

Dec. 1, 1942.

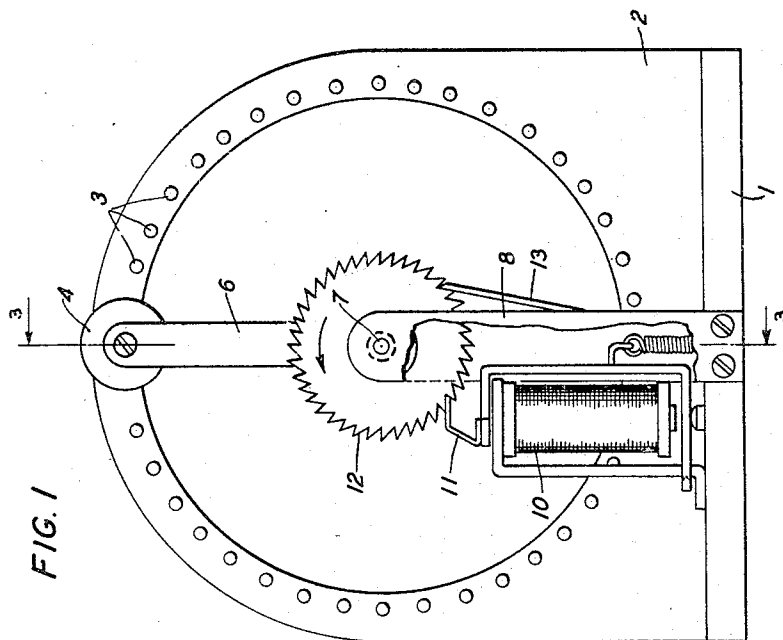
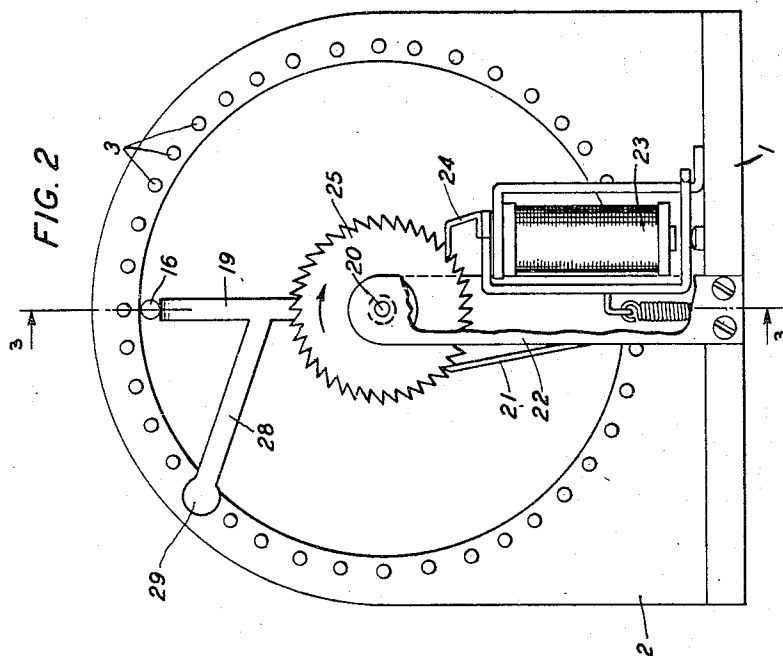
T. L. DIMOND

2,303,918

IMPULSE TRANSMISSION

Filed March 7, 1941

3 Sheets-Sheet 1



INVENTOR
T. L. DIMOND
BY *W. D. McJannet*
ATTORNEY

Dec. 1, 1942.

