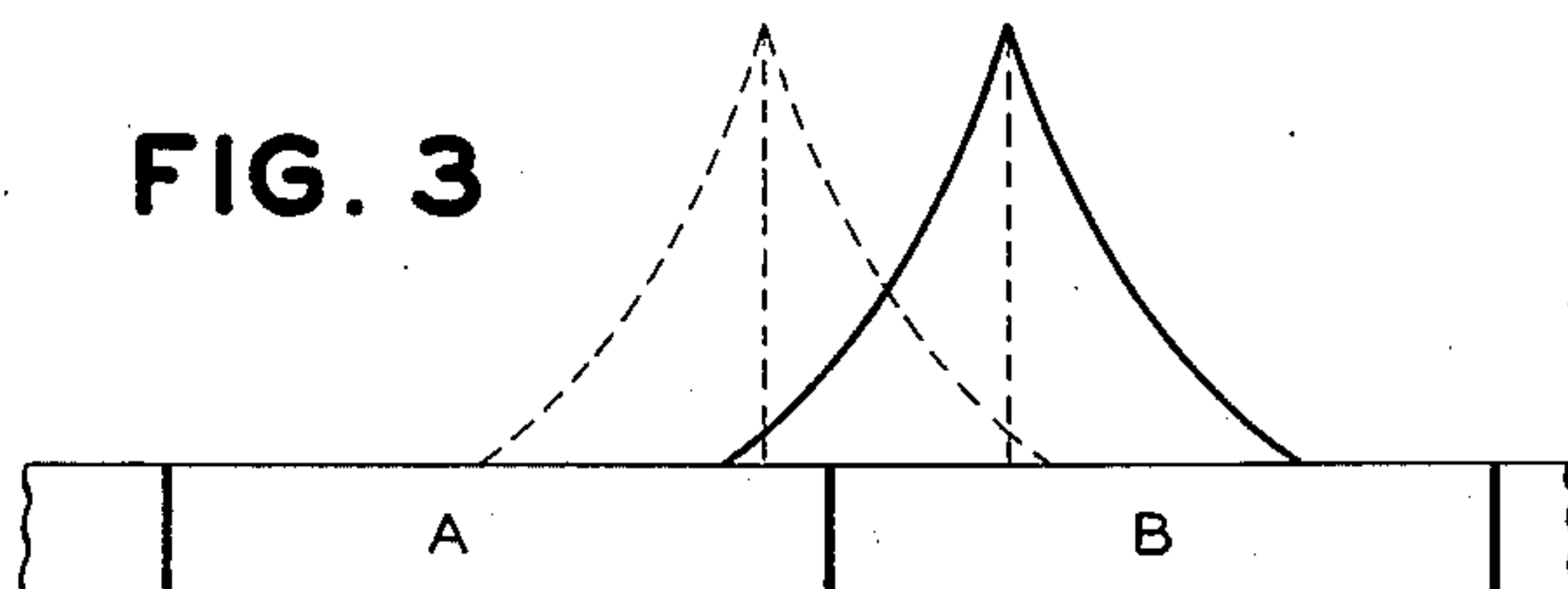
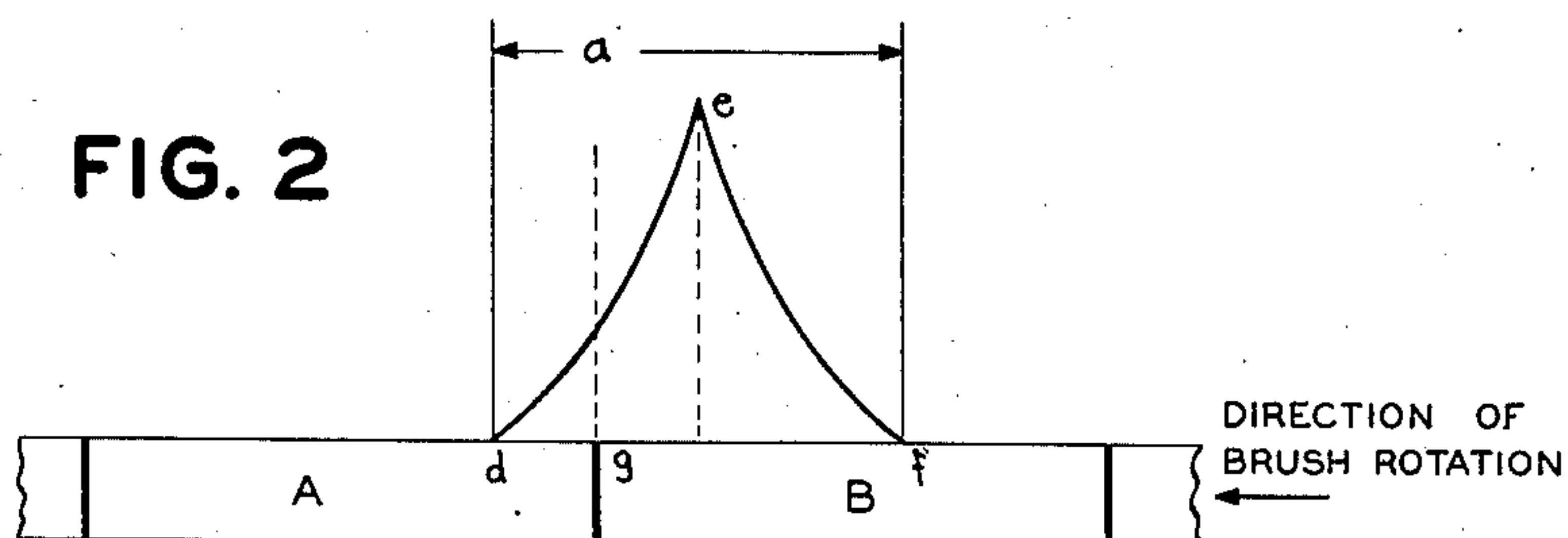


FIG. 2



INVENTOR

O. E. PIERSON

BY *Luis* ATTORNEY

Engel C. Brown

Aug. 22, 1933.

O. E. PIERSON

1,924,050

CORRECTING MECHANISM FOR SYNCHRONOUS APPARATUS

Filed May 15, 1931

4 Sheets-Sheet 2

FIG. 6

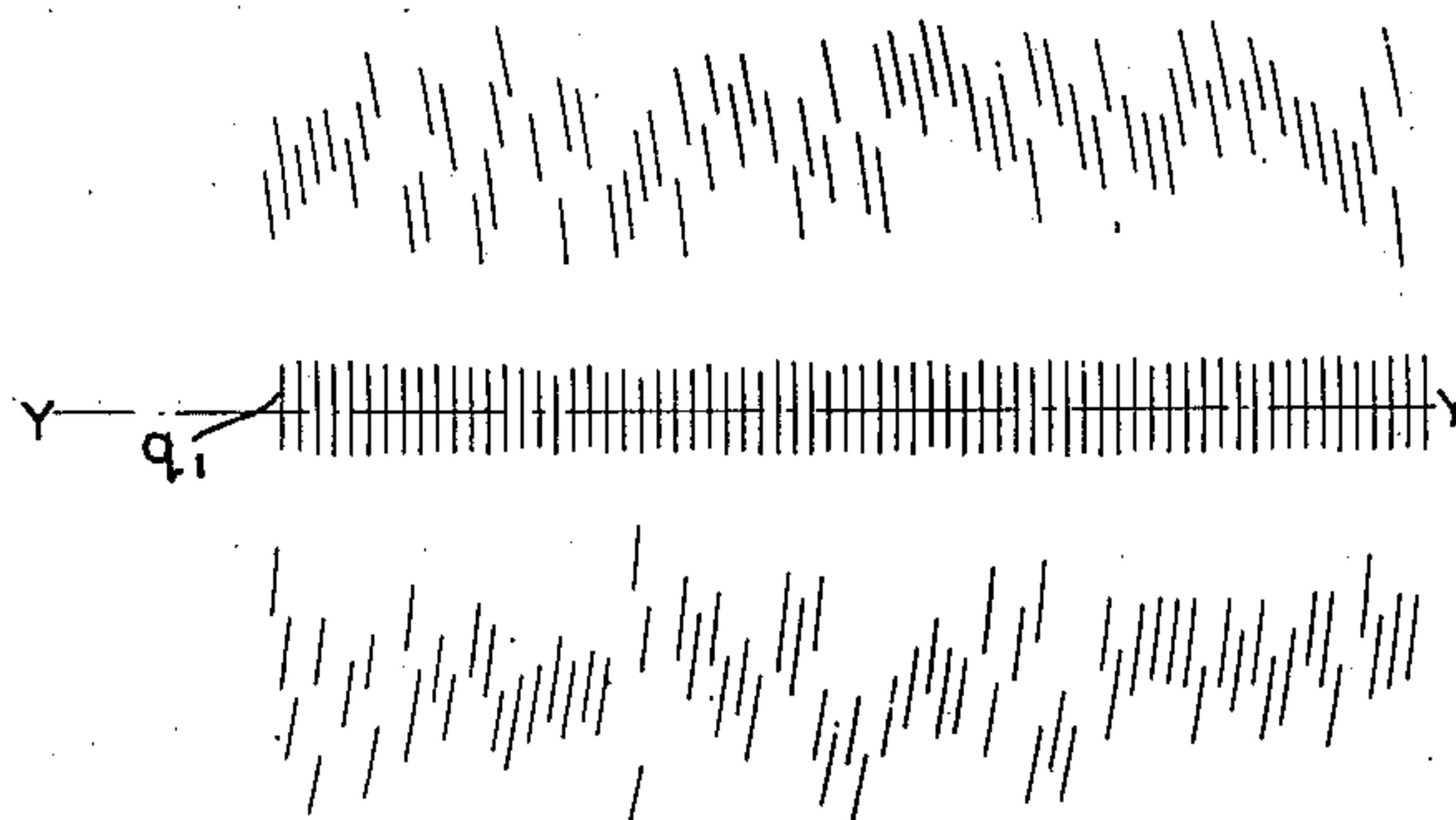
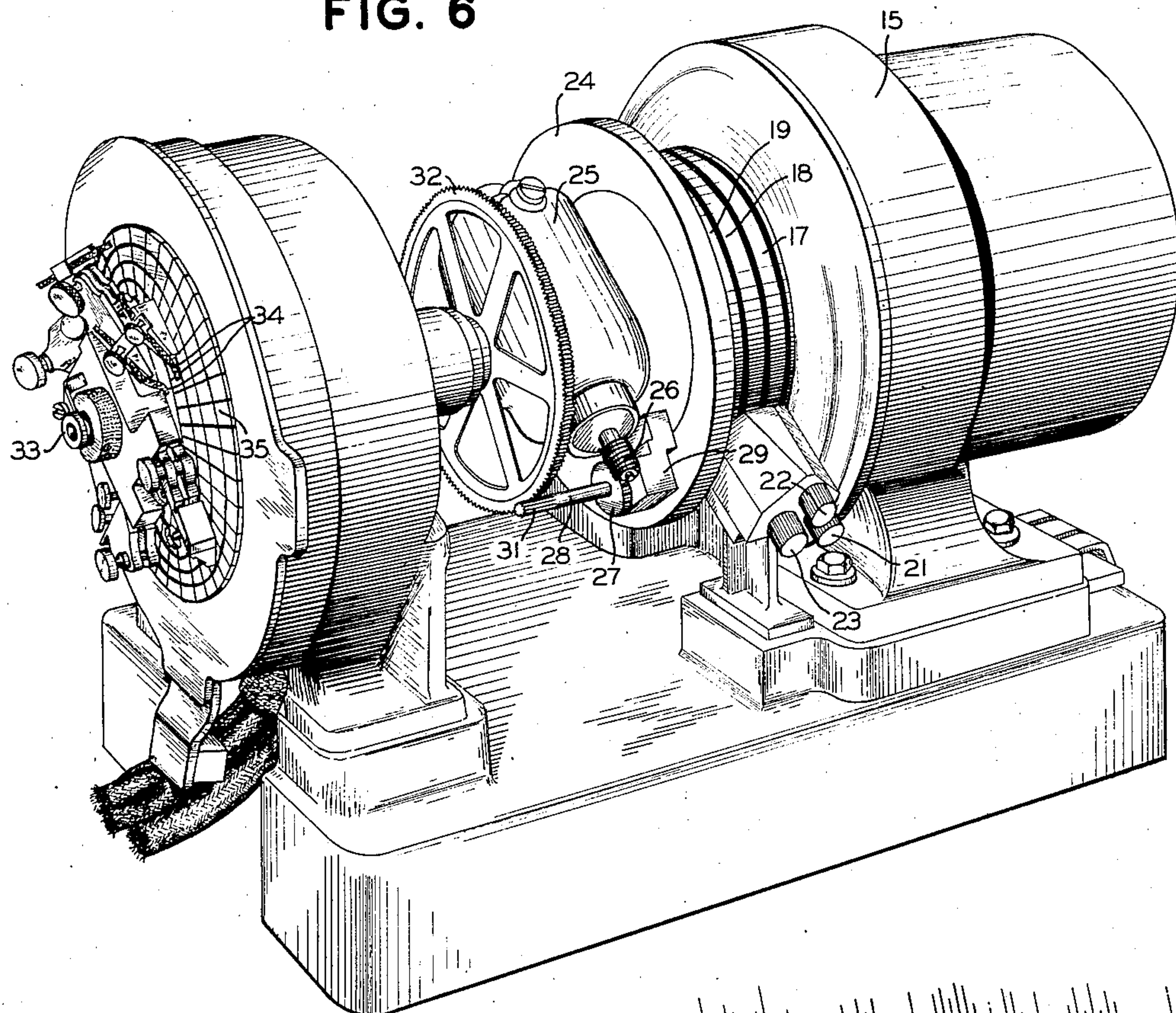


FIG. 4

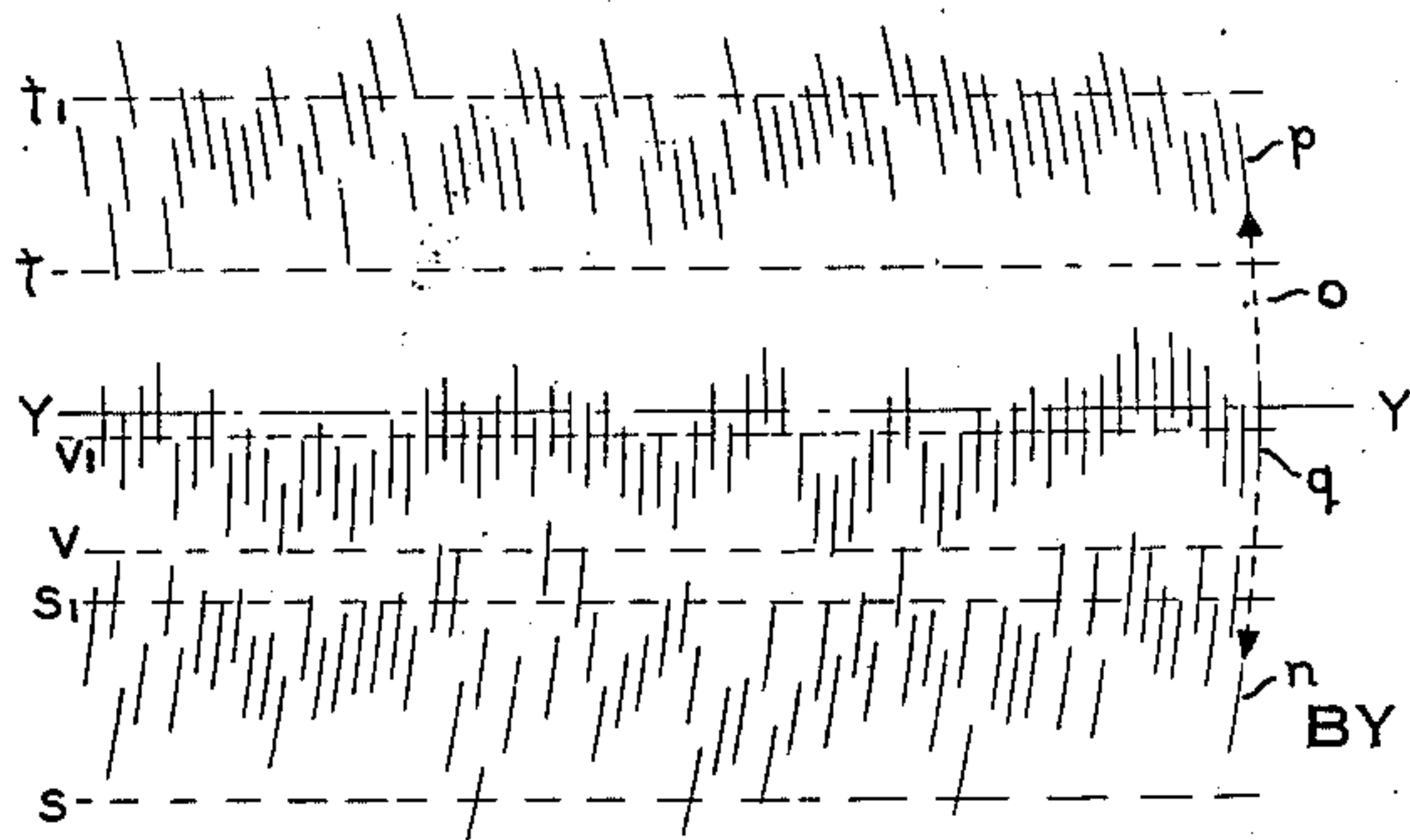


FIG. 5

INVENTOR

O. E. PIERSON

BY *his* ATTORNEY

Eugene C. Brown

Aug. 22, 1933.

O. E. PIERSON

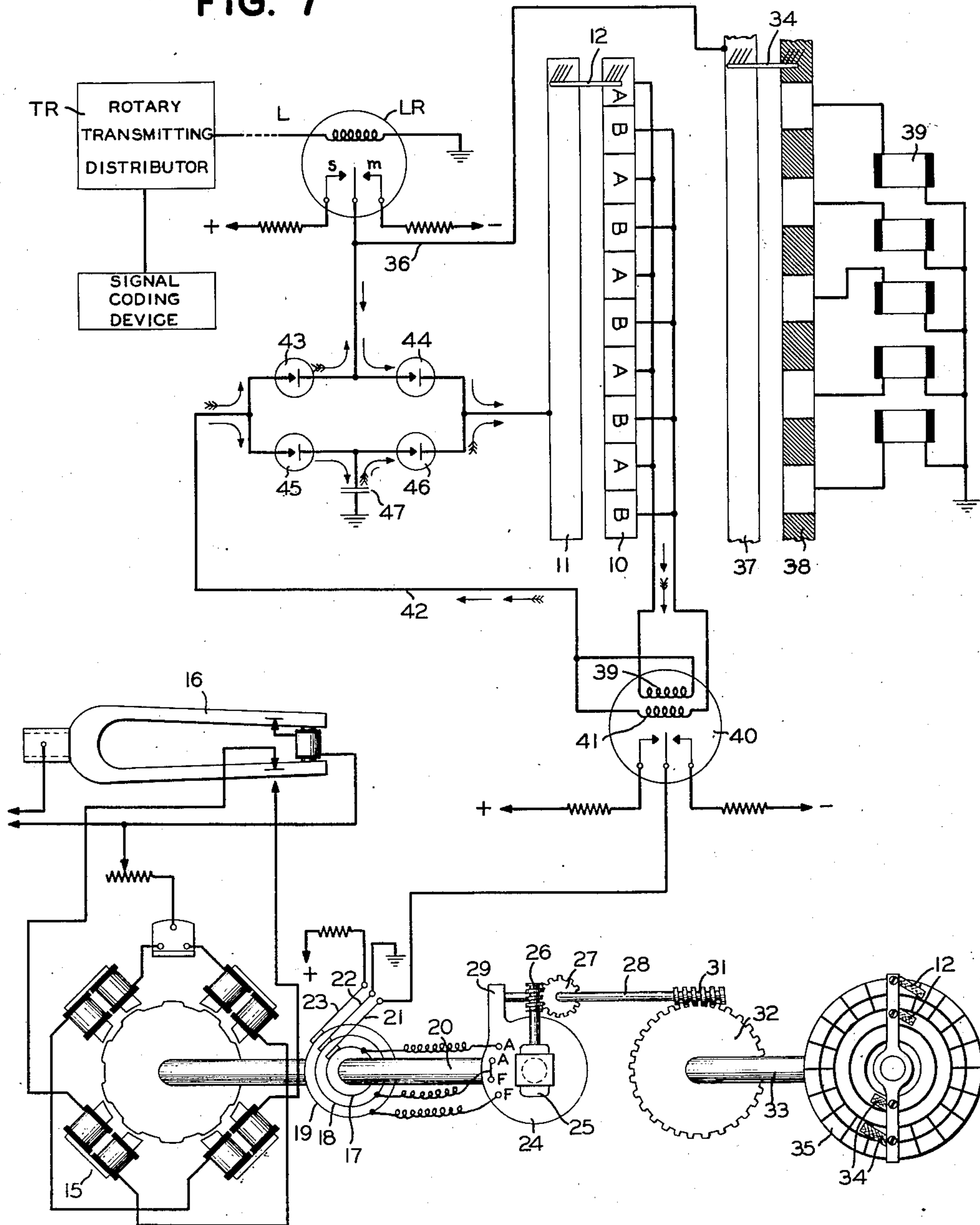
1,924,050

CORRECTING MECHANISM FOR SYNCHRONOUS APPARATUS

Filed May 15, 1931

4 Sheets-Sheet 3

FIG. 7



INVENTOR

O. E. PIERSON

BY *his* ATTORNEY

Engel & Brown

Aug. 22, 1933.

O. E. PIERSON

1,924,050

CORRECTING MECHANISM FOR SYNCHRONOUS APPARATUS

Filed May 15, 1931

4 Sheets-Sheet 4

FIG. 8

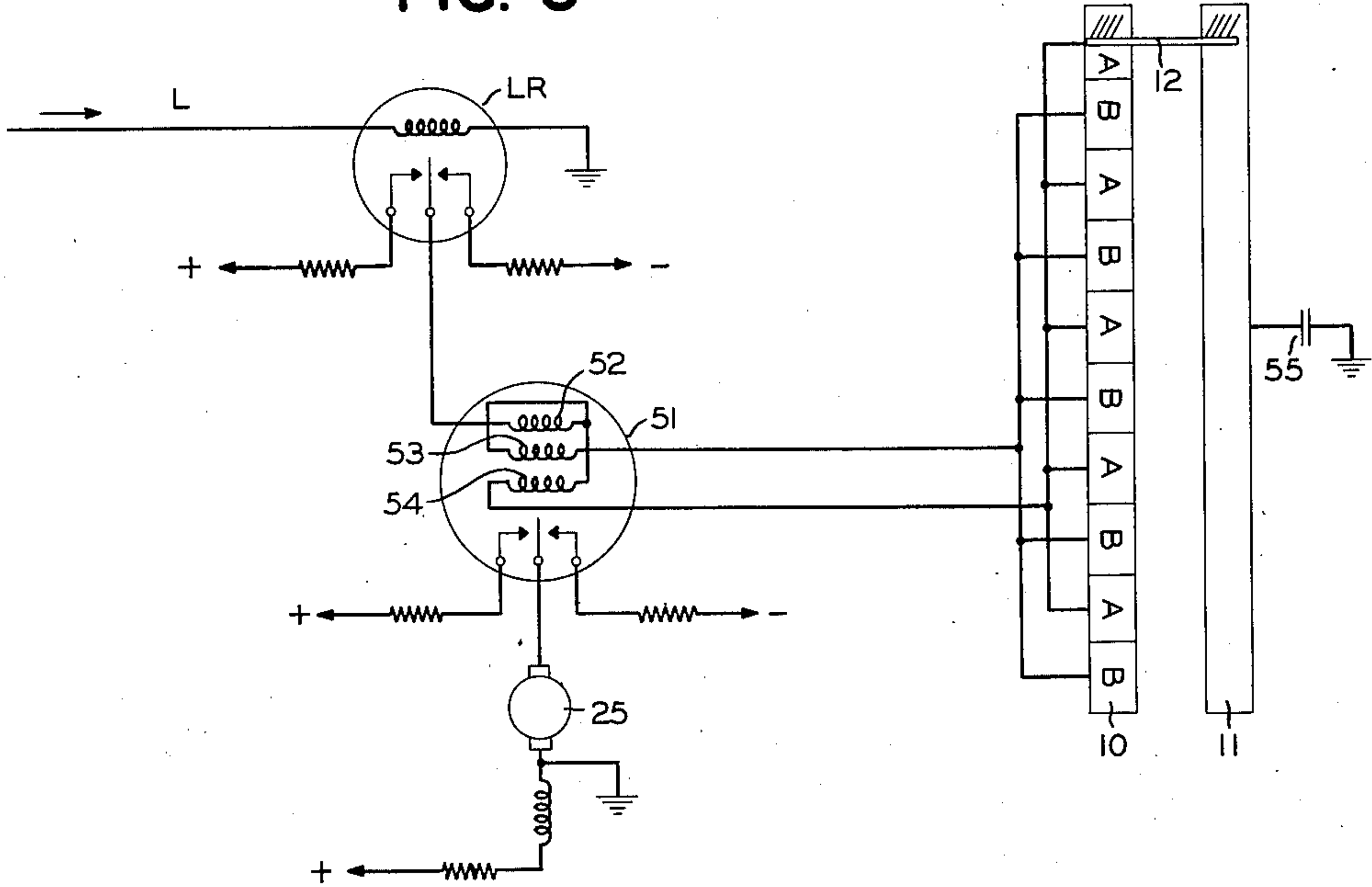
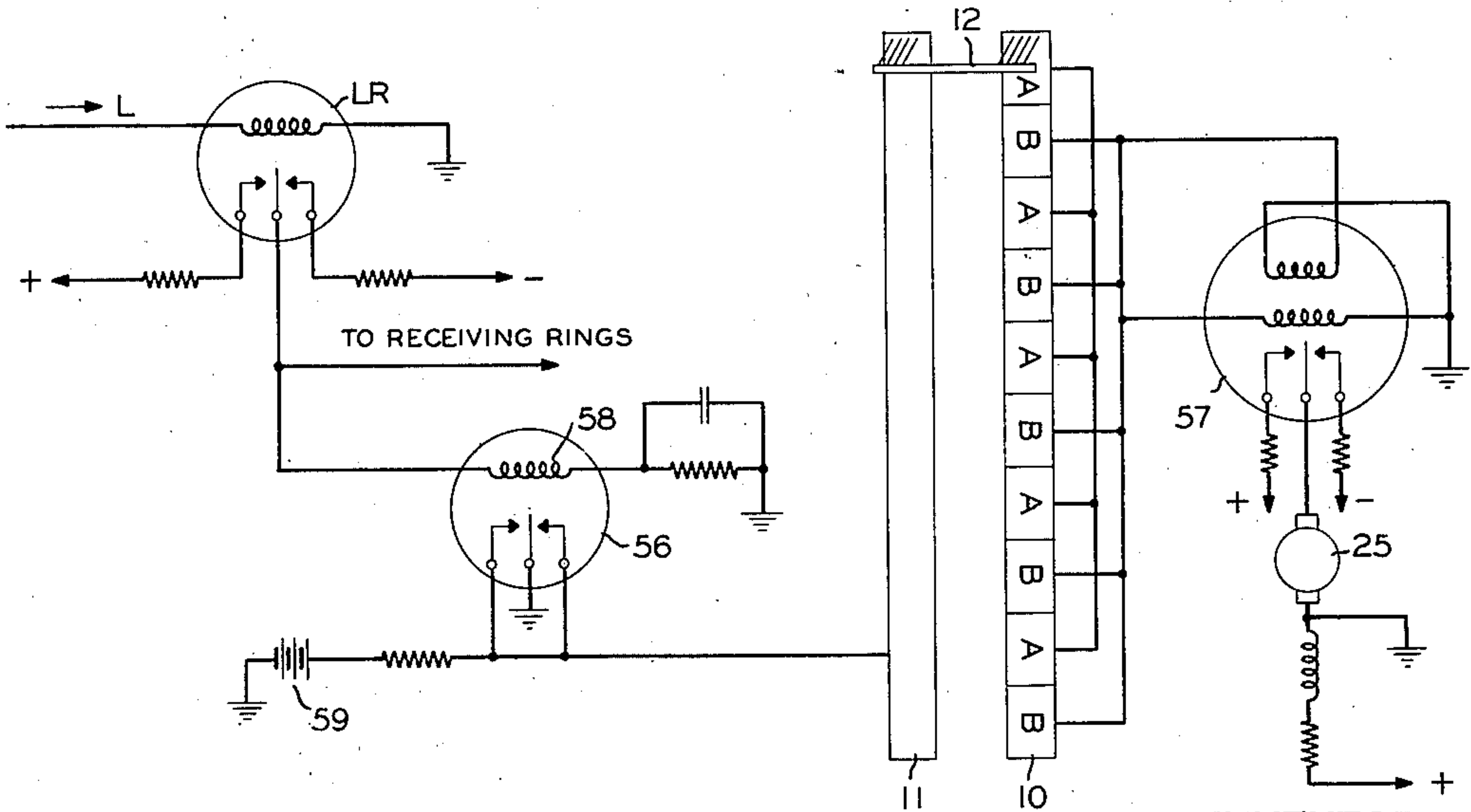


FIG. 9



INVENTOR

O. E. PIERSON

BY *huc* ATTORNEY

Eugene C. Brown

UNITED STATES PATENT OFFICE

1,924,050

CORRECTING MECHANISM FOR SYNCHRONOUS APPARATUS

Oscar E. Pierson, Brooklyn, N. Y., assignor to
The Western Union Telegraph Company, New
York, N. Y., a Corporation of New York

Application May 15, 1931. Serial No. 537,732

19 Claims. (Cl. 178—53)

This invention relates to a method of and apparatus for maintaining synchronism and proper phase relation between rotary transmitting and receiving apparatus located at spaced points. It has particular reference to a high speed printing telegraph system but it is not restricted thereto, the invention also being applicable to picture transmission or television systems and similar installations where it is desired to maintain very exact synchronism between rotary or vibratory parts.

In the synchronizing systems in common use in high speed multiplex telegraphy, the receiving distributor is operated by a constant driving source, such as a fork controlled LaCour motor, which maintains a very nearly constant speed, and a corrector mechanism which operates in conjunction therewith to restore the proper phase relationship between sending and receiving distributors at frequent intervals.

This correction may be applied directly to the driving fork to increase or decrease its frequency as the phase relation varies, but this has not proven satisfactory since there is an appreciable time lag between the application of the correcting influence to the fork and the resultant change in the speed of the motor. Therefore, although the average speed is maintained in correspondence with that of the sending apparatus, the receiving device "hunts" over a limited range of speeds, alternately slowing-up below average and speeding-up above average.

Consequently the preferred practice is to apply the correcting influence directly to the distributor brush shaft by rotating the same either forward or backward with respect to the motor shaft. Practically it has proven more satisfactory with correcting systems as heretofore employed to permit the motor of the receiving distributor to maintain a speed either slightly greater or slightly less than that of the transmitter and to correct, in each instance, by a slight retardation or advancement of the brush shaft relative to the driving motor. Briefly, the correcting mechanism in this latter system comprises a magnet mounted on the motor shaft and revolving with it. Whenever a correction is required the magnet is energized to operate a pawl which, through a small pinion geared to the distributor brush shaft, rotates the brush shaft through a small angle, in practice about $1\frac{1}{2}$ degrees, with respect to the motor shaft. The necessity for effecting the correction is determined by observing the position of the receiving device at each instant of reversal of line current either from positive to

negative or from negative to positive or both, and when the receiving device tends to drift away from its proper position, supplying the energizing impulses to the corrector magnet to mechanically restore the proper phase relation.

These correcting systems which depend upon the use of the instant reversal of individual signal impulses are unreliable for maintaining extremely close phase relationship since the moment of reversal is subject to irregular variations. This irregularity may be attributed mainly to two causes. First, due to the presence of extraneous currents in the telegraph wire and because the receiving relay responds to the joint effect of these extraneous impulses and the actual signalling current, the moment at which the receiving relay responds to a reversal the current will vary over an appreciable element of time. The second type of phase distortion is due to the magnetic characteristic of the relays and is usually referred to as characteristic distortion. The unit impulses are of such short duration in high speed telegraph systems that the magnetism of the relays does not have sufficient time to reach a steady state in response to a single impulse before the succeeding reversal occurs. However, since actual signalling consists of successive transmission of groups of impulses of various lengths and polarities, it follows that during a long impulse of one polarity a condition of steady state may be reached. The moment of response to a change in the polarity, therefore, will be dependent somewhat upon the condition in which the relay was left by the preceding impulse.

The effect of these two causes of phase distortion is to divide the received signals into two parts. One a reliable portion during which it may be safely assumed that the receiving relay is resting firmly on the desired contact, and the other an unreliable portion during which the relay tongue may or may not be resting upon proper contact, depending upon the fortuitous condition of the line and relay magnetism.

Since any single reversal may occur at any point in this unreliable portion of the signal interval it is obvious that the correction will be irregularly influenced thereby. If neither of these causes were present the moment of response of the receiving relay would always bear a constant relation to the moment of transmission at the distant point and any portion of the signal could be used as a reference from which to determine the operation of the corrector mechanism.

Correction which is effected by always setting the distributor brush shaft in one direction is

not efficient since it must necessarily function in response to those reversals which fall at one or the other extremity of the unreliable portion of the signals. If the mechanism is one that operates by retarding the receiving device the reversals which cause it to operate will be those occurring at the most delayed extremity of the unreliable area. This results in a large phase distortion since the edge of the unreliable portion is not a definite point but one which varies constantly with every change in line conditions and with every change in the nature of the signals. The same is true if the correcting device operates by accelerating the receiving device, in which case the other extremity of the unreliable portion will be used for determining the phase correction.

Such systems do not maintain accurate phase relation but permit the receiving apparatus to shift backward and forward relative to the transmitting apparatus, over a range depending upon the fineness of the individual adjustments and the line conditions.

One of the objects of the present invention is to eliminate such phase hunt and to maintain with great exactness synchronism between the transmitting and receiving apparatus at spaced points.

A more specific object is to continuously maintain synchronism by causing the receiving apparatus to operate at exactly the same speed as that of the associated transmitting apparatus, in contrast with those systems in which the receiver runs at a speed inherently different from that of the transmitter and is periodically corrected to synchronism with the transmitter.

Another object is to eliminate false correction of the receiving apparatus due to phase shift of the signals during transmission, to compensate for line bias and other irregular effects.

Another object is to determine the phase relation with respect to the center of the received signals instead of one edge thereof.

Other objects and advantages of the invention will appear from the following description taken in connection with the accompanying drawings and appended claims.

In accordance with one feature of my invention I integrate each reversal that occurs and maintain the phase relation with respect to the average reversal, which will necessarily be at the center of the area over which the reversals occur.

Another feature of the invention resides in the use of an electric motor for adjusting the brush shaft relative to its driving motor, as distinguished from the usual stepping magnet, thereby permitting a continuous adjustment in either direction by infinitesimal increments.

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

Fig. 1 is a diagrammatic illustration of the correcting ring of a receiving distributor, with relation to the transmitted and received signals, showing the unreliable portion of the signals;

Figs. 2 and 3 are graphic representations of the distribution of current reversals within the unreliable portion of the signal, shown with reference to the adjacent segments of the correcting ring;

Fig. 4 is a reproduction of a record taken by a signal testing machine showing the irregularities in the occurrence of the reversals and the phase shift of a distributor corrected in accordance with the edge of the signals;

Fig. 5 is a similar reproduction taken from a

distributor corrected in accordance with the present invention;

Fig. 6 is a perspective view of a receiving distributor embodying one feature of the invention;

Fig. 7 is a diagrammatic illustration of one form of correcting system embodying the invention; and

Figs. 8 and 9 are diagrammatic illustrations of modified forms of correcting circuits.

Referring first to Figure 1, curve C represents a set of block signals, such as might be taken directly from the contacts of the transmitting relay. Curve D represents the form of the line signals or instantaneous value of the received current, in a line containing a number of repeating relays, plotted with respect to time. If there were no disturbing effects on the signals the reversals of polarity of the line signals would occur, in each instance, as the wave D intersected the lines "c" projected from the point of reversal of the transmitted signals. However, due to extraneous currents on the line, which effect the operation of the repeating relays, the reversals may actually occur to one side or the other of the line "c", that is, either prior to or after the theoretically correct instant of reversal.

The distribution of the reversals within the unreliable portion of the signals is far from uniform. An examination of the nature of the various currents which control the receiving relay discloses the reason for this lack of uniformity.

The magnetism of the receiving relay is determined partly by the value of the signaling current and partly by a great number of fortuitous impulses of various intensities due to extraneous effects, such as induction from neighboring circuits, leakage between circuits, improper balance of duplex equipment, etc. As the line current changes from a maximum in one direction to a maximum in the other direction it successively passes through all intermediate values. The slope of the curve in passing from one polarity to the other will depend upon the electrical constants of the circuit.

The extraneous currents may be represented by two lines m_1 — m_1 and m_2 — m_2 , parallel to the X axis of the curve D, one on the positive side and the other on the negative side. The ordinants of these lines represents the maximum values to which the extraneous currents rise.

It is evident that as long as the line current exceeds the maximum value of the extraneous currents, the receiving relay will not be affected thereby. However, as the line current gradually falls towards zero, there will be an appreciable interval of time during which the line current is less than the maximum value of the extraneous currents and during which period the relay will be subject to the control of the extraneous currents.

It will be evident from the curve D that the line relay may respond to extraneous currents between the two points m — m whenever the maximum value of these currents exceeds the line current. The distance "a" between the two points "m," measured along the X axis, will be equal to the unreliable portion of the signal, since the actual response of the line relay to the line reversals may occur anywhere between these two points.

The actual instants of reversals of the preceding repeating relay are indicated at R1 to R7 along the X axis. The unreliable portion of the original signal wave C is represented at "a" and the reliable portion at "b".

The extraneous currents in a telegraph line may be thought of as a great number of small impulses, each one rising to a certain level. It is obvious that only an occasional impulse will reach the maximum level shown by the lines m_1 and m_2 , while successively greater numbers will reach successive levels below the maximum. It is evident, therefore, that the line relay will respond only occasionally at the limits of the unreliable portion since the probability of a maximum extraneous impulse occurring is relatively small. It is obvious that the number of times the relay responds so as to move its armature from one side to the other at any point within the unreliable portion or area of uncertainty, will vary directly as the number of extraneous impulses which can reach the level of the line current at this point. Hence a far greater number of reversals will occur near the center of the area of uncertainty than at its limits, the average of the reversals occurring at the theoretically correct instant of reversal. If the number of reversals that occur within each small element of the area of uncertainty be counted and the result plotted it will appear as shown in the curve $d-e-f$ in Figure 2.

The shape of this curve will not remain constant, its extent along the horizontal axis varying with every variation of line conditions and its height varying with the rate of signaling. A correcting mechanism which is controlled by reversals at the extremity of the area of uncertainty will have a phase stability dependent upon the stability of its extremity. Every variation in the extent or height of the area of uncertainty will result in a corresponding phase variation.

A certain portion of the area must be used to operate the correcting mechanism. This area is graphically represented as that contained between the points "d" and "g" in Figure 2.

The control mechanism of most types of correctors consists in part of pairs of equal segments, the first and second segment of one pair being connected to the first and second segments respectively of every other pair. A typical correcting ring 10 is shown at the bottom of Figure 1 and comprises a plurality of pairs of segments A and B, the A segment being strapped together electrically and the B segments being likewise connected together. A solid ring 11 and a brush 12 cooperate therewith.

In the usual correcting system, in which the brush is retarded to effect a correction, if the distributor brush is rotated in synchronism with the signals, each reversal will always occur while the brush is upon one of the B segments. In this event no correction will be applied. However, if the distributor brush gains relative to the rate of signal transmission so that a reversal occurs while the brush is on one of the A segments, a correcting impulse is produced which acts to set the brush back, relative to the driving motor shaft so as to restore it to the proper B segment. However, if, for example, the reversal does not occur at the theoretically correct instant, that is, at the intersection of the X axis with the lines "c," but prior thereto, even though the brush may have drifted considerably ahead of the signals, it may still be upon the B segment at the time a reversal occurs and consequently no correction will be applied, although at the proper instant of reversal the brush may have passed on to one of the A segments, as indicated in dotted lines at 12a. Due to these irregularities

in the instants of reversal, the brush may creep sufficiently out of phase to require a succession of correcting impulses to restore it.

If the corrector is of the type that operates by retarding the brushes of the receiving device, it is necessary to adjust the speed of the driving mechanism so that the brushes will have a slight tendency to gain in phase with respect to the brushes at the transmitting station. This will cause a slow creep of the area of uncertainty over the segments in the direction of brush rotation. As the area tends to creep on to the forward one or A segment as shown in Figure 2, it will only be able to reach a position such that the proportion of the area that extends over the A segment will just contain the number of reversals necessary to effect the required retardation and it will "hunt" back and forth as the control mechanism attempts to hold that portion of it necessary for compensation, over the segment. Figure 3 illustrates the two extreme positions the area of uncertainty may assume due to variations in line conditions. It is evident, therefore, that since a corrector of this type attempts to hold phase relation with respect to a reference line which is not fixed there will be a phase hunt equal to the variations in the line of reference.

The record illustrated in Figure 4 was taken on an actual line between New York and Boston, by means of a signal testing machine of the general nature shown in patent to Milnor, et al., No. 1,775,687. It shows graphically the variations which occurred in the instants of reversal under actual operating conditions. The revolving stylus of the signal testing machine was rotated across the impregnated tape in unison with the transmitting distributor and the circuits were adjusted so that the stylus marked during the time the tongue of the line relay was off of its contacts, that is, during the travel time of the relay tongue. Consequently upon each sweep of the stylus the mark "n" indicates the period of signal reversal, say from marking to spacing, the portion "o" represents the time the relay tongue remains on its marking contact or the length of the signal and the mark "p" indicates the travel time of the relay from its marking to its spacing contact, or the moment of reversal in the opposite direction. The variations in the spacing of the marks "n" and "p" from the central axis Y indicates the variations in the times of occurrence of the signal reversals.

The portion of the chart between the parallel lines s, s1 and t, t1 respectively, denotes the unreliable portion of the signal and the distance between the lines s1 and t represents the reliable portion. It will be noted that the unreliable portion is about one half of the reliable portion or one third of the entire signal period.

The central row of marks "q" indicates the time of passage of the distributor brush over a particular segment or the time during which the receiving apparatus is connected to the line relay through the receiving segments. If absolute synchronism was maintained the marks "q" would all be symmetrical with respect to the Y axis. The deviation of the marks from this axis indicates the amount of phase hunt. The limits of the phase hunt are indicated by the parallel lines v, v1, which it will be noted, constitutes a considerable portion of the entire reliable signal period. The distance between the lines s1 and t minus the length of the line P (representing the length of the signal received upon the distributor

segments) defines the amount of margin present in the operation of the system.

Obviously if the area of uncertainty overlapped into the range of hunt of the distributor there would be a possibility of a reversal occurring during the time the receiving distributor brush was on a live segment, resulting in false operation.

Figure 5 shows a corresponding diagram obtained with the correcting system of the present invention. The central row of marks q_1 indicates the unusual degree of accuracy with which the distributor brush is maintained in phase, the hunt being substantially entirely eliminated. The margin of speed is greatly increased, thereby permitting a much higher speed of operation or shorter signal impulses without danger of the area of uncertainty encroaching upon the working portion of the signals.

The method and means by which this degree of synchronism is maintained will now be described. In accordance with the present invention the correcting device operates by both retarding and accelerating the receiving device as the need may be and holds the phase relation with respect to the center of the unreliable portion of the signal. Since a change in the extent of the unreliable portion is always accompanied by a corresponding but opposite change in the reliable portion of the signal it follows that by holding the phase relation with respect to the center of the unreliable portion it is effectively maintained with respect to the center of the reliable portion which is the result desired. Moreover, since the number of reversals that occur at the center of the unreliable portion is far more numerous than the number near the extremities thereof for a given element of time, a small change in phase relation with the present type of corrector will produce a much greater response in the control mechanism than will be the case with one which is controlled by reversals at the extremities.

Referring now to Figures 6 and 7, the receiving distributor comprises a driving motor 15 of the LaCour type controlled by a vibrating fork 16, to operate in substantial synchronism with the transmitting distributor. A series of three slip rings 17, 18 and 19 carried by the motor shaft 20 are engaged by brushes 21, 22 and 23 respectively. Also mounted upon the motor shaft is a disc 24 carrying a small direct current motor 25 having one terminal of its armature connected to the slip ring 17, the other armature terminal and one terminal of the field winding being joined to slip ring 18 and the opposite field terminal being connected to ring 19. The motor 25 is adapted to rotate in either direction by reversing the polarity of either its field or armature windings. A worm 26 on the end of the motor shaft meshes with a gear 27 on a stub shaft 28 bearing in a block 29 carried by the disc 24. The free end of the shaft 28 has a pinion 31 engaging with a large gear 32 fixed on the end of the distributor brush shaft 33. The distributor brushes 12 and 34 carried by the shaft 33 rotate across the face plate 35 of the distributor in the usual manner.

The driving force of the LaCour motor 15 is transmitted to the brush shaft 33 entirely through the stub shaft 28 and gear 32, the motor shaft 20 and brush shaft 33 normally rotating in unison.

The brush shaft may be advanced or retarded relative to the motor shaft 20, however, by operating the direct current motor 25 either forward or backward as will be obvious and such relative

adjustment of the brush shaft may occur in infinitesimal increments.

In the modification shown in Figure 7 the incoming line L terminates at a line relay LR by which the received signals are repeated over a conductor 36 to the receiving rings 37 and 38 of the distributor by which they are distributed to the selecting magnets 39 of a receiving printer. Receiving rings 37 and 38 and the correcting rings 10, 11 form part of the face plate 35 and are traversed by the brushes 34 and 12 respectively in substantial synchronism with the transmitting distributor TR, which is disposed at the opposite end of the line L.

The A and B segments of the correcting ring or commutator 10 are shifted slightly with respect to the receiving segments 38 so that the line of division between the B and A segments occurs midway of the dead segments of the ring 38 and when correct phase relation is obtained the correcting brush 12 passes from a B segment to an A segment at each instant reversal.

The A segments are connected to one winding 39 of a polarized relay 40 and the B segments are connected in a reverse direction to the other winding 41 of the relay. The opposite terminals of the windings 39 and 41 are joined by conductor 42 to one terminal of a rectifying bridge comprising four unilateral devices 43, 44, 45 and 46 of any suitable type, such as copper-oxide rectifiers. The opposite terminal of the rectifying bridge is joined to the solid correcting ring 11. The rectifiers are arranged for conduction from left to right as viewed in Figure 7 and the midpoint between the rectifying elements 43 and 44 is connected to the tongue of the line relay, the opposite intersection being grounded through condenser 47.

The contacts of the relay 40 are connected to battery of opposite polarity and the tongue is connected to the slip ring 17 through the brush 21. Brush 22 of the slip ring 18 is grounded and brush 23 is connected to positive battery. Consequently, the field current is maintained continuously in one direction and the armature current reversed through the contacts of the relay 40.

The operation of the system is as follows. Assuming a reversal to occur from negative to positive, the tongue of line relay LR will engage its spacing contact "s", completing a circuit from positive battery through a path indicated by the plain arrows and including the rectifier 44, solid ring 11, brush 12, one of the segments, A or B, depending on the position of the brush 12 at the instant of reversal, then through one winding, 39 or 41, of the relay 40, conductor 42, rectifier 45 and condenser 47 to ground. Due to the action of the condenser 47 this current flow is only momentary but of relatively high amplitude throwing the tongue of relay 40 to one of its contacts or the other depending upon the winding energized. This momentary current flow is necessary since it is the position of the brush 12 at the instant of reversal that determines the corrector adjustment. If the brush was on a B segment at the time of the reversal the winding 41 would be energized moving the relay tongue to its negative contact and rotating the motor 25 in a direction to advance the brushes 12 and 34 relative to the motor driving shaft 20. If the reversal had occurred with the brush on an A segment the winding 39 would have been energized, thus reversing the direction of the correcting motor 25 to retard the brush. The constant tendency is to shift the brush in such a direction

as to maintain it at the junction of the B and A segments at the time of reversal of the signals.

Upon the next reversal from positive to negative the tongue of the line relay returns to its marking contact "m" completing a circuit indicated by the feathered arrows. This circuit extends from ground through the condenser 47, rectifier 46, rings 11 and 10, relay windings 39 or 41, conductor 42, rectifier 43 and marking contact of the line relay LR to negative battery. It will be noted that the direction of the impulse through a particular winding of the relay 40 is in the same direction irrespective of whether the reversal of the line signal is from negative to positive or from positive to negative. Hence every reversal of line current is used to effect a correction. This is in contrast to the correcting systems in which only the reversals in one direction are employed for correction purposes.

If successive reversals fell on the segments A and B alternately, the motor 25 would merely vibrate back and forth equally in each direction without appreciably affecting the adjustment of the brush shaft. However, if for any reason the brush tends to drift out of phase, as for instance due to a temporary variation in the speed of the driving motor 15, so that more reversals occur with the brush on the A segment, the positive battery supplied to the motor will preponderate over the negative battery supplied thereto and the motor will rotate in such a direction as to retard the brush until the number of reversals occurring on each of the A and B segments will be the same.

The effect of this arrangement is to maintain phase relation between the brushes 12, 34 and the average period of the signals, such that the average reversal, which occurs in the center of the unreliable portion, will occur when the brush is at the junction between the B and A segments. The effect of this on the tongue of the relay 40 will be to move it neither to the right nor left. Actually the relay 40 will flutter from right to left and each reversal that occurs will have its effect on the speed of the motor.

This action is equivalent to integrating all of the reversals that take place and only affecting the motor 25 by an extent proportional to the difference between the number of reversals that fall on each of the pairs of segments. It is evident, therefore, that one-half of the unreliable area must lie on the first or B segment and the other half on the second or A segment. A very slight tendency to alter this relation results in immediate response in the motor tending to restore the relation.

In Fig. 8 a modification is shown employing a relay 51 of special construction. This relay is of the polar type but without the permanent magnet used in all types of polar relays. The relay may be either of the type having an electromagnet in place of the usual permanent magnet or it may be a standard polar relay adapted for the present purpose by removing the permanent magnet and reversing the connections to one of its coils so that this coil will function as a magnetizing coil. Coil 52 serves this purpose. Coils 53 and 54 are two equal operating coils connected in such direction that if the brush 12 is on the B segment when the relay LR reverses the resulting flow of current into the condenser 55 connected, to the brush 12 through the solid ring 11, will tend to move the tongue of the relay 51 to the right, thereby actuating the motor 25, to accelerate the brush relative to its driving shaft. If the brush 12 is on one of the A seg-

ments when the reversal occurs, the flow of current into the condenser will be through the winding 53, thus moving the relay tongue to the right, thereby actuating the motor 25 to decrease the brush speed.

It will be noted that due to the substitution of an electrical source of magnetism for the usual permanent magnet, the action of relay 51 is independent of whether the reversal is from positive to negative or negative to positive, always being to the left if the reversal occurs on the A segment and to the right if the reversal occurs on the B segment.

In Fig. 9 a further modification is disclosed employing two polar relays 56 and 57, the first responding to the reversals of either direction, repeated by the line relay LR, to supply impulses of uniform direction to the relay 57. The tongue of the line relay is connected through the winding 58 of relay 56 to ground. The contacts of the relay 56 are both connected to a grounded battery 59 and to the solid correcting ring 11. The tongue of the relay 56 is grounded. The A and B segments are connected, respectively, to the oppositely disposed windings of the relay 57 and thence to ground. The tongue of the relay 57 controls the reversal of the current to the motor 25 in the manner described in connection with Fig. 7. When the tongue of the relay 56 is on either contact, the battery 59 is grounded and the windings of the relay 57 are short circuited. When a reversal occurs the tongue of the relay 56 leaves one of its contacts and travels to the other. During the time the tongue is off of both contacts current flows from the battery 59 through either an A or a B segment of the correcting ring to one winding of the relay 57, depending upon whether the reversal occurs prematurely or whether it occurs after its natural period. The motor 25 is thus caused to rotate either forward or backward depending upon the out-of-phase condition of the brush 12. This operation occurs regardless of the direction of travel of the tongue of the relay 56, that is, irrespective of whether the reversal is from negative to positive or from positive to negative.

While the foregoing description has illustrated the correcting motor as mounted on the receiving device and turning with it, this is not an essential feature of the invention. The principles of phase control described herein apply equally well if the motor is mounted outside the rotary receiving device and is made to alter the phase relation of the brushes by other mechanisms or it may act directly upon the driving coils of the motor so as to shift them to effect the adjustment in the phase relation of the brushes relative to the signals.

Therefore, I do not desire to be limited to the specific arrangement shown and described but contemplate all modifications which come within the scope of the appended claims.

What I claim is:

1. In a signal system having a source of current reversals, a method of integrating every reversal to obtain the relative position of the average reversal comprising producing an electrical impulse of short duration and uniform direction in definitely timed relation to each reversal, utilizing said impulses which occur in advance of the average position to supply current of one polarity to a circuit, utilizing the impulses occurring at the other side of the average position to supply current of the opposite polarity to said circuit, current of only one polarity being sup-

plied at a time through said circuit and controlling an indicating device by the current in said circuit.

2. In a signal system having a rotary apparatus and a source of current reversals, the method of
5 maintaining substantially uniform speed of said rotary apparatus in synchronism with the position of the average of said reversals comprising producing an electrical impulse of short duration and uniform direction in definitely timed relation to each reversal, utilizing said impulses which
10 occur in advance of the average position to supply current of one polarity to a circuit, utilizing the impulses occurring at the other side of the average position to supply current of the opposite polarity to said circuit, current of only one
15 polarity being supplied at a time through said circuit, and adjusting the phase position of said rotary apparatus by the average current in said circuit.

20 3. In a telegraph system, a receiving rotary apparatus, a source of signals, driving means for said rotary apparatus operating in substantial synchronism with said signals and an electric motor mounted to rotate bodily with said driving
25 means and having its rotating parts associated with said rotary apparatus so as to revolve the same in a gradual manner relative to the driving means.

30 4. In a telegraph system, a receiving rotary apparatus, a source of signals, driving means for said rotary apparatus operating in substantial synchronism with said signals and an electric motor mounted to rotate bodily with said driving
35 means and having its rotating parts geared to said rotary apparatus so as to accelerate or retard the same by infinitesimal steps relative to said driving means.

40 5. In a telegraph system, a receiving rotary apparatus, a source of signals, driving means for said rotary apparatus operating in substantial synchronism with said signals and an electric motor mounted to rotate bodily with said driving
45 means and having its rotating parts geared to said rotary apparatus so as to accelerate or retard the same relative to said driving means, by infinitesimal steps, and means for applying operating current to said motor at any instant in a direction depending upon the phase relation of
50 said rotary apparatus with respect to said signals.

55 6. In a telegraph system a receiving rotary apparatus, a source of signals consisting of two different line conditions of irregular duration, driving means for said rotary apparatus, operating in substantial synchronism with said signals,
60 an electric motor associated with said rotary apparatus so as to rotate the same in a gradual manner relative to the driving means to apply a corrective movement thereto, to compensate for deviation in the phase position of said rotary apparatus, and means responsive to each reversal of said signals for determining the direction of phase correction.

65 7. In a telegraph system a receiving rotary apparatus, a source of signals consisting of two different line conditions of irregular duration, driving means for said rotary apparatus operating in substantial synchronism with said signals, means associated with said rotary apparatus for rotating the same in a gradual manner relative
70 to the driving means to apply a gradual corrective movement thereto to compensate for deviation in the phase position of said rotary apparatus, and means responding to each reversal of said signals for determining the direction of the phase
75 correction.

8. In a telegraph system a receiving rotary apparatus, a source of signals consisting of two different line conditions of irregular duration, driving means for said rotary apparatus operating in substantial synchronism with said signals, means associated with said rotary apparatus for accelerating or retarding the same by infinitesimal steps, relative to said driving means, and means responding to each reversal of said signals for determining the direction of said adjustment at any instant. 80 85

9. In a signaling system a source of periodic signals, a rotary apparatus operating in substantial synchronism with said signals, means acting in response to each reversal of said signals for producing electrical impulses of short duration and uniform direction, a commutator operating in unison with said rotary apparatus and having at least one pair of segments, means for transmitting said impulses through one or the other of said segments of said pair depending upon the position of the rotary apparatus at the time said impulses occur, and means for adjusting the phase relation of said rotary apparatus and said signals either forward or backward depending upon whether said impulses are transmitted through one of said segments or the other. 90 95 100

10. In a signaling system a source of periodic signals, a rotary apparatus operating in substantial synchronism with said signals, means for adjusting the phase relation of said rotary apparatus with respect to the average period of said signals comprising a distributor operating in unison with said rotary apparatus, a relay responsive to the polarity of said signals, and means connected electrically intermediate said relay and distributor for producing impulses of short duration and uniform polarity for each reversal of said signals, said distributor distributing said impulses to the phase adjusting means selectively in accordance with the phase position of said signals relative to said rotary apparatus. 105 110 115

11. In a signaling system a source of periodic signals, a rotary apparatus operating in substantial synchronism with said signals, means for adjusting the phase relation of said rotary apparatus with respect to the average period of said signals comprising a distributor operating in unison with said rotary apparatus, a relay responsive to the polarity of said signals, and a unilateral conducting bridge connected intermediate the tongue of said relay and said distributor for producing impulses of short duration and uniform polarity for each reversal of said signals, said distributor distributing said impulses to the phase adjusting means selectively in accordance with the phase position of said signals relative to said rotary apparatus. 120 125 130 135

12. In a signaling system, a source of periodic signals, a rotary apparatus operating in substantial synchronism with said signals, means for adjusting the phase relation of said rotary apparatus relative to the average period of said signals, comprising a distributor operating in unison with said rotary apparatus, said distributor having a plurality of pairs of segments, a relay having windings acting oppositely upon the tongue of the relay, the corresponding segments of each pair being connected to one winding of said relay and the remaining segments of each pair being connected to the opposite winding, means for supplying impulses of uniform polarity to one or the other of said windings through its corresponding segments, depending upon the po- 140 145 150

sition of the distributor brush at the instant a reversal occurs in said signals, and means responsive to the position of said relay for adjusting the phase relation of said rotary apparatus either forward or backward.

13. In a signaling system, a source of periodic signals, a rotary apparatus operating in substantial synchronism with said signals, means for adjusting the phase relation of said rotary apparatus relative to the average period of said signals, comprising a distributor operating in unison with said rotary apparatus, said distributor having a plurality of pairs of segments, a relay having windings acting oppositely upon the tongue of the relay, the corresponding segments of each pair being connected to one winding of said relay and the remaining segments of each pair being connected to the opposite winding, a rectifying system in circuit with said source of signals and having a common unidirectional path for signals of each polarity, said distributor segments and relay windings being included in said path whereby impulses of uniform polarity are applied to one or the other of said windings depending upon the position of the distributor brush when a reversal occurs in said signals, and means responsive to the position of said relay for adjusting the phase relation of said rotary apparatus either forward or backward.

14. In a synchronizing system, a source of periodic signals, a rotary apparatus operating in substantial synchronism with said signals, a correcting system for said rotary apparatus comprising a relay having oppositely disposed windings in circuit with said source of signals, each winding acting upon the tongue of the relay oppositely in response to signals of either polarity, a correcting ring, a brush transversing said ring in unison with said rotary apparatus, the position of said brush at the instant of each reversal determining the operating winding of said relay, whereby the relay tongue will be moved to one contact or the other depending upon the phase position of each reversal relative to the rotary apparatus, and phase correcting means selectively controlled by the position of said relay contact.

15. In a synchronizing system, a synchronous distributor, a source of signal impulses, means for producing a correcting impulse in response to each reversal in polarity of said signal impulses, an electromagnetic device having two oppositely disposed coils, means for distributing said correcting impulses directly to one or the other of said

coils depending upon the phase relation of the corresponding reversal, and means associated with said electromagnetic device for advancing or retarding said distributor depending upon the particular coil energized.

16. In a synchronizing system, a synchronous distributor, a source of signal impulses, means for producing a correcting impulse in response to each reversal in polarity of said signal impulses, a relay having oppositely disposed windings, means for distributing said correcting impulses directly to one or the other of said windings depending upon the phase relation of the corresponding reversal, a motor operable in opposite directions for accelerating or decelerating said distributor, and means for supplying current of one polarity to the motor when the relay is on one of its contacts and for supplying current of the opposite polarity to the motor when its tongue is on the opposite contact.

17. In a synchronizing system, a synchronous distributor, a source of signal impulses, means for producing a correcting impulse in response to reversals in polarity of said signal impulses, a motor for accelerating or decelerating said distributor and a relay responsive to each correcting impulse and operable to supply current of opposite polarities to said motor whereby to reverse the direction of rotation thereof.

18. In a synchronizing system, a synchronous distributor, a source of signal impulses, means for producing a correcting impulse in response to reversals in polarity of said signal impulses, a relay responsive to individual correcting impulses and operable to one side or the other depending upon the time of occurrence of said individual impulses relative to an average position and means controlled by said relay for accelerating or decelerating said distributor.

19. In a synchronizing system, a synchronous distributor, a source of signal impulses, means for producing a correcting impulse in response to reversals in polarity of said signal impulses, a relay responsive to individual correcting impulses and operable to one side or the other depending upon the time of occurrence of said individual impulses relative to an average position, a motor for accelerating or decelerating said distributor, said relay acting to supply current of one polarity to the motor, when actuated to one of its contacts, and to supply current of the opposite polarity to the motor when actuated to its other contact.

OSCAR E. PIERSON.