

May 26, 1931.

H. ANGEL ET AL

1,807,368

METHOD OF AND APPARATUS FOR OPERATING CABLE TELEGRAPH SYSTEMS

Filed March 30, 1929

9 Sheets-Sheet 1

Fig. 1.

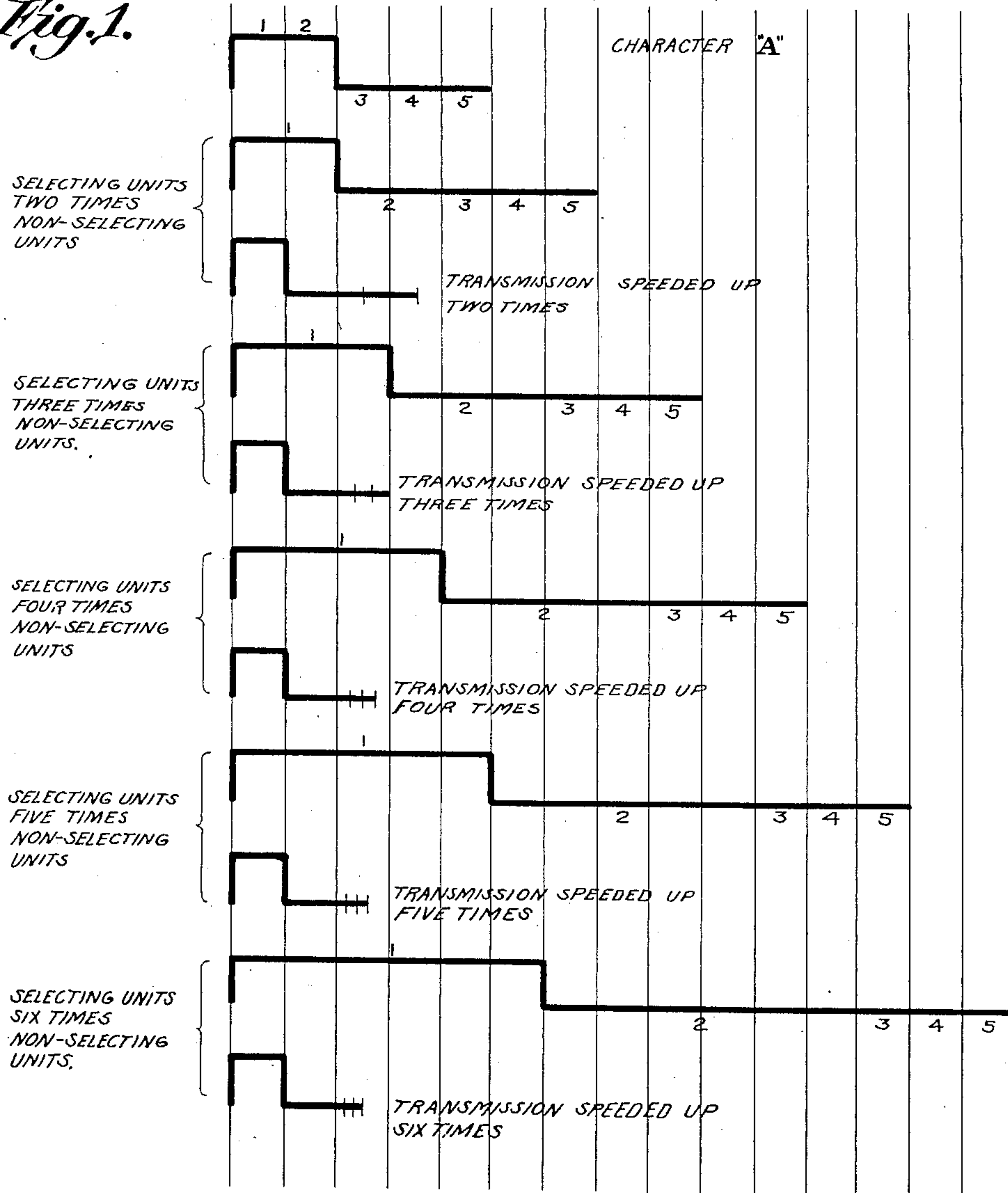
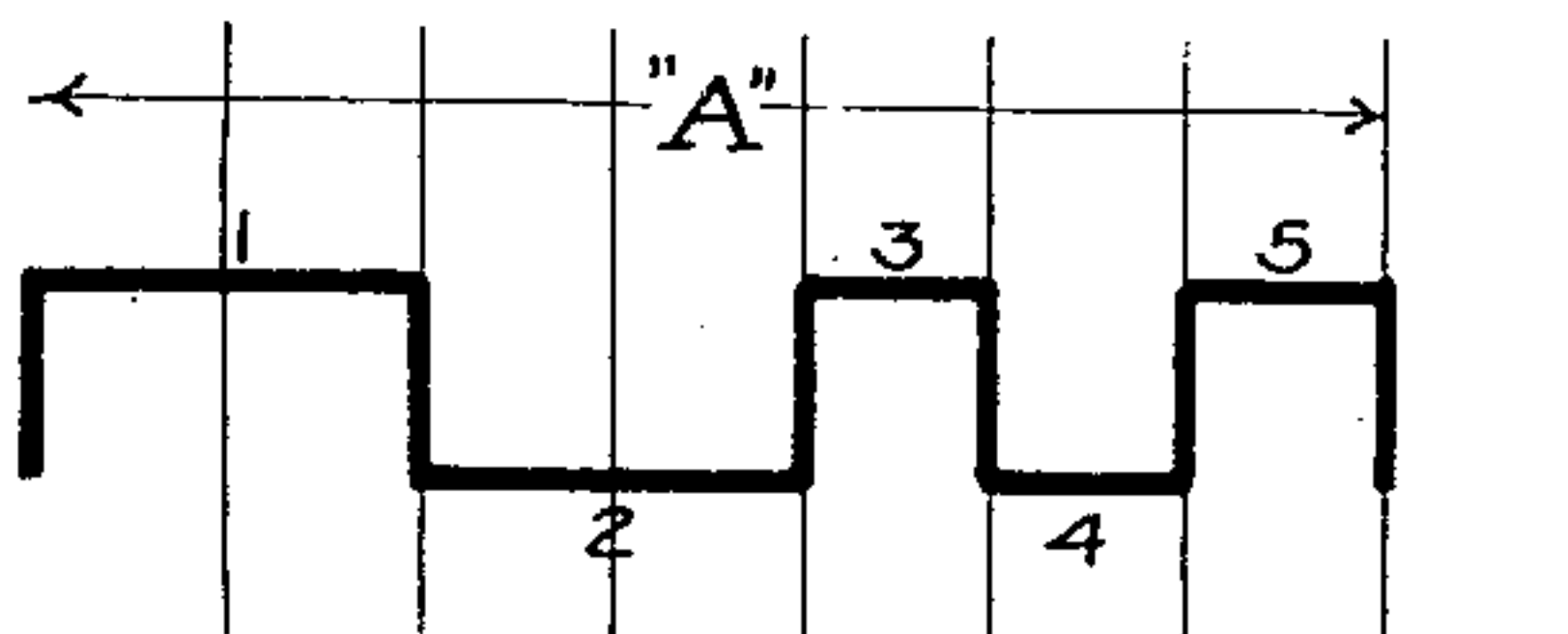


Fig. 2.



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9 Sheets-Sheet 2

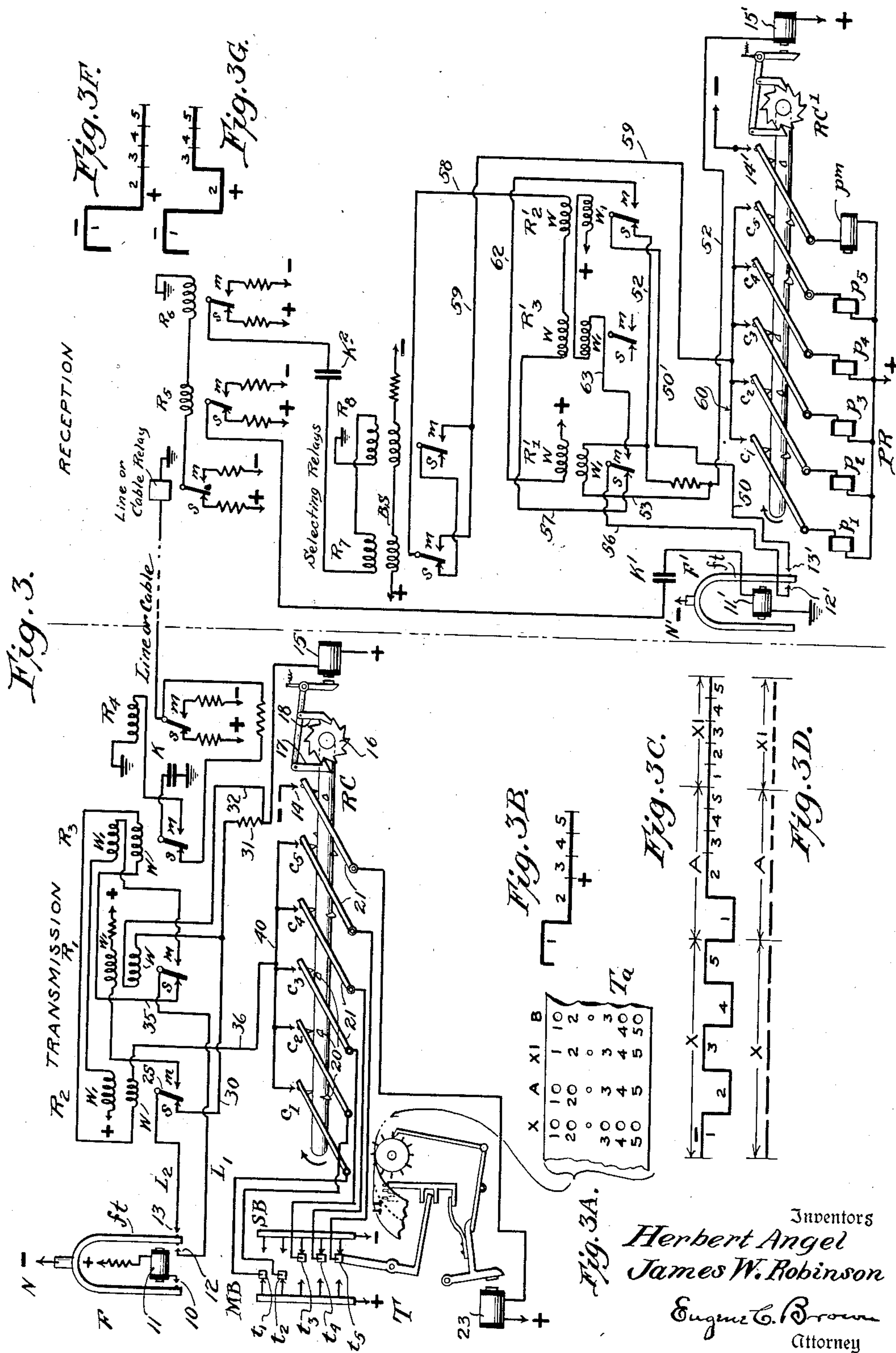


Fig. 3F.

Fig. 3G.

Fig. 3B.

Fig. 3C.

Fig. 3D.

Fig. 3A.

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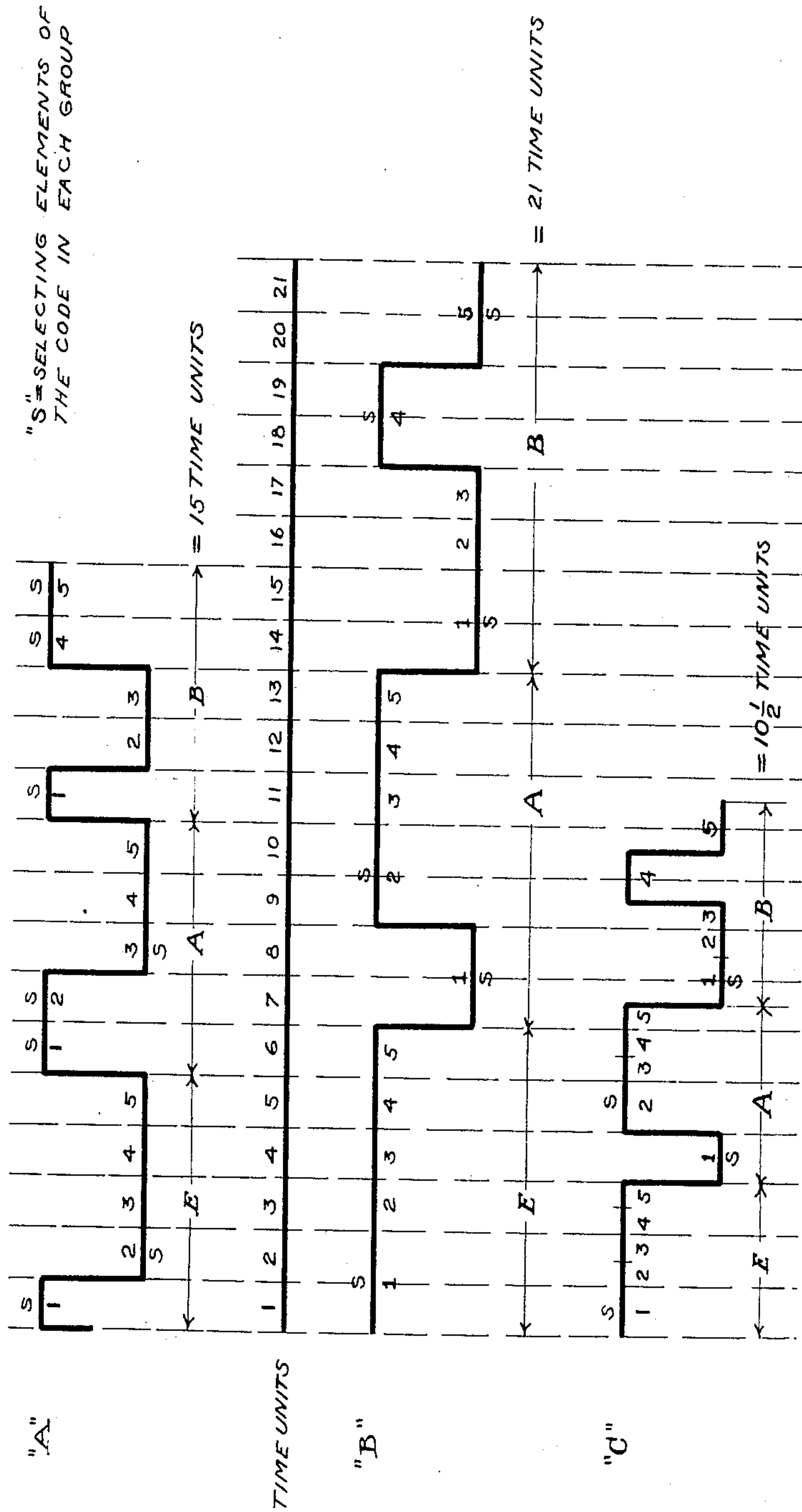
1,807,368

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Filed March 30, 1929

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Fig. 4.



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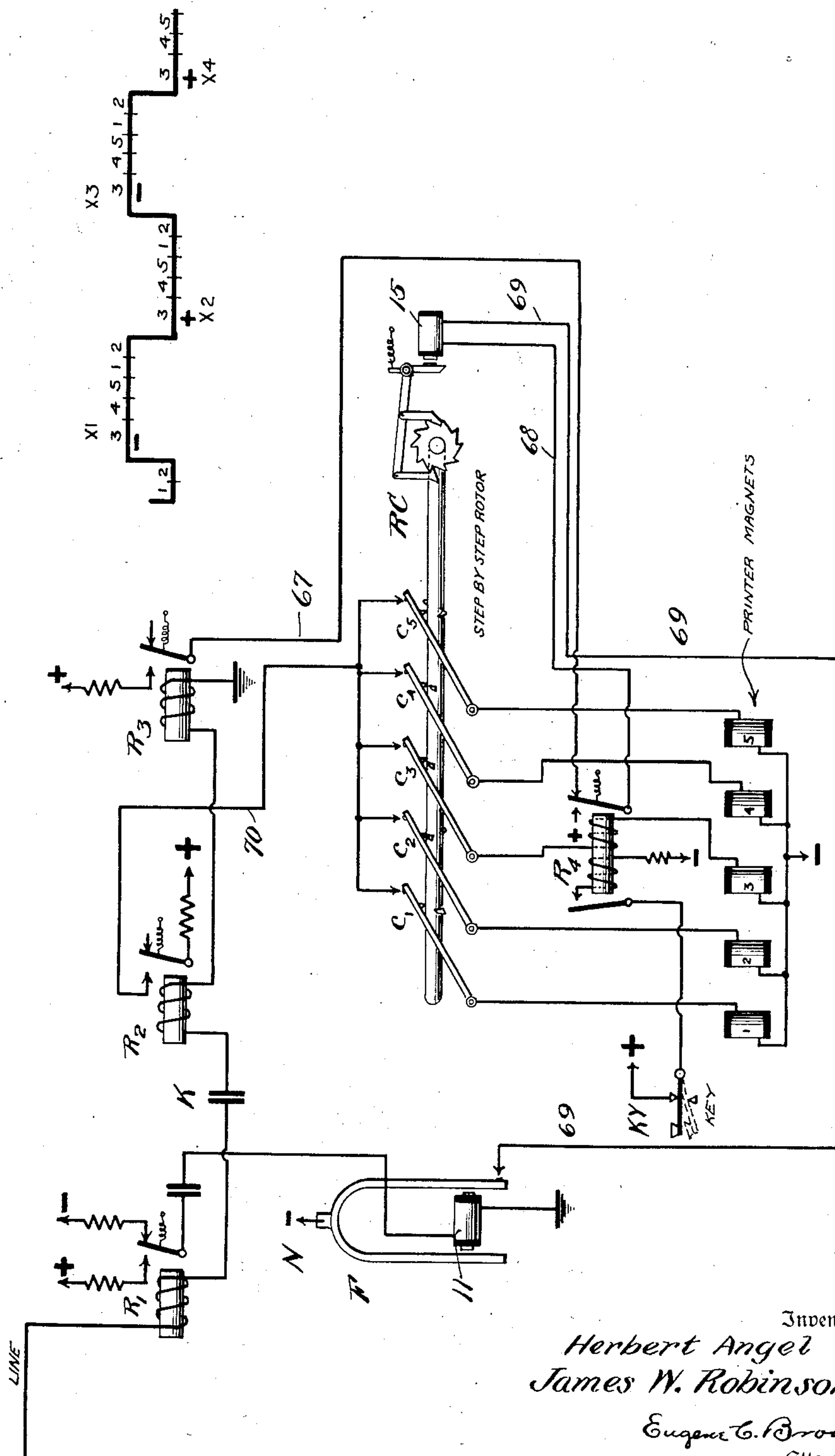
1,807,368

METHOD OF AND APPARATUS FOR OPERATING CABLE TELEGRAPH SYSTEMS

Filed March 30, 1929

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Fig. 5.



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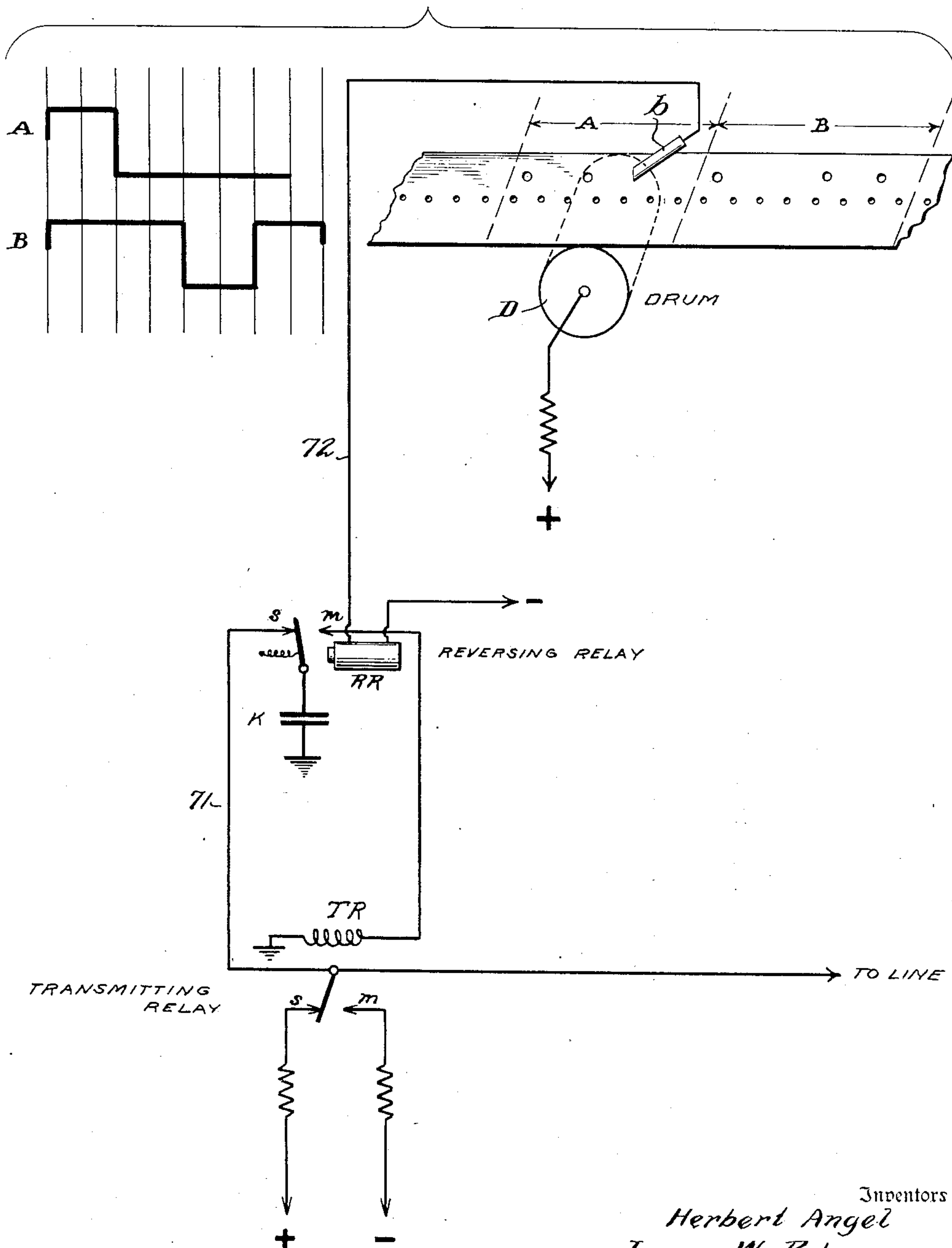
1,807,368

METHOD OF AND APPARATUS FOR OPERATING CABLE TELEGRAPH SYSTEMS

Filed March 30, 1929

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Fig. 6.



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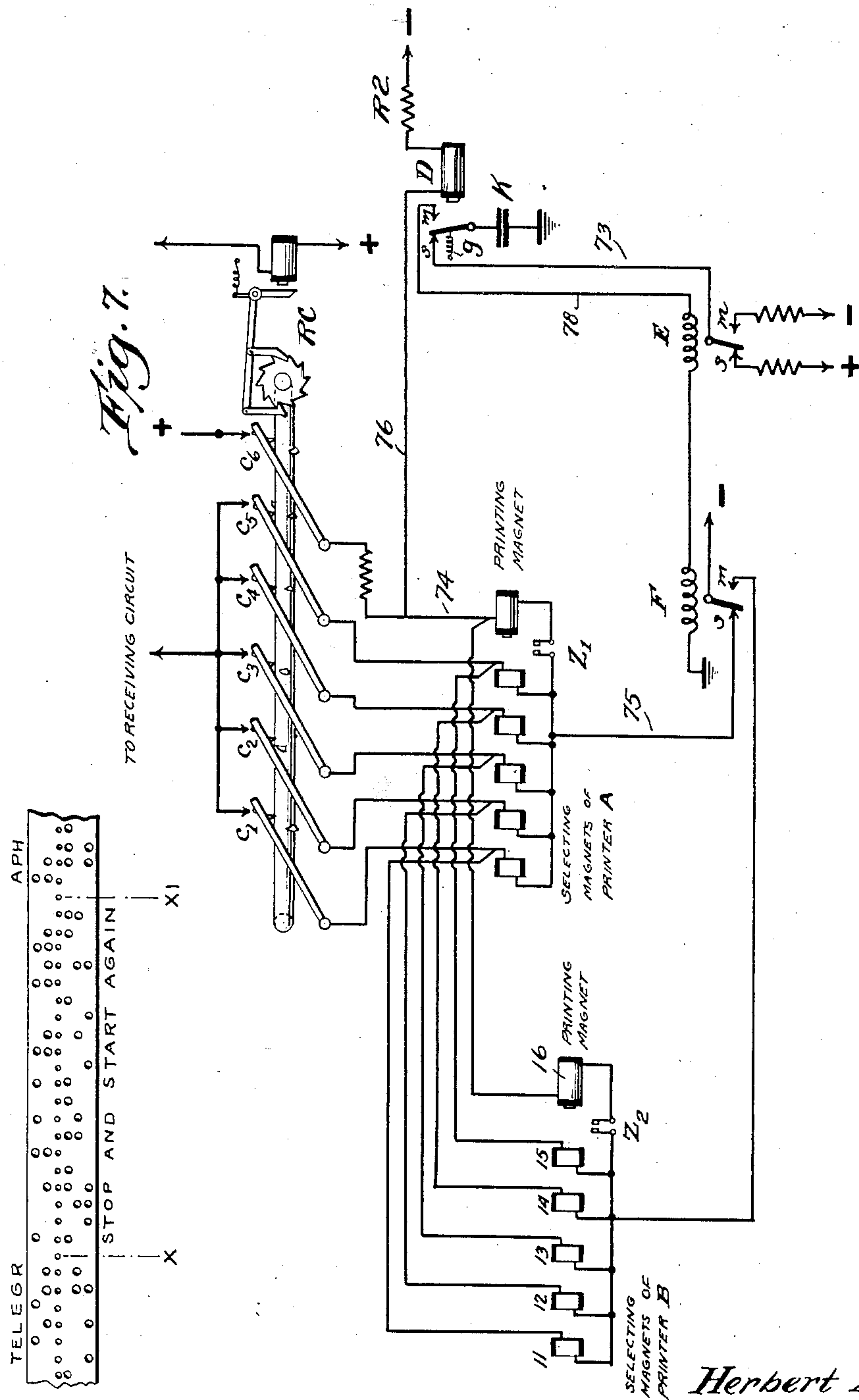
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1,807,368

METHOD OF AND APPARATUS FOR OPERATING CABLE TELEGRAPH SYSTEMS

Filed March 30, 1929

9 Sheets-Sheet 6



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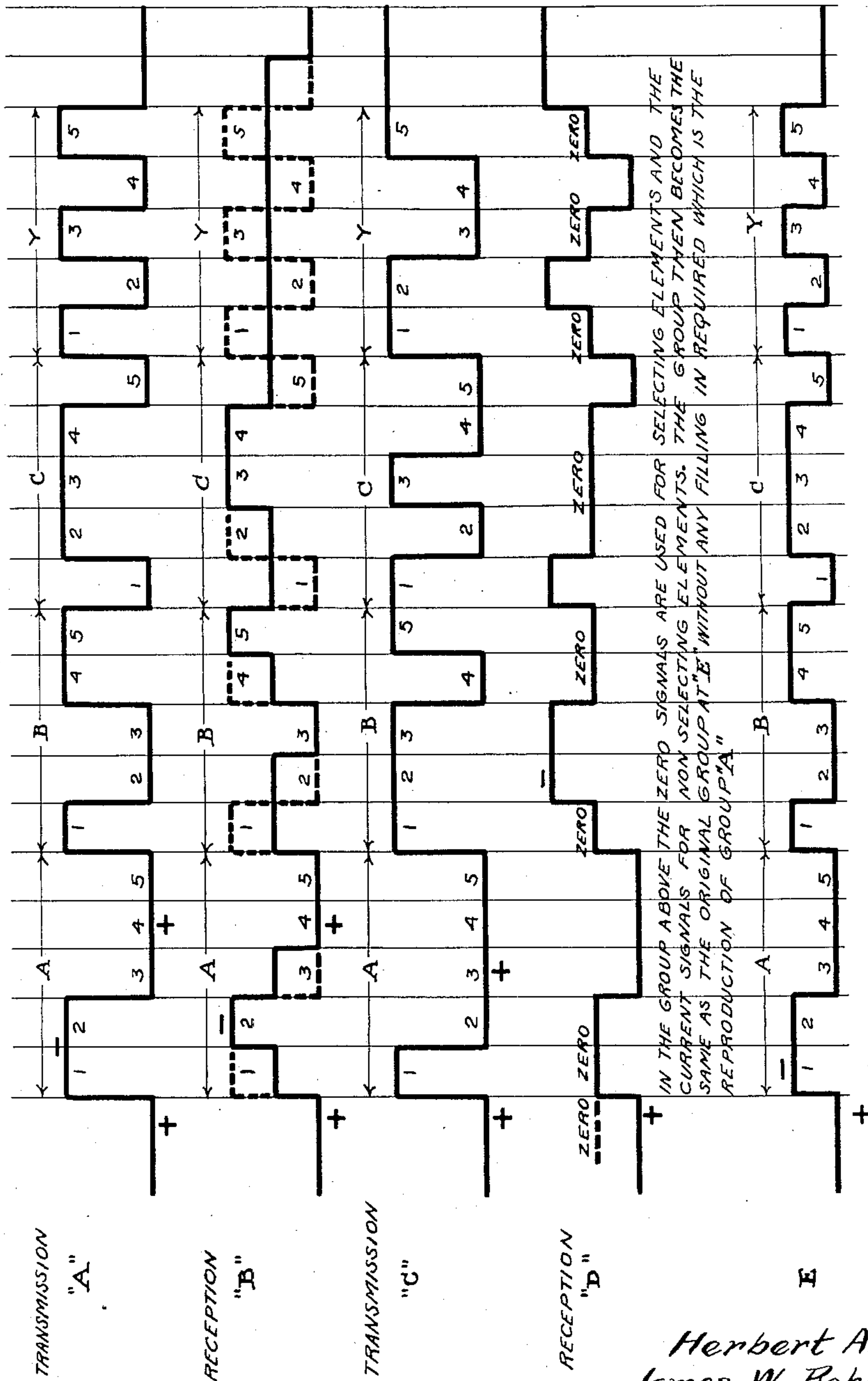
1,807,368

METHOD OF AND APPARATUS FOR OPERATING CABLE TELEGRAPH SYSTEMS

Filed March 30, 1929

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Fig. 8.



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METHOD OF AND APPARATUS FOR OPERATING CABLE TELEGRAPH SYSTEMS

Filed March 30, 1929

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Fig. 9.

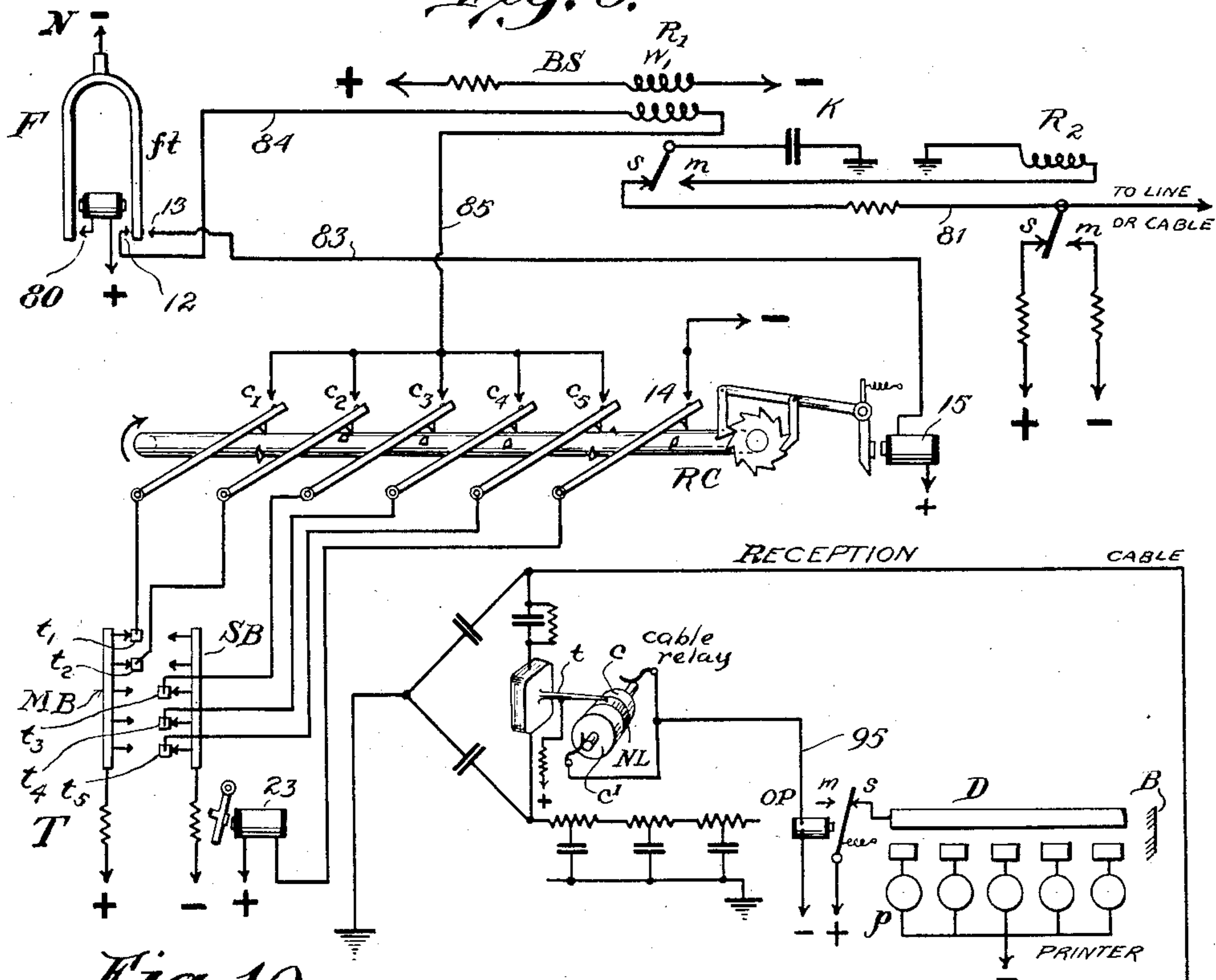
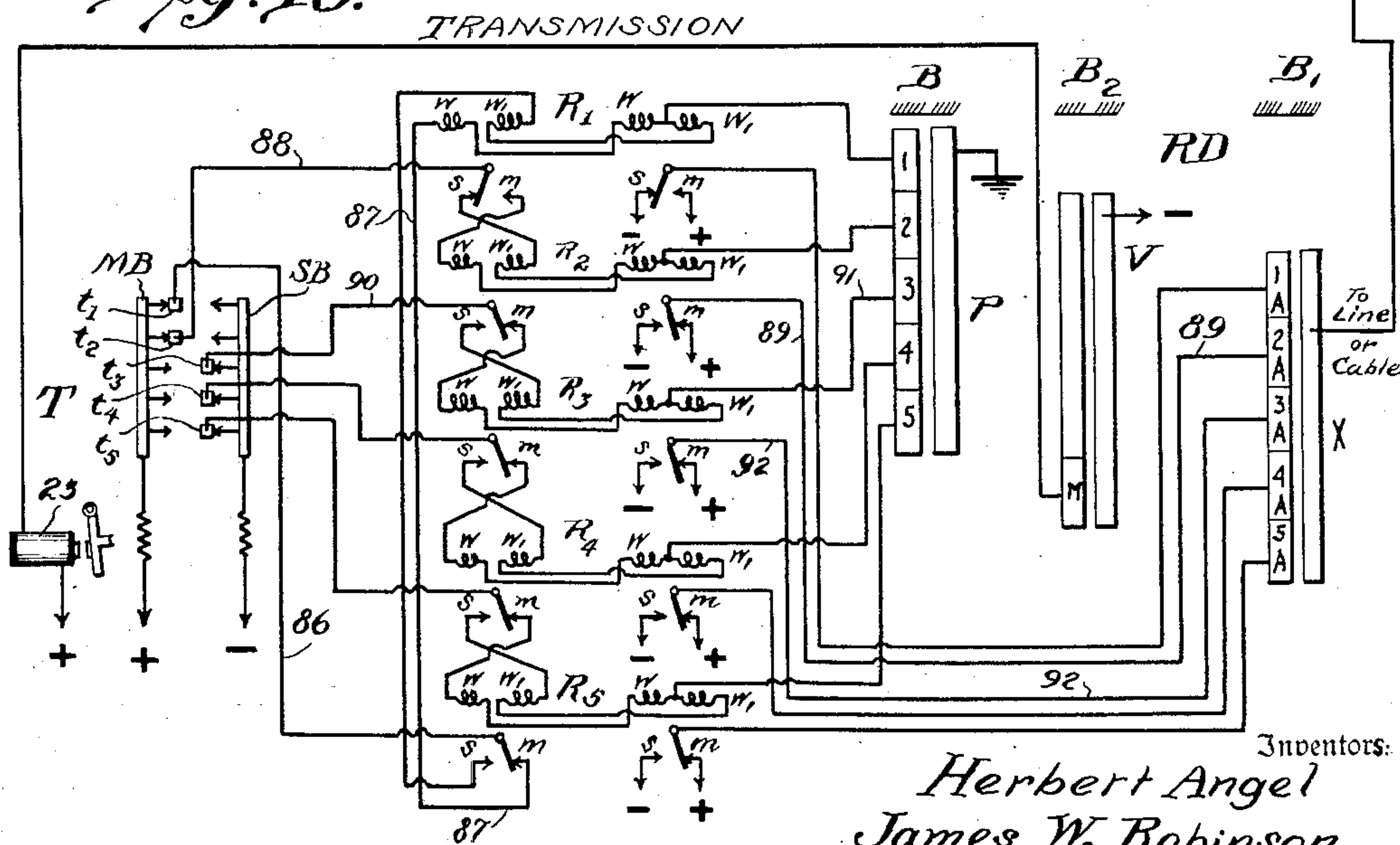


Fig. 10.



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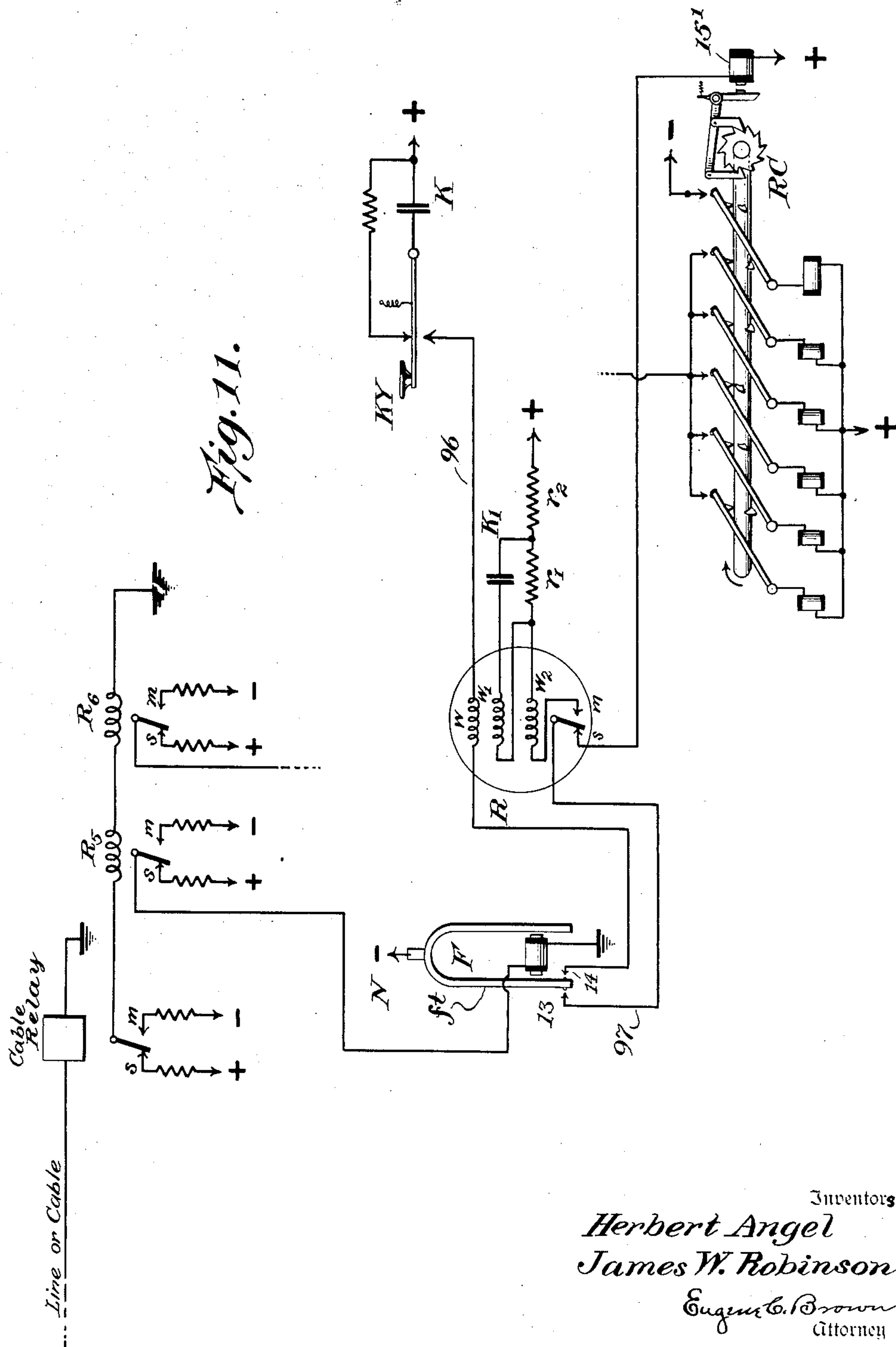
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1,807,368

METHOD OF AND APPARATUS FOR OPERATING CABLE TELEGRAPH SYSTEMS

Filed March 30, 1929

9 Sheets-Sheet 9



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METHOD OF AND APPARATUS FOR OPERATING CABLE TELEGRAPH SYSTEMS

Application filed March 30, 1929. Serial No. 351,379.

This invention relates to the operation of printing telegraph systems over ocean cables but it is also applicable to the operation over land lines and radio circuits. The purpose of the invention is to increase the output by reducing the original fundamental frequency of a standard uniform code, such as the five-unit Baudot code, and transmitting it as a non-uniform or differential code. Our invention also makes it possible to detect errors caused by line failure, relay sticking and other causes.

In order to operate duplexed submarine cables with the least amount of signal distortion, it is desirable to operate them with two-current signals and at the lowest possible rate of fundamental frequency. Cables are operated at present with three-current codes and with two-current codes. In the latter case, however, the received signals arrive as three-current signals owing to the fact that the two-current codes must be transmitted at a relatively high rate of speed in order to deliver an output equal to that obtained with the three-current code. For this reason the single elements or a series of single elements of a two-current code are attenuated to such an extent that they fail to arrive at the distant end and appear on the cable receiving apparatus as zero signals which must be filled in or interpolated into the original reversal elements by complicated rotary devices, vibrating fork devices or Gulstad relay devices. Furthermore, on account of the high frequency to which these two-current codes are transmitted, the cable balance is more difficult to procure and to maintain and the zero signals are subjected to more or less distortion by the unbalanced condition of the cable.

We have found that the above mentioned defects in transmission can be overcome by changing the construction of the code signals before they enter the cable so that, in one case, the two-current code can be transmitted at a lower rate of fundamental frequency than its original rate at a given output and also the two-current code can be transmitted at its original rate of fundamental frequency, so that the arrival or received zero and current waves may be repeated directly into the

standard multiplex receiving apparatus without requiring auxiliary rings or segments on the distributor or tuning forks or Gulstad relays for interpolating the zero waves or impulses into their constituent reversal elements. For this purpose we have invented a telegraph system in which the standard two-current codes now used can be changed between the passing of the tape through the transmitter and the transmission of the signals into the cable by the transmitting relay, whereby the signal impulses can be transmitted into the cable at a lower rate of fundamental frequency than the original frequency of the code as indicated by the perforated transmitting tape and with an output equal to that obtained with the Cable-Morse code. Again, by means of our invention we are able to change the construction of a standard code as it enters the cable, so that said code may be transmitted at its original high rate of fundamental frequency over high speed cables, the missing attenuated signals which arrive as zeros being repeated directly into the standard multiplex printer receiving apparatus without requiring any of said interpolating devices which have heretofore been required to interpolate the zero signals into their constituent reversal elements.

Another important feature of this invention brought about by changing the construction of the code just as it enters the cable, is the means for automatically detecting any errors caused by electrical and mechanical troubles which are common in telegraph operation. With our system, if a signal arrives different from the original transmitted signal, the receiving apparatus is thrown out of synchronism, thereby making it apparent to the operator that an error has occurred.

In the following detailed description we shall refer to the accompanying drawings in which—

Figure 1 illustrates diagrammatically how the uniform code is changed in construction to a non-uniform code.

Figure 2 shows another modification of the manner of changing the code.

Figure 3 is a diagrammatic illustration of apparatus for transmitting and receiving a

two-unit code in accordance with our invention.

Figure 3A illustrates a fragmentary portion of transmitting tape.

Figure 3B, 3C, 3D, 3F and 3G illustrate the effects produced by the change in the construction of the code.

Figure 4 illustrates diagrammatically the manner of changing the standard Baudot uniform code into a non-uniform or differential code for the purposes of our invention.

Figure 5 is a diagrammatic illustration of an arrangement of apparatus for synchronizing the apparatus at the receiving station with the transmitter after an idle period in the cable.

Figure 6 is a diagrammatic illustration of a brush-type constant speed continuously rotating transmitter for operation in accordance with our invention.

Figure 7 is a diagrammatic illustration of apparatus for permitting the interruption of a printing telegraph and the interjection of a "request message", usually referred to as an "RQ message" which is received upon a separate printer after which the regular message proceeds as before.

Figure 8 is a diagrammatic illustration showing specific examples of the manner of changing or reconstructing the standard uniform two-current code as now used for multiplex operation on ocean cables so that they may be transmitted and recorded exactly as they were transmitted.

Figure 9 is a diagrammatic illustration of a circuit arrangement for converting the signals in the manner illustrated in Fig. 8.

Figure 10 is a diagram of circuits showing a transmitting apparatus using the standard multiplex tape, perforated with the uniform code and which electrically reconstructs the code by co-action of the transmitter, distributor and relays so that the marking or selecting elements of the code are transmitted as reversals and the non-selecting elements are of the same polarity as a preceding element, the reconstructed code being transmitted into the cable or line as a uniform code as distinguished from a non-uniform code disclosed in the preceding figures; and

Figure 11 is a diagrammatic illustration of an arrangement of circuits at the receiving station under the control of the receiving operator for readily bringing the receiving distributor into synchronism with the transmitter at the distant sending station.

We will first describe the method of transmitting the standard code, such as the Baudot uniform five-unit code, at a lower rate of fundamental frequency than its original rate of frequency, in accordance with our invention. The transformation of the code in accordance with our invention differs from the conventional codes in several particulars. The marking elements may be upon either

side of the zero line and likewise the spacing elements may be upon either side thereof. A spacing element is arranged to be on the same side of the zero line as the preceding marking element and each marking element is of reverse polarity to the preceding marking element. The code is made up of non-uniform elements and may be described as a differential five-unit, two-current code in which the marking or selecting elements may be two or more time units in length while the spacing of non-selecting elements may be one time unit or less in length. However, a one-time unit signal is never transmitted alone because a spacing element (or elements) are transmitted with the same polarity as the preceding marking or selecting element and hence there will never be less than three units transmitted for a two-unit selecting element code. It will be clear, therefore, that for a given output in letters per minute, the fundamental frequency of this transformed code is lower than the frequency of the conventional two-current codes because no elements of one-time unit length are transmitted.

A novel feature of this code is that the rate of speed, that is, the number of letters per minute, may be increased without increasing the fundamental rate of transmission frequency. This is accomplished by increasing a selecting element to two, three, four or more time units in length while the non-selecting elements are made of one time unit or less in length.

It will be obvious, therefore, that if the selecting elements are made to comprise three time units, the perforated tape may be passed through the transmitter at one and a half times as fast as the code in which the selecting elements are two time units in length. Or if the selecting elements are four time units in length, the tape may be passed through the transmitter at twice the rate of speed as a tape containing two-unit selecting elements, while the fundamental frequency will be exactly the same rate in cycles per second as the frequency transmitted by a tape containing selecting elements of two time units. The output in letters per minute, however, will be greater.

We give below an approximate comparison of the relative difference in outputs for two, three, four, five and six-unit length selecting elements.

A three-unit selecting element yields 12% more than a two-unit.

A four-unit selecting element yields 20% more than a two-unit.

A five-unit selecting element yields 25% more than a two-unit.

A six-unit selecting element yields 28.8% more than a two-unit.

The fundamental operating frequency for codes having selecting elements three, four, five and six time units in length is the same

as the two-unit selecting element code. This is graphically illustrated in Figure 1 which shows diagrammatically—(1) the letter "A" in the usual uniform length five-unit code; (2) the selecting elements each two-units in length, with the second element of reversed polarity, and the non-selecting elements each one unit in length; and then as this transformed code becomes when the speed of the tape is doubled; (3) the length of each selecting unit trebled and the transmission speed trebled; (4) the length of the selecting units and the speed of transmission quadrupled; (5) the length of the selecting units and the speed of transmission increased five times; (6) and the selecting units and speed of transmission increased six times.

Figure 2 shows a modification in which the selecting elements may be two or more units in length of opposite polarity and the non-selecting elements of one unit length, each of opposite polarity to the preceding selecting element and each non-selecting element of opposite polarity to its preceding non-selecting element. This construction is not so practicable for ocean cable operation because it increases the fundamental frequency of the code and the result would be a three-current code received at the end of the cable more or less distorted by the unbalance caused by the transmission of the high frequency code. It, however, provides the means for detecting the errors previously referred to.

It therefore becomes possible by means of this invention to operate a long ocean cable with a two-current code having a lower fundamental operating frequency than any other known code at a given rate of speed and whereby all of the transmitted signals are received with equal amplitude at a rate of speed which can be obtained with a three-current code or with the existing two-current codes when all of the signal impulses of these codes are received.

Furthermore since it is possible to receive all of the transmitted signals, the well known cable relays, such as drum relays, which employ relatively widely separated contacts including a no-mans-land for recording the three-current signals may be dispensed with and a faster or more efficient relay having two contacts separated by a very small gap may be employed. This obviously produces signals of clearer definition and allows of overriding a greater amount of duplex unbalance.

Also because of the automatic means for detecting errors caused by mechanical and electrical troubles, the degree of accuracy will be much greater with this system of printing telegraphy than is obtainable with those now used for ocean cable operation.

Before further describing the operation of the apparatus, reference will be made to the code of signals which we have devised to bring about the desired results. As already

stated, the code when transmitted to the line is not a uniform five-unit code such as the Baudot code in which each character is five equal units in length, but is a differential five-unit code in which the units are of unequal length. This is done for the purpose of shortening the time length of the Baudot or uniform code, which correspondingly reduces the transmission rate of fundamental frequency and at the same time provides for the reception of all of the transmitted signals.

Figure 4 illustrates diagrammatically how the Baudot or uniform code is differentialized for the purposes above mentioned. In this figure the group "A" represents the characters E, A, B of the Baudot code in which each character contains five equal units with a total of fifteen time units. The group "B" shows the same characters when the uniform code is differentialized. The code thus transformed is longer than the corresponding uniform Baudot code characters, because each selecting element now occupies two time units. This is done to permit the tape to be passed through the transmitter twice as fast as a tape with uniform length elements. When the speed of the tape is thus increased, the 21 time units shown in group "B" occupy only the time of $10\frac{1}{2}$ time units, as indicated in group "C", a saving of 30% in time over the time required when the tape is prepared with uniform length elements. Although the tape is moved through the transmitter at double the normal speed permitted for the code of uniform length elements, the selecting elements of the code will all be received at the distant end of the cable with the same amplitude and duration as the single unit signals of group "A", because each selecting element in group "B" is two time units in length.

Figure 3 is a schematic diagram of apparatus embodying our invention for transmitting and receiving the two-unit code. The transmitting apparatus includes a tape transmitter T of the type disclosed in Benjamin Patent No. 1,298,440, a step-by-step rotating contacting device RC, a synchronizing tuning fork F and relays R. A portion of perforated tape Ta is shown at Fig. 3A, containing one or more characters, the transmission of which will be described. The apparatus at the receiving station includes the synchronizing tuning fork F¹, step-by-step rotating contacting device RC¹, printer PR and relays R¹.

A hole or perforation in the tape Ta represents a selecting element of the code and a corresponding imperforate portion represents a non-selecting element. As will appear, a hole in the tape will cause the contacting device RC to hold a contact closed for two time units and a corresponding imperforate portion for one time unit. Hence if the tape is perforated with five holes, as shown at X in Fig. 3A the contacting device will be

stepped around five teeth, each step being held two time units in length. If the tape contains no selecting holes as shown at X1, the step-by-step rotor RC is stepped around five teeth with one time unit length per tooth. So that as the tape Ta containing the characters shown is passed through the transmitter the character "A" will cause the step-by-step rotor to be stepped to its first tooth and be held for two time units, then to its second tooth for two time units, then to its third, fourth and fifth teeth for one time unit each.

For the character "B", illustrated in the fourth row of holes in the tape Ta, the rotor steps to its first tooth for two time units, its second and third for one time unit each, to its fourth and fifth for two time units each and so on. This mechanical sequence can be followed by imagining the rotor stepping around with short and long steps something like the sound of the dots and dashes of the Morse code. For example the group X in Ta would sound like five dashes of the Morse code shown at 3D. The character "A" would sound like two dashes and three dots and so on.

The sequence for the character B can be followed in a similar manner.

At the receiving end of the cable or circuit the transmitted signals shown at Fig. 3C are received with the same shape and are passed into the receiving apparatus. The sequence of events which happen at the receiving end are similar to those just described in reference to the sending end of the circuit. That is to say a selecting signal, which is always a reversal, will cause the step-by-step receiving rotor RC¹ to be stepped to a tooth for a two time unit length and a non-selecting signal will cause it to be stepped to a tooth or teeth for one time unit each. To differentiate the non-selecting part of a received character from the selecting part, the received signals are locally reshaped before they enter the printer apparatus. They are reshaped so that only the reversals or the selecting elements are sent into the printer apparatus. So that the character "A", as shown at 3F when locally reshaped appears as shown at 3G, in which case the only signals sent into the selecting mechanism of the printer are the ones which are the selecting elements of the code.

Having described the general scheme of transmission and reception, the actual transmission and reception of the character "A" will now be described in detail.

The character "A" as shown in tape Ta has two selecting units, namely, the first and second, indicated by the holes in the first and second positions. When a tape passes through the transmitter T certain tongues of the transmitter will be operated to the selecting or marking bar MB and others to the non-selecting or spacing bar SB. The

tongues operated to the marking bar will be the ones corresponding to the holes in the perforated tape. In this case tongues t_1 and t_2 will be operated to the selecting bar and tongues t_3, t_4, t_5 to the non-selecting or spacing bar. The selecting tongues t_1 and t_2 will thus be connected to the positive battery and the non-selecting tongues t_3, t_4, t_5 to the negative battery. As already stated a selecting signal operates the step-by-step rotor RC for two time units and a non-selecting signal for one time unit.

In this case the sending cam rotor RC will step to its first position and close contacts c_1 for two time units, then it will step to its second position and close contacts c_2 for two time units, following this it will step to its third, fourth and fifth positions and close contacts c_3, c_4, c_5 for one time unit each. The rotor cam shaft RC is moved step by step by the magnet 15 which actuates the ratchet wheel 16 by means of the dogs 17 and 18. The shaft is provided with a series of cam projections 20 which successively lift the pivoted levers 21 into engagement with the contacts $c_1, c_2, \dots, c_5$.

The means for bringing about the differential stepping of the cam rotor and consequently the differential transmission of the code is as follows:—The tuning fork F is vibrated in the well-known manner through a make and break contact 10 which alternately closes and opens the local circuit of the magnet 11. The contacts 12 and 13 of the fork, control a train of relays R_1, R_2, R_3 which in turn cause the rotor cam shaft RC to be stepped up for two or for one time unit per tooth.

For instance let it be assumed that when the contacts 14 were closed, they operated the magnet 23 of the transmitter T, which in turn moved the perforated tape in a position so that tongues t_1 and t_2 connected with the selecting bar MB and tongues t_3, t_4 and t_5 remained against bar SB. Further let it be assumed that the tine ft of the fork F swung outwards to contact 13. In this case negative battery at N flows into circuit L_2 to tongue 25, contact s of relay R_2 into conductor 30, through resistance 31 and the rotor magnet 15 to plus battery. This causes the cam shaft RC to be stepped, we will say, to its first position, thus closing its contacts c_1 . At the same time the shunt circuit 32 operated relay R_1 to its spacing contact s . Now the fork tine ft swings inward to contact 12 so that negative battery from N flows into circuit L_1 through tongue and spacing contact s of relay R_1 , conductor 35, winding W of relays R_3 and R_2 , conductor 36 to the common connector 40 of the cam rotor contacts, through the closed contacts c_1 to positive battery via the tongue t_1 and selecting bar MB of the transmitter T. This circuit causes relay R_2 to be operated to its contact

m which opens the circuit to the cam rotor magnet 15 and prevents the cam rotor from being influenced upon the next outward stroke of the fork. This same circuit also operates relay R_3 to its marking contact m , which in turn, by discharging condenser K , operates relay R_4 to its contact m , thereby transmitting the first selecting signal impulse of the character "A" as shown at Fig. 3B.

As the fork tine ft now swings outward to engage contact 13, current from negative battery N flows into circuit L_2 but cannot flow into conductor 30 because the tongue of relay R_2 is on its contact m . The rotor RC therefore will not be energized on this stroke of the fork and will be held for two time units or while the fork is making four half swings.

The circuit, therefore, through L_2 is now diverted from conductor 30 to circuit L_2 via the tongue and m contact of relay R_2 into winding W_1 of relay R_1 . This circuit causes relay R_1 to operate to its marking contact m , thus preparing a path for restoring the relay R_2 to its normal contact s upon the next inward swing of the fork. When the fork tine swings inward to contact 12, current from negative battery N flows through circuit L_1 , the tongue and contact m of relay R_1 , and winding W_1 of relays R_3 and R_2 to positive battery. This operates relays R_3 and R_2 to their normal contacts s .

The train of relays are now restored to their normal s contacts and upon the next outward swing of the fork tines the cam rotor RC will be stepped to its second position. Hence because the tongue t_1 of the transmitter T was on the selecting bar MB of the transmitter T , the relay train was energized and caused the cam rotor magnet 15 to be held or unoperated for two time units or the equivalent of four half swings of the fork.

Since tongue t_2 of the transmitter T is also on the marking or selecting bar MB , the same sequence of events will happen when the fork swings outward and steps the cam rotor RC to its second position, thus closing its contacts c_2 . (It should be noted that the rotor contacts c_1 open when contacts c_2 close and the latter open when contacts c_3 close, and so on.) Simultaneously with the operation of the cam rotor magnet 15, current through the shunt circuit 32, energizes the winding W of relay R_1 and restores its tongue or armature to its normal contact s . Now when the fork tine swings inward to contact 12, current flows through circuit L_1 , energizing relay R_3 and moving its tongue to its marking contact m , which causes the condenser K to discharge through the winding of line relay R_4 . The tongue of relay R_4 moves to its marking contact s and thereby sends current from the positive pole of the line battery over the line or cable to produce the second selecting signal impulse of the char-

acter "A", as shown at Fig. 3B. The cam rotor RC is held for two time units, in this case in the same manner as previously described in sending the first selecting impulse of the character "A".

Now because the third, fourth and fifth elements of the character "A" are non-selecting, indicated by the absence of holes in tape D , the tongues t_3 , t_4 and t_5 of the transmitter T are shown on the spacing or non-selecting bar SB of the transmitter T . In this case no current will flow in circuit L_1 when the fork makes contact with contact 12 because the two sources of current, namely, battery N connected to the fork and the battery connected to bar SB of the transmitter T are both of the same polarity and hence nothing will happen to the train of relays. Therefore because relay R_2 will not be operated to its marking contact for the third, fourth and fifth elements of the character "A", the rotor magnet 15 will be stepped forward one tooth for one time unit per tooth, for each outward swing of the fork.

The operation for any other character is brought about in a similar manner. So for the character "A" perforated as shown at Fig. 3A, the actual signals transmitted to the line are as shown at Fig. 3B. It will be remembered that the code may be constructed so that each selecting element may be two or more units in length and each non-selecting element one unit each in length, and that the non-selecting elements are transmitted with the same polarity as the preceding element. Hence in this case, the first selecting element of character "A" is transmitted with two units of negative current, the second selecting element with two units of positive current, the third non-selecting element with one unit of positive current, followed by the fourth and fifth non-selecting one unit elements.

Receiving circuit

At the receiving end of the line or cable the transmitted signals arrive as shown at Fig. 3F.

The relays R_5 and R_6 are operated by the cable relay, which operates in the usual manner and hence will not be described. The remainder of the receiving apparatus functions practically the same as already described in connection with the operation of the transmitting apparatus. The receiving apparatus differs from the sending apparatus in that the relays R_7 , R_8 and the printer PR take the place of the transmitter T of the sending apparatus.

The actual reception of the character "A" as shown at Fig. 3F is as follows:—The relays R_5 , R_6 operate to their marking contacts m for the first negative selecting impulse of "A".

The relay R_5 is for the purpose of vibrat-

ing the fork F' . As the relay operates to its s and m contacts, it energizes the fork magnet $11'$ with sudden impulses from the condenser K' and causes it to vibrate in synchronism with the fork F at the transmitting end. The relay R_6 and condenser K^2 are for the purpose of locally reshaping the received signals before they are sent into the actual receiving or translating apparatus.

The signals for the character "A" shown at Fig. 3F are reshaped by means of the condenser K^2 so that they appear as indicated at Fig. 3G. The only signals actually set into the translating apparatus are the selecting elements of the character. These selecting elements cause the receiving apparatus to function in exactly the same manner as the transmitting apparatus was operated by the selecting elements from the transmitter T . In other words a selecting element received on either of the selecting relays R_7 or R_8 will cause the relay train R'_1, R'_2, R'_3 to step up the receiving rotor RC' for two time units per step and a non-selecting element or elements will cause it to be stepped up for one time unit per step.

The actual operation of the receiving circuit for the character "A" is as follows:—As the tine f of the fork F' swings to contact $13'$ the cam rotor magnet $15'$ is actuated by current from negative battery N' over a circuit from contact $13'$, through conductor 50, tongue and s contact of relay R'_2 , conductor 52, magnet $15'$ to positive battery. Simultaneously current through shunt circuit 53 caused relay R'_1 to move its tongue to its normal or spacing contact s . In this case assume that the cam rotor shaft RC' was stepped to its first position, thus closing its contacts c_1 . When the fork F' swings to contact $12'$, the relays R'_3 and R'_2 will operate their tongues to their m contacts, because the selecting relay R_7 is closed by the reception of the first element of the character "A". The circuit may be traced from negative battery N' , contact $12'$ of the fork, conductor 56, tongue and s contact of relay R'_1 , conductor 57, windings W of relays R'_3 and R'_2 , conductor 58, tongue and contact m of selecting relay R_7 , conductor 59, common connector 60, contacts c_1 of the cam rotor RC' , first selecting magnet p_1 of the printer to positive battery.

The rotor cam shaft RC' will remain in this position for two time units, or until the receiving relay R_6 is reversed by the line signal. During this time the fork makes four half swings, which is the exact equivalent of a two-unit selecting signal. When the fork swings to contact $13'$ during this period, the rotor magnet $15'$ is not energized because its circuit is open at contact s of relay R'_2 , its tongue being on its contact m . At this instant when the fork is on contact $13'$ the relay R'_1 is energized through its winding W , via

conductors 50 and 62 and operates its tongue to its contact m .

The next inward swing of the fork to contact $12'$ operates relay R'_3 to its contact s and relay R'_2 to its contact s over a circuit from contact $12'$, through conductor 56, tongue and contact m of relay R'_1 , conductor 63, and windings W_1 of relays R'_3 and R'_2 . Upon the fourth swing of the fork to contact $13'$, the rotor will be stepped to its second position and held there for two time units, because the next received signal is a selecting signal which will close the selecting relay R_8 and open the selecting relay R_7 . The relay R'_1 also operates to its normal contact s at this time. The same sequence of events are repeated as described for the first element of character "A" and the second selecting magnet p_2 of the printer is energized.

Now for the third, fourth and fifth elements of character "A", the two selecting relays R_7 and R_8 are operated to their spacing contacts by the biasing circuit BS , and remain on their spacing contacts s for the zero portion of the character "A" shown at Fig. 3G. In this case no current can flow through windings WW of relays R'_2, R'_3 and these relays remain on their normal spacing contacts for the zero portion of the character "A". Under this condition the rotor magnet $15'$ will be energized and stepped around one tooth for each outward swing of the fork during the zero portion of the signal, and the contacts c_3, c_4 and c_5 of the rotor will close successively. No current, however, will flow into the printer selecting magnets p_3, p_4 and p_5 because the selecting relays R_7 and R_8 are on their spacing contacts, which open the circuit leading to these magnets, namely, conductor 59.

The two selecting elements of the character "A" operated two magnets of the printer, namely, the first and second and the character "A" was printed when the sixth rotor contact $14'$ closed the local circuit through the printing magnet pm .

Any other character is transmitted and received in a similar manner.

The relay R'_3 is employed to repeat into another line the regenerated signals which come from relay R_6 and are timed by the fork to correspond exactly with the length of the original selecting and non-selecting elements. As will be understood, the relay R'_3 will control another transmitting relay in the same manner as the relay R_4 is controlled by the relay R_3 at the transmitting end.

Automatic synchronism

When no message or intelligence signals are being transmitted over a line or cable, some means must be provided for keeping the sending and receiving apparatus in synchronism during this interval, or means must be provided at the receiving end for bringing

the apparatus into synchronism when a message is started in case the cable has been idle. This is accomplished in the present invention in either of two methods. The first is accomplished when the tape runs out of the transmitter, and all of the transmitter pins naturally bear against the marking bar. According to our invention, continuous reversals will be transmitted until a new tape is inserted in the transmitter. In other systems special current switching devices and cam devices must be provided to bring about the automatic synchronizing feature. In the present invention the means whereby each selecting impulse is transmitted with reversed polarity to its preceding impulse causes continuous reversals to be transmitted when the tape runs out.

The other method of synchronizing according to the present invention is brought about by providing an automatic synchronizing means at the receiving end of the circuit. For this purpose a message is started with a repeated character containing one selecting element which, for example, may be the "space" character in which the selecting element is in the third position.

At the receiving end this repeated character will operate a selecting device which causes the step-by-step rotor to step around to its third position, which is the synchronizing position for the repeated character. The message can then follow along and will be received in proper synchronism. It is known, of course, that the stop and start printing systems which use the equivalent of a seven or eight element code can be stopped and started in synchronism, but in the case of continuous transmission using a five element code it has not been possible heretofore to completely stop the transmission and then be able to start up immediately with a message which will automatically arrive in synchronism at the distant end.

An arrangement for synchronizing at the receiving end of the line or cable is shown in Fig. 5. The series of repeated characters transmitted as indicated in Fig. 5 are received over the line and operate the three relays R_1 , R_2 and R_3 . Relay R_1 controls the operation of the magnet 11 to keep the fork F in synchronism with the incoming signal impulses. Relay R_2 controls the impulses sent into the printer magnets, and relay R_3 controls the stepping of the cam rotor RC. These relays operate momentarily through the condenser K. The key KY is for the purpose of unlocking the relay R_4 whenever the transmission stops. Then the key KY is momentarily depressed into the dotted line position and is immediately released to its upper full line position.

Assume now that the line has been idle and that a message is to be transmitted which is preceded by a series of the repeated charac-

ters as shown at the right hand side of Fig. 5. This repeated character represents the "space" signal in which the third element is a selecting two-unit element. Let it further be assumed that when the transmission previously stopped, the receiving cam rotor was in its fourth position. The rotor will therefore be out of step when the transmission starts, for instance, with number one signal element. The rotor will be only stepped by the line signals until it is in proper synchronism. The signal impulse indicated at X1 in the first character will operate relay R_3 which will step the rotor via the circuit from positive battery, through the front contact and tongue of relay R_3 , conductor 67, back contact and tongue of relay R_4 , conductor 68, rotor magnet 15, conductor 69, contact and tine of fork F to negative battery. Operation of magnet 15, steps the cam rotor from the fourth to the fifth position. The next signal reversal, indicated at X2, charges the condenser K in the reverse direction and the condenser current operates the relays, thus causing the magnet 15 to step the cam rotor RC from the fifth position to the first position; likewise for the reversal X3 it will be stepped to its second position and for the reversal X4 to its third position.

As the rotor RC is stepped to its third position during the transmission of the fourth repeated code character, current flows from positive battery through the tongue and front contact of relay R_2 , conductor 70, contact c_3 of rotor RC, right-hand winding of relay R_4 , printer magnet 3 to negative battery. Relay R_4 is now continuously energized by a locking circuit from positive battery through key KY, conductor 71, tongue and left hand winding of relay R_4 to negative battery. The rotor RC will thereafter be stepped in synchronism with the incoming signals by a circuit from positive battery through the front contact and right hand tongue of relay R_4 , conductor 68, magnet 15, conductor 69, contact and fork F to negative battery N. In this manner, by simply transmitting a given character a few times before starting the message, the receiving apparatus is automatically brought into synchronism with the transmitter at the sending end.

In the previous description of the operation of apparatus for carrying out our invention we have used for purposes of illustration, a code arrangement in which the selecting elements were two time units in length, and the relay train consists of three relays R_1 , R_2 and R_3 . The selecting elements may be made longer if desired by merely increasing the number of relays in the train. For selecting elements equal in length to three time units, a train of four relays may be employed and so on for selecting elements of other lengths such as illustrated in Fig. 1.

We have illustrated in Fig. 11, another cir-

cuit arrangement at the receiving end of the cable for readily restoring the receiving apparatus to synchronism with the transmitter during the reception of a message in case the receiving distributor should fall out of step due to line failure or for any other reason.

By introducing a key and relay in the distributor stepping circuit, the attendant or operator is enabled to control the stepping operation, one step at a time until synchronism and proper phase relation is attained. The operation of the apparatus at the receiving station illustrated diagrammatically in Fig. 11 will be readily understood.

Normally the tongue of the relay R remains against its stop *s* so that a circuit is established for actuation of the stepping magnet 15' of the rotary cam distributor RC each time the tine *ft* of the fork F engages its outer contact 13 and hence the cam shaft of the distributor is moved the distance of one ratchet tooth for each signal impulse received by the cable relay.

If the operator observes that the characters coming from the printer are unintelligible, he depresses the key KY for an instant, thereby closing a circuit from negative battery N, fork tine *ft*, contact 12, winding W of relay R, conductor 96, key KY, condenser K to positive battery. The charging current of condenser K energizes winding W and causes the tongue of relay R to move to its contact *m*. Upon the next outward swing of the fork tine a circuit is closed from negative battery N through fork tine *ft*, contact 13, conductor 97, tongue, contact *m* and winding W₂ of relay R, resistances *r*₁ and *r*₂ to positive battery. The energization of winding W₂ holds the relay tongue against its *m* contact and the drop of potential across resistance *r*₁ charges the condenser K₁, the current through winding W₂ and the condenser charging current through winding W₁ being in a direction to hold the tongue against contact *m*. As the fork tine moves from contact 13, condenser K₁ discharges through winding W₁ in a direction to return the tongue of relay R to its *s* contact, thereby restoring the receiving apparatus to normal condition.

The operation just described caused the stepping magnet 15 to remain unenergized during the reception of one signal impulse so that the rotary contact cam shaft RC of the receiving distributor dropped back one impulse with respect to the sending distributor. If this was sufficient to correct the phase relation to bring the receiving apparatus into synchronism, the characters now printed by the printer will be correct. If, however, the printed characters are still unintelligible, the operator will again depress the key KY and repeat the phase correcting operation. It is obvious that a five-unit code will require a maximum of four correcting operations which will consume only a fraction of a min-

ute. The circuits for transferring the signal impulses from the receiving relays to the printer have not been shown in Fig. 11 as they have been fully described in connection with Fig. 3 and other figures.

We have described the invention applied to only one channel arrangement but it will be perfectly evident to engineers that it may be used in a multiple channel system. Several transmitters may be used and the rotor cam shaft of the sending distributor arranged with several groups of cams. Likewise the receiving distributor may be arranged with several groups of cams or segments connected to different printers.

It will be further understood from the description that the transmission is a continuous transmission. That is to say, no line time is required between the last element of the code and the first element for operating the transmitter magnet or printer magnet. This continuous transmission is illustrated in U. S. patent to G. R. Benjamin #1,447,748 and U. S. patent to G. R. Benjamin and H. Angel #1,579,999. In both of these patents overlap circuits are shown for making possible continuous transmission.

It will be further understood that the differential transmission of the uniform two-current code referred to, may be accomplished by using a Wheatstone type of transmitter or any type of a constant speed continuously rotating transmitter, such as the brush type shown in the Figure 7. The perforator in this case would be a differential perforator which is well known to those familiar with the art.

Referring to Fig. 6, a selecting signal element in the longitudinally perforated tape consists of a perforation followed by a unit blank portion, so as to make the time length equal to two units, while a non-selecting signal element consists of a single blank portion. The perforations in the tape cause the current applied to the line to be reversed while a blank portion allows the current to remain unchanged.

When there is no perforation passing under the brush *b* of the transmitter there is no contact between the brush and drum D, and no current can flow in the winding of relay RR. The tongue of relay RR rests on its contact *s*, and since the circuit to the winding of relay TR is broken at contact *m* of relay RR, the tongue of relay TR will remain on the contact to which it was last operated. For example, assume that the tongue of relay TR rests on its contact *s*. Condenser K is charged with positive battery through contact *s* and tongue of relay TR, conductor 71, contact *s* and tongue of relay RR, and condenser K to ground.

When a perforation appears under brush *b* of the transmitter, contact is made with the drum D and the tongue of relay RR is

operated to its contact *m*. The circuit may be traced from positive battery through drum D and brush *b* of the transmitter, conductor 72, winding of relay RR to negative battery.

5 The tongue of relay RR causes the condenser K to discharge into the winding of relay TR, operating the tongue of relay TR to its opposite contact. In this case condenser K discharges through the tongue and contact *m* of relay RR, winding of relay TR to ground, thus operating the tongue of relay TR to its contact *m*, and connecting battery of the opposite polarity to the line.

10 Thus for each perforation in the tape the line battery is reversed and for the absence of a perforation in the tape the line battery remains the same as it was for the preceding signal.

20 Signaling system

To those familiar with printing telegraph systems it will be known that in using page printers, it is undesirable to transmit any other signals than those which go to make up the message. That is to say should it be necessary to transmit an "RQ message" or what is known as a "request", asking for a repetition or some other routine request, the page upon which the regular message is being received would be spoiled if the RQ were injected into this message.

We have overcome this undesirable feature with our signaling device by using a spare combination of the code which may not be used for other purposes but when transmitted over the line will, by means of a selecting device at the receiving end, transfer the signals which follow this particular code combination into a separate printing or recording apparatus, conveniently located remote from the regular receiving printer or where the RQ attendant is located.

With this kind of a signaling device it becomes practicable to operate printing telegraph circuits with page printers without spoiling the copy when RQ signals are transmitted. It will be further understood by those familiar with the printing codes that other characters than the Roman characters may be used for the RQ signals. For instance on the upper case of one type bar of the printer there is a period or dot and on another type bar there is a dash, so that Morse characters could be transmitted by using the code combination for a period, for the Morse dot, and the other combination for the Morse dash.

The arrangement for the "RQ" signaling circuit is shown in Figure 7. In the perforated tape at the transmitting station the RQ message is preceded and followed by a signal of five non-selecting elements, as shown at X, X1 in the specimen of tape. At the receiving station, the tongues of relays D, E and F normally rest on their *s* contacts. Condenser

K is charged with positive battery through the contact *s* and tongue of relay E, conductor 73, contact *s* and tongue of relay D, and condenser K to ground.

The printers A and B are equipped with the usual cut-out contacts *Z*₁ and *Z*₂, which are closed mechanically only when any one or more of the selecting magnets operate. When these contacts close they complete the circuit through the printing magnet of their respective printers.

Since the tongue of polar relay F rests on its *s* contact, the selecting magnets of printer A, only, will be actuated by the received signals and contacts *Z*₁ will close, the circuit of printer B being open at the *m* contact of relay F.

When contacts *c*₆ of the distributor close, current flows from positive battery through contacts *c*₆, conductor 74 printing magnet 6, contacts *Z*₁, conductor 75, contact and tongue of polar relay F to negative battery. A current also flows from positive battery through contacts *c*₆, conductor 76, winding of relay D, and resistance *R*₂ to negative battery, but *R*₂ is a high resistance in comparison with the resistance of the printing magnet 6, so that this current is not of sufficient strength to cause the tongue of relay D to operate against the tension of spring *g*.

When the signal of five non-selecting elements is received the selecting magnets are not actuated and contacts *Z*₁ remain open and break the circuit through the printing magnet. Now when contacts *c*₆ close, all of the current flows from positive battery through contacts *c*₆, conductor 76, winding of relay D, resistance *R*₂ to negative battery, causing the tongue of relay D to move to its *m* contact. Condenser K discharges through the tongue and *m* contact of relay D, conductor 78 and windings of relays E and F to ground. The tongues of both relays E and F operate to their *m* contacts. The negative battery return is transferred by the tongue of relay F, from the magnets of printer A to those of printer B.

When the contacts *c*₆ open, the current will cease to flow in the winding of relay D and the tension on spring *g* will cause the tongue to move to its *s* contact. Condenser K will now take up a negative charge through contact *m* and tongue of relay E, conductor 73, contact *s* and tongue of relay D, and condenser K to ground.

The selecting elements of the next character received, actuate the selecting magnets of printer B, contacts *Z*₂ close and when contacts *c*₆ close, the printing magnet 16 operates, thus causing the proper letter to be printed on printer B.

A small current flows through the winding of relay D, but this current is not of sufficient value to operate the tongue of relay D against the tension of spring *g*. Printer

B will continue to operate, the tongue of relay D will rest on its contact *s*, and the tongues of relays E and F will rest on their *m* contacts until a signal of five non-selecting elements is received.

When this signal is received, at the end of the "RQ" signal, none of the selecting magnets 11, 12, 13, 14, 15 are operated and contacts *Z*₂ remain open. Then when contacts *c*₆ close, all of the current flows from positive battery through contacts *c*₆, conductor 76, the winding of relay D, and resistance *R*₂ to negative battery and the tongue of relay D operates to its *m* contact. Condenser K discharges through the tongue and *m* contact of relay D, conductor 78, and windings of relays E and F to ground. The tongues of relays E and F are operated to their *s* contacts, which is their normal position. The negative battery return is transferred back from the magnets of printer B to those of printer A by the tongue of relay F.

When contacts *c*₆ open, the circuit through the winding of relay D is broken at *c*₆ and the tongue of relay D returns to its *s* contact. Condenser K is charged with positive battery through the *s* contact and tongue of relay E, conductor 73, contact *s* and tongue of relay D, and condenser K to ground. The tongues of relays D, E and F will remain on their *s* contacts, and printer A will continue to operate in the regular manner.

The circuits from the distributor unit to the first and second selecting magnets of the printers are provided with the usual overlap relays, as disclosed in the patents above referred to.

Hence on printer A the word "telegraph" is printed without any mutilation between the letters R and A and the RQ "stop and start again" is printed on the printer B.

In the above description we have shown that by changing the construction of the original two current code as it enters the cable we are able to receive all of the transmitted signals when delivering an output equal to that of the cable Morse code.

The invention for changing the construction of the code as it enters the cable is not limited to the above but in cases where it is desirable to transmit the two-current code into a high speed circuit and in which case the fundamental waves, that is to say, the single reversal waves or a series of reversal waves are attenuated and arrive as zero signals at the end of the cable, the reconstruction of the two-current code as it enters the cable causes the signals to arrive at the distant end in such a manner that the zero signals and current signals may be repeated directly into the standard types of Baudot or multiplex receiving apparatus or Wheatstone receiving apparatus without requiring any interpolating means for filling in the signals which failed to arrive.

The reconstruction of the standard two-current code for transmitting under the above conditions and the reception thereof is shown theoretically in Figure 8, wherein the groups A and B represent the uniform two-current code as now used for multiplex operation on ocean cables. The group "A" represents the transmitted signals which are transmitted at such a high rate of speed that they arrive as represented at "B" in which case the fundamental waves, that is, the single unit waves or a series of single unit waves arrive as zero waves and have to be filled in by rotating distributors, tuning forks or whatever may be used as illustrated in U. S. Patent #1,579,999 for interpolating the zero signals.

The groups C, D and E show the standard code characters at "A" transposed or reconstructed so that they are transmitted as at C, with each selecting element transmitted with reversed current and the non-selecting elements transmitted with the same polarity as the preceding selecting element.

The group D shows the arrival of these signals with the fundamental waves missing as shown at the zero portions. If then the zero portions of this group are considered as the selecting elements which, of course, they are, the local relay which goes back to its spacing contact upon the receipt of these zero signals and goes to its marking contact on the receipt of current signals, will transform the group D into group E, which is the exact reproduction of the uniform code for these characters shown at group A.

The circuit arrangement for transposing the uniform code at the sending end is shown in Figure 9 which is practically the same as shown in Figure 3, but more simple. It will be obvious, of course, that the arrangement of the code may be reversed both at the sending and receiving ends. That is to say the non-selecting elements may be reversals and the selecting elements of the same sign as the preceding non-selecting element.

Figure 9 is the circuit arrangement for showing the adaptation of our invention in relation to Figure 8 in which we convert the signals of a uniform two-current code before it enters the cable and transmit it with a new electrical construction and as a uniform code, and not as a non-uniform code as described for the low frequency transmission.

Only enough apparatus is shown to clearly describe this adaptation of the invention which is to so change the electrical construction of the code as it enters the cable that the attenuated or missing received signals do not have to be filled in or interpolated into their constituent reversal elements. In all prior systems the attenuated signals which arrive as zeros must be filled in or interpolated into their constituent reversal elements.

The apparatus is controlled by the fork F,

which is vibrated by means of the make and break contact 80. On each outward swing of the fork tine *ft* the rotor magnet 15 is energized and the cam rotor shaft is stepped around one tooth. Each time the shaft is stepped a tooth, one of the contacts c_1 — c_5 closes and the preceding contact opens. When the contact 14 of the rotor closes, the transmitter stepping magnet 23 is energized and the tape is stepped forward in the transmitter T. The five pins of the tape transmitter are shown in the position for the character "A", that is with t_1 and t_2 in contact with the selecting bar MB, and with t_3 , t_4 and t_5 in contact with the non-selecting bar SB.

Assume that the tongue of relay R_2 rests on its *s* contact. The tongue of relay R_1 also rests on its *s* contact, due to the bias circuit BS through winding W_1 and condenser K is charged with positive battery via circuit from positive battery through *s* contact and tongue of relay R_2 , conductor 81, *s* contact and tongue of relay R_1 and condenser K to ground.

The fork tine *ft* swings outward, completing the circuit to the rotor magnet 15 from negative battery at N via the fork, contact 13, conductor 83, and rotor stepping magnet 15 to positive battery. The rotor contacts c_1 close.

On the inward swing of the fork, contact 12 is closed, which completes a circuit from negative battery at N, through the fork, contact 12, conductor 84, winding W of relay R_1 , conductor 85, contact c_1 of cam rotor, pin t_1 of the tape transmitter and selecting bar MB to positive battery. The current in winding W of relay R_1 is greater than the biasing current in winding W_1 and hence the tongue of relay R_1 moves over to its *m* contact. Condenser K discharges its positive charge into the winding of relay R_2 and operates the tongue to its *m* contact. This transmits negative battery to the line for the first element of the character "A".

As the fork tine *ft* swings outward again closing the contact 13, the magnet 15 steps the rotor cam shaft RC to open the contact c_1 and close contact c_2 . At this time the biasing current in winding W_1 of relay R_1 operates its tongue to the *s* contact so that condenser K is charged from negative battery over a circuit from negative battery through contact *m* and tongue of relay R_2 , conductor 81, contact *s* and tongue of relay R_1 and condenser K to ground.

On the next inward swing of the fork, tine *ft* makes contact at 12, completing a circuit from negative battery at N through the fork and contact 12, conductor 84, winding W of relay R_1 , conductor 85, contact c_2 of cam rotor RC, pin t_2 of the tape transmitter, and selecting bar MB to positive battery. The tongue of relay R_1 is operated to its *m*

contact, and condenser K discharges its negative charge into the winding W of relay R_2 in such a direction as to operate the tongue of relay R_2 to its *s* contact. This transmits positive battery to the line for the second element of the character "A."

Up to this point instead of transmitting the first two elements of the character "A" with the same polarity as is done with the standard transmission, shown at A in Figure 8, they are transmitted with opposite polarity as shown at C in Figure 8. For the third, fourth and fifth elements of the character "A", the rotor shaft is stepped around each time the fork makes contact at 13, thus closing the rotor contacts c_3 , c_4 and c_5 successively.

However, each time the fork tine makes contact at 12, the circuit set up from negative battery at N returns through the non-selecting bar SB to negative battery and hence no current flows in winding W of relay R_1 . The tongue of relay R_1 is held on its *s* contact by the bias circuit BS through winding W_1 , and the tongue of relay R_2 remains on its *s* contact for the duration of the third, fourth and fifth elements of the character "A", thereby transmitting positive battery to the line for these three elements. So that the character "A" as shown at A, Figure 8 which is the standard form of transmission, has been converted and transmitted as shown at C, Figure 8.

Another modification for converting the uniform code is shown in Figure 10. In this case referring to Figure 10 only the uniform code as perforated on the standard multiplex tape is referred to and is converted through the medium of the transmitter, distributor and relays so that the marking or selecting elements of the code are transmitted as reversals and the non-selecting elements with the same polarity as the preceding element. The reconstructed code, however, is transmitted as a uniform code and not as a non-uniform code as described for the low frequency transmission.

The operation of the arrangement shown in Fig. 10 is as follows: Any one contact pin *t* of the tape transmitter T operates a pair of relays R through the contacts of a relay included in the pair of relays operated by the preceding pin of the transmitter. That is to say, pin t_2 for instance of the transmitter, operates the pair of relays R_2 through the contacts *s* or *m* and tongues of the pair of relays R_1 , which are operated by contact pin t_1 of the transmitter.

These relays are merely for the purpose of converting a series of selecting elements of a character of one polarity into elements of reversed polarity. For example, the two tongues t_1 and t_2 being on the selecting bar MB of the transmitter represents the character "A". These two elements of like sign

must be transmitted with opposite polarity and the other three non-selecting elements with the same polarity as the second element of "A".

5 In the example shown, the contact pin t_1 of the tape transmitter is connected to positive battery and causes current to flow over a circuit from positive battery through conductor 86, tongue and contact m of the left
10 hand relay of pair R_5 , conductor 87, winding W of the left hand pair of relays R_1 , winding W of the right hand relay of pair R_1 , segment 1 and brush B of distributor rings P to ground or return. This operates the tongues
15 of relays R_1 to their left contacts s , and thereby places negative battery on transmitting segment 1A of the distributor rings X . Hence the first element of character "A" is stored as negative current on segment 1A of
20 rings X .

As the brush B passes to segment 2 of rings P , the contact pin t_2 of the tape transmitter, which is also connected to positive battery, causes current to flow over a circuit
25 from positive battery through conductor 88, tongue and contact s of the left hand relay of pair R_1 , windings W_1 of both relays of pair R_2 , segment 2 of rings P , brush B and solid ring to return or ground. This causes
30 the tongues of both relays R_2 to move to their contacts m . This in turn connects positive current to segment 2A of the transmitting distributor rings X via contact m and tongue of the right hand relay of pair R_2 and
35 conductor 89 to segment 2A. Hence instead of transmitting the first two elements of character "A" with the same polarity, as is done with the standard transmission, they are transmitted with the first element of negative
40 polarity and the second element of positive polarity.

The following three non-selecting elements of character "A" must now be transmitted with the same polarity as the preceding element which was positive. This is accomplished in the following manner. The pin
45 t_3 of the tape transmitter is in non-selecting position resting against the bar SB . Current of negative polarity therefore flows through a circuit from negative battery through bar
50 SB , pin t_3 , conductor 90, tongue and m contact of the left hand relay of pair R_2 , windings W of both relays of pair R_3 , conductor 91, segment 3 of distributor rings P and to ground return via brush B . This energizes
55 the pair of relays R_3 and operates their tongues to their m contacts. A circuit is thereby closed from positive battery through the m contact and tongue of right hand relay of pair R_3 , conductor 92, to segment 3A of
60 transmitting distributor rings X . Hence there is now stored on transmitting segments 1A, 2A and 3A, negative, positive and positive polarities respectively, which agrees with

the signal construction shown at C, in Figure 8.

The remaining fourth and fifth elements of character are also non-selective, the pins t_4 and t_5 of the tape transmitter being on the non-selecting bar SB . The sequence of operations which follow and store positive polarity on transmitting segments 4A and 5A will be obvious from the above description of the selection of the stored impulse upon
75 segment 3A from the non-selecting pin t_3 .

In this manner the character A of the uniform code shown at A in Fig. 8, has been electrically reconstructed and transmitted as at C in Fig. 8. Any other code character will be electrically reconstructed by the operation of the apparatus described in a similar manner.

The tape stepping magnet 23 in the transmitter T is operated in the usual manner by the brush B_2 passing over the segment M in the rings V.

It will be observed that the rings X are so positioned on the rotary distributor RD that the brushes B_1 pass thereover two segments
80 later than the brush B passes over the corresponding segments of the rings P . This is for the purpose of allowing the tongues of the relays to settle in case they should chatter upon striking their contacts. Hence the character "A" at A in Fig. 8, is transmitted as at C, Fig. 8, and is received as at D, Fig. 8, and passes into the printer apparatus as at E, Fig. 8.

Apparatus at the receiving end of the cable for receiving the signals as indicated at D in Fig. 8 and transmitting the signals to the printer as at E is shown at the upper right hand portion of Fig. 10.

The current signals of positive or negative potential operate the tongue t of the cable relay to one contact or the other while the zero signals cause the tongue to remain in central position on "no man's land" NL.

When current signals of either polarity are received, the tongue of the cable relay will move to one or the other contact c , c' , thus closing a circuit from positive battery through relay tongue t , contact c or c' , conductor 95, operating relay OP to negative
115 battery. The armature of magnet OP moves to its front contact m so that no current flows to the printer while the brush B of the distributor passes over the corresponding segment.

When a zero signal is received, or one which is so attenuated that it cannot operate the cable relay, the tongue t of the relay remains on the central insulated part NL and the relay magnet OP is not operated. Hence
125 the armature is on its back contact s and closes a circuit from positive battery through the armature and back contact of relay OP, the solid bar, brush B and a segment of the distributor D, the corresponding selecting
130

magnet *p* of the printer to negative battery. In this manner it will be seen that the zero elements of the code indicated at position D in Fig. 8, are translated by the operation of the relays and distributor at the receiving end of the cable into the selecting elements indicated at E in Fig. 8, and serve to actuate the selecting magnets of the printer.

The above arrangement for converting a uniform code into a new electrical construction and for transmitting the new construction as a uniform code is one of many embodiments of our invention. The fundamental idea which we have disclosed herein is to arrange the electrical construction of a standard two-current code before it enters the cable so that the missing attenuated received signals do not have to be filled in or interpolated into their constituent reversal elements. All prior schemes in this particular art, transmit the signals so that the attenuated signals which arrive as zeros have to be filled in or interpolated into their constituent reversal elements.

We have shown the above arrangement so that it can be extended for as many channels as may be used in multiplex operation. While one preferred form of apparatus is shown for the purpose of fully disclosing the invention, it will be obvious to engineers that other means may be employed. For instance a motor with a clutch may be used instead of the stepper device for the cam shaft.

We claim:

1. The method of transmitting telegraph code signals over a line or cable from a transmitting station to a receiving station which consists in transmitting the elements of the code characters in such a manner that succeeding selecting or marking elements shall be of opposite polarity, the spacing or non-selecting elements of the same polarity as the preceding selecting element, the selecting elements having a duration of at least one time unit and the spacing elements having a duration less than the selecting elements.

2. In the method set forth in claim 1, transmitting all of the elements of the code characters either as positive or negative impulses, and at the receiving station transforming the non-selecting elements into impulses of zero polarity.

3. The method of transmitting telegraph code signals over a line or cable which consists in transmitting over the line characters of the usual uniform element code, such as the Baudot five-unit code, as a non-uniform element code wherein the selecting elements have a duration of at least one time-unit, and the non-selecting elements have a shorter duration than the selecting elements, and wherein all of the elements of each character are received either as positive or negative impulses, so that there are no missing impulses to be supplied or interpolated.

4. The method as defined in claim 3 wherein the non-selecting elements of the received impulses of the code characters are transformed and delivered to a recorder as zero impulses.

5. The method of transmitting telegraph code signals over a line or cable which consists in preparing a message in code characters having selecting and non-selecting elements and prolonging the normal transmitting time length of either the selecting or the non-selecting elements.

6. The method of transmitting telegraph code signals over a line or cable which consists in punching a transmitting tape with perforations indicating a message according to a uniform code composed of selecting and non-selecting elements, and prolonging the transmitting time of certain of said elements beyond the normal unit time length.

7. The method of transmitting telegraph code signals which consists in setting up an intelligence message in code characters of selecting and non-selecting elements of uniform time-unit length, translating said code characters into characters having elements of differential length, transmitting said differentialized characters continuously, and receiving said differentialized elements in continuous succession, whereby any error in said reception immediately destroys the proper sequence in the reception and renders the code characters unintelligible.

8. The method of transmitting telegraph code signals which consists in setting up an intelligence message in code characters of selecting and non-selecting elements of uniform time-unit length, translating said code characters into characters having elements of differential length wherein certain of said elements are increased to a greater length than the time length of a uniform code element and other elements are shorter than said unit time length, whereby the transmitting rate of code letter speed may be greater than the letter speed of said uniform code while maintaining the same fundamental unit-time length of the transmitting frequency.

9. The method of transmitting intelligence code messages at a greater speed than can be attained with a uniform code at the same fundamental frequency of transmitted unit time elements, which consists in setting up an intelligence message in code characters wherein the selecting and non-selecting elements of the usual uniform code are differentialized so that the elements of one kind have a duration of at least one time unit and those of the other kind are shorter in duration than said time unit, transmitting said elements with succeeding elements of said first kind of reversed polarity and causing said elements of reversed polarity to effect the recording of the intelligence code message.

10. The method of transmitting telegraph

messages with code characters having a uniform number of elements or impulses at such a speed that single time unit elements are attenuated and too feeble to be received, which consists in transmitting succeeding selecting impulses of each character with reversed polarity and the non-selecting elements of the same polarity as the preceding selecting element, and causing the non-selecting elements to effect the operation of receiving apparatus and the recording of the intelligence code messages.

11. The method of transmitting telegraph messages with code characters at such a speed that the reversal elements are attenuated and too feeble to be received, which consists in transmitting succeeding selecting impulses of each character with reversed polarity and the non-selecting elements of the same polarity as the preceding selecting element and causing the non-selecting elements to effect the operation of the receiving apparatus and the recording of the intelligence code messages.

12. The method of transmitting telegraph messages with code characters at such a speed that the reversal elements are attenuated and too feeble to be received, which consists in transmitting succeeding elements of one length with reversed polarity and elements of another length of the same polarity as the preceding element and causing the receiving apparatus to be operated only by the elements of one length.

13. The method of transmitting telegraph messages with code characters at such a speed that the reversal elements are attenuated and too feeble to be received, which consists in changing the transmission of the original code as it enters the cable or attenuating circuit, by transmitting the selecting elements of the code with reversed polarity and the non-selecting elements with the same polarity as the preceding element or vice versa, and causing the signals which fail to arrive to function the recording apparatus in their received block form without requiring any local interpolating means for converting the zero signals into their transmitted reversal form.

In testimony whereof we affix our signatures.

HERBERT ANGEL.
JAMES W. ROBINSON.