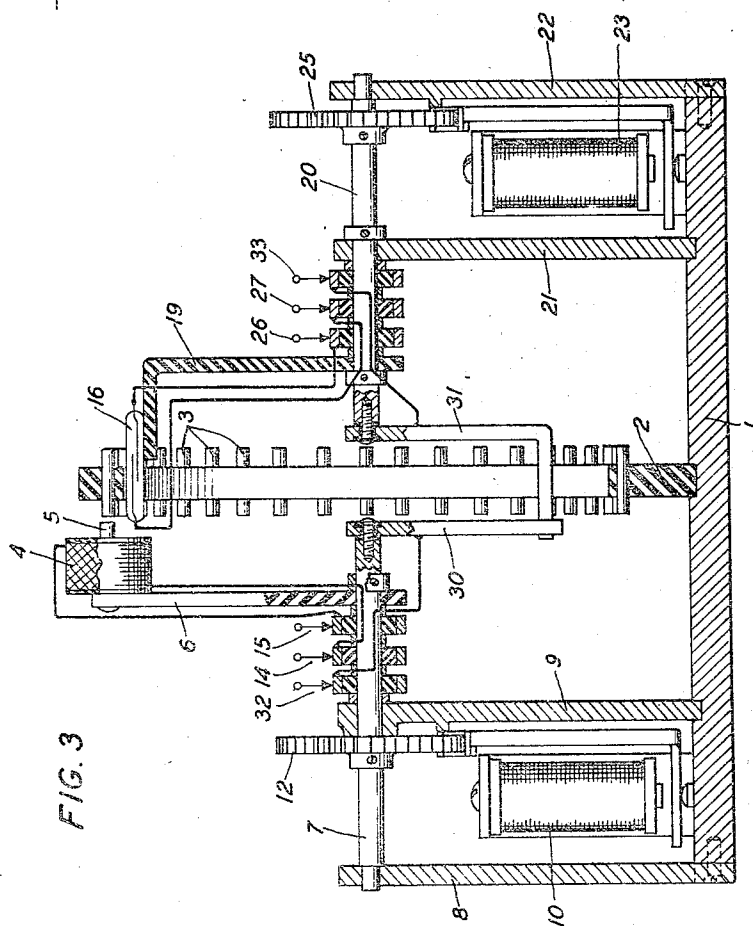
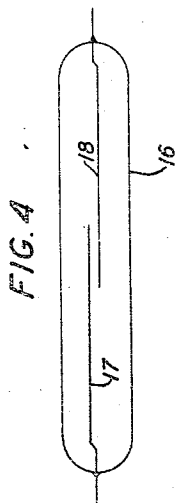
T. L. DIMOND

2,303,918

IMPULSE TRANSMISSION

Filed March 7, 1941

3 Sheets-Sheet 2



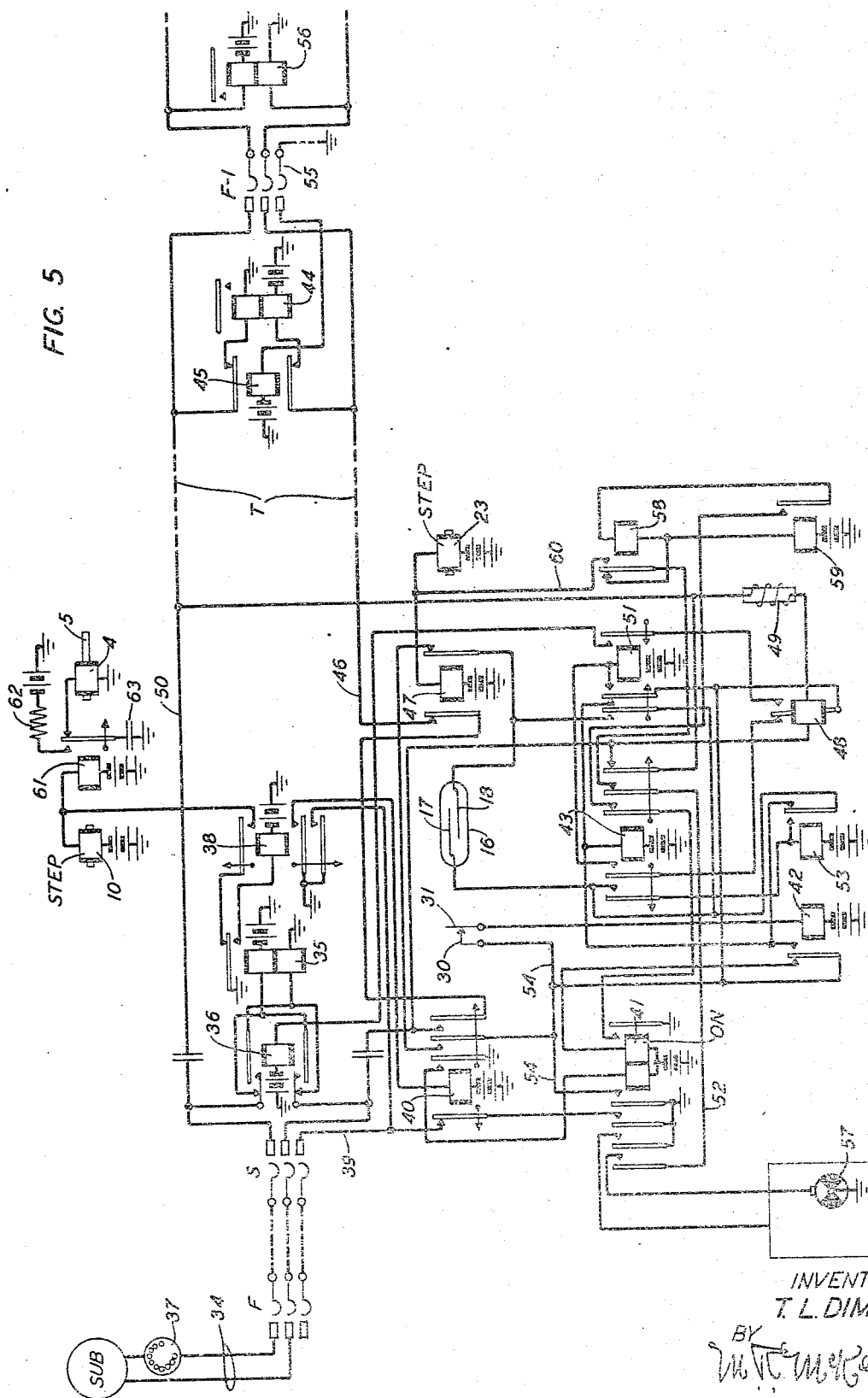
Dec. 1, 1942.

T. L. DIMOND
IMPULSE TRANSMISSION
Filed March 7, 1941

2,303,918

3 Sheets-Sheet 3

FIG. 5



INVENTOR
T. L. DIMOND

BY
W. T. McGurney
ATTORNEY

UNITED STATES PATENT OFFICE

2,303,918

IMPULSE TRANSMISSION

Thomas L. Dimond, Rutherford, N. J., assignor to
Bell Telephone Laboratories, Incorporated,
New York, N. Y., a corporation of New York

Application March 7, 1941, Serial No. 382,157

8 Claims. (Cl. 179-16)

This invention relates to the transmission of impulses and particularly to impulse repeaters used in telephone or other communication systems.

The objects of the invention are to simplify the structure and the operation of impulse repeaters; to obtain improvements in the registration and counting of the impulses; to enable the immediate seizure and operation of an impulse repeater; and otherwise to improve these devices.

For some purposes it is desirable to use an impulse repeater in which each series of impulses is momentarily stored or registered and is then retransmitted. Usually the incoming series of impulses is registered on a stepping switch which advances and marks a terminal corresponding to the number of impulses; and the number of outgoing impulses is counted by a counting switch which steps over its terminals until it reaches the position marked by the register switch.

According to the present invention improvements are obtained over these prior repeating mechanisms by making use of magnetic elements for marking the number of impulses in an incoming series and for counting the number of impulses in an outgoing series. More specifically a feature of the present invention is an impulse repeater comprising a series of magnetic elements preferably arranged along the arc of a circle, a magnetizing device which is driven by the incoming impulses over the series of elements to select and magnetize any desired element marking the number of incoming impulses, and a magnetically responsive device which is driven in synchronism with the outgoing impulses into operative relation with the successive magnetic elements until it reaches one that is magnetized. When a magnetized element is encountered, marking the number of impulses in the incoming series, the magnetically operable device responds and terminates the transmission of the outgoing impulses.

One of the advantages of the present invention is that many of the moving magnetic parts, usually employed in impulse repeaters of this kind, have been eliminated, and in place of these magnetically controlled elements have been substituted.

The foregoing and other features of the invention will be described more fully in the following detailed specification.

In the drawings accompanying the specification:

Fig. 1 is a view showing one end of an impulse

repeating mechanism incorporating the features of this invention;

Fig. 2 is a view of the opposite end of this device;

Fig. 3 is a front view of the structure partly in cross-section;

Fig. 4 is an enlarged view of the magnetic relay which serves to count the outgoing impulses; and

Fig. 5 shows the circuits of the repeater when applied to an automatic telephone system.

This invention may be used wherever it is desired to repeat series of impulses and particularly where it is advantageous to store the impulses briefly and to retransmit them in corrected or modified form. Such a repeater is useful in automatic telephone systems where it is necessary to receive impulses from subscribers' dials, from operators' dials or from central office senders and to repeat them over outgoing circuits to switches or senders beyond. Although not so limited, the invention is applied, as illustrated in Fig. 5, to an outgoing repeater in a telephone system. It could, of course, be applied equally as well to incoming repeaters or to repeaters or regenerators when used for other purposes in systems of this kind.

The structure of the repeater, illustrated in Figs. 1, 2 and 3, includes a base or frame member 1 having an annular shaped plate 2 of non-magnetic material secured thereto. The plate 2 supports a series of magnetic elements in the form of pins 3. These pins are fixed around the circumference of the annular plate 2, projecting from either side thereof as illustrated best in Fig. 3. There may be any suitable number of pins in the series depending upon the requirements of the repeater, such as the number of impulses necessary to send in each series and the number of successive series that the repeater may be called upon to receive and retransmit. These pins may be of any suitable magnetic material and are preferably made of some material that is readily magnetized and demagnetized.

The magnetizer, which serves to select and magnetize the pins 3, consists of an electromagnetic coil 4 wound about a core 5, which in turn is secured to the rotatable arm 6. The arm 6, which may be of any suitable insulating material, is attached to a shaft 7, and the latter is journaled for rotation in the upright supports 8 and 9. The shaft 7 is driven in a step-by-step movement to advance the magnetizer from each pin position to the next by a pulse receive-

ing magnet 10. The magnet 10 drives the shaft 7 by means of a stepping pawl 11 which engages the ratchet wheel 12 secured on the shaft. The shaft is held in any position to which it is advanced by means of a holding pawl 13 which also cooperates with the teeth of the ratchet wheel 12.

As soon as the magnetizing coil 4 has been advanced by the magnet 10 through the number of positions corresponding to the incoming series of impulses and is brought to rest with the core 5 in close proximity to the pin 3 in the selected position, the coil is energized to set up a magnetic field in the core 5 which magnetizes the selected pin. The circuit for energizing the coil 4 extends through the brushes 14 and 15 and the associated slip rings, mounted on the shaft 7 and insulated therefrom.

The number of outgoing impulses transmitted is counted by a counting mechanism including a magnetic relay 16. The relay 16, shown more clearly in Fig. 4, consists of a small vessel of glass or similar material within which the two flexible magnetic contacts 17 and 18 are sealed. These contacts are normally separated and are flexed into engagement with each other when the relay is adjacent to one of the magnetized pins 3. The magnetic relay 16 is mounted on the arm 19, which is rotatable to move the relay around the inner periphery of the annular plate 2, bringing said relay into close proximity with the successive pins 3. The arm 19 is rotated in a step-by-step movement by the shaft 20, which is journaled in the upright supports 21 and 22. The stepping movement of the shaft 20 for advancing the magnetic relay 16 through the successive pin positions is effected by a stepping magnet 23 having a stepping pawl 24 which cooperates with the ratchet wheel 25 secured to the shaft. The holding pawl 21 serves to hold the shaft 20 centered with the relay 16 in close proximity to the magnetic pin in the associated position. The circuit controlled by the magnetic contacts 17 and 18 extends through the brushes 26 and 27 and the associated slip rings, which are mounted on the shaft 20 and insulated therefrom.

The rotating arm 19 has an extension arm 28 thereon (Fig. 2) carrying a magnet 29 for the purpose of demagnetizing the pins 3 over which it passes. The magnet 29 may be a permanent magnet, or, if desired, it may be energized by a coil over a circuit extending through brushes and slip rings on the shaft 20.

It will be noted that the shaft 7 carries a rotating arm 30 and that shaft 20 carries a similar arm 31. They are made of conducting material and are in contact with each other when the magnetizer 5 and the magnetic relay 16 occupy the same position, that is, when the magnetizer and relay are in proximity to the same magnetic pin 3. These contact arms 30 and 31 are insulated from the shafts 7 and 20, respectively, to which they are attached. When they engage each other, a circuit is closed which leads through the brush 32 and its slip ring on the shaft 7 and through brush 33 and its slip ring on the shaft 20. This electrical circuit, as will be explained later, serves to determine when the impulse receiving or registering part of the repeater and the impulse counting or transmitting part of the repeater are occupying the same position.

A description will now be given of the operation of the repeater and for this purpose it may

be assumed that the subscriber of line 34, shown in Fig. 5, is in the process of establishing a telephone connection by transmitting successive series of impulses. When the subscriber initiates a call, the line finder F operates in the well-known manner to seize the calling line, and, thereafter, selector switches including the switch S are operated in response to impulse series sent over the calling line to seize the outgoing repeater shown in detail in the drawings. The function of the repeater thus seized by the selector switch S is to repeat succeeding series of impulses over the trunk T outgoing to a distant office where it appears in the bank of a finder switch F-1, the purpose of which may be to extend the trunk to a series of selector switches or to a register sender.

As soon as the repeater is seized a circuit is closed from battery through the upper winding of the impulse relay 35, normal contacts of relay 36 thence over one side of the extended connection through the subscriber's station including the dial 37 and returning over the other side the connection through the normal contacts of relay 38 and the lower winding of relay 35 to ground. Relay 35 operates and closes an obvious operating circuit for slow release relay 38. Relay 38 places a guarding ground potential on the sleeve conductor 39 and also closes an operating circuit for slow release relay 40. Relay 40 closes the outgoing trunk to establish a circuit which may be traced from battery through the lower winding of line relay 44 at the distant office, normal contacts of cut-off relay 45, conductor 46, normal contacts of relay 47, closed contacts of relay 40, winding of polarized relay 48, retard coil 49, and in parallel through the normal contacts of relay 43, conductor 50, contacts of relay 45 to ground through the upper winding of relay 44. Line relay 44 operates and in the well-known manner initiates the hunting operation of the finder switch F-1. The current flowing over the trunk T in the circuit above traced is in the proper direction to operate the polarized relay 48 when the short circuit is removed by relay 43. Relay 40 also closes an operating circuit for the off-normal relay 41.

Assuming that the repeater is at rest at the moment it is seized by the switch S, the contact making arms 30 and 31 are in electrical engagement with each other, and the magnetizer 5 and relay 16 are occupying the same position. When, therefore, the off-normal relay 41 operates it closes a circuit from ground through the engaged contact arms 30 and 31, winding of relay 42 to battery. Relay 41 also closes a circuit from ground through the inner left armature and contact of relay 51 to battery through the winding of relay 43. Relay 42 operates and closes a second circuit from ground through the contact of relay 41, front contact of relay 42 and the winding of slow release relay 43 to battery and ground. Relay 43 operates and opens the short circuit around relay 48 and retard coil 49, permitting relay 48 to operate. Relay 43 also prepares a circuit for the supervisory relay 51, but this circuit is now opened at the back contacts of the operated relay 48. Furthermore relay 43 opens the impulse conductor 52 to prevent the sending of outgoing impulses until all of the necessary conditions have been satisfied. Relay 43 in operating at this time also closes a circuit from battery through the winding of relay 53, front contacts of relay 43 and back contacts of relay 51, normal contacts of impulse

relay 47, closed contacts of relay 40, conductor 54 to ground at the contact of relay 41. If the pin 3 opposite which the relay 16 was left on the last use of the repeater is sufficiently magnetized at this time, the contacts 17 and 18 are still closed, and a parallel circuit for relay 53 may be traced through said contacts 17 and 18. Relay 53 operates and locks through its front contact and thence as above traced through the contacts of relay 51 and the contacts of relay 16 in parallel to ground on conductor 54.

When, following the seizure of the repeater the calling subscriber transmits the next series of impulses, relay 35 releases and reoperates for each impulse of the series. At each release of the relay 35 a circuit is closed from ground through the back contact of said relay, contacts of relay 38 and in parallel through the winding of slow release relay 61 and stepping magnet 10. Relay 61 operates and remains energized throughout the series, and magnet 10 follows the impulses to step the shaft 7 and the magnetizer 5 through one position for each impulse in the series. At the end of the series relay 35 remains operated, and relay 61 releases after an interval. While relay 61 was operated it closed a charging circuit from battery through the resistance 62 for condenser 63. Upon the release of relay 61 the condenser 63 discharges and energizes the magnetizing coil 4. Coil 4 magnetizes the core 5 and the pin 3 in the position to which the magnetizer has been driven by the incoming series of impulses. When the shaft 7 takes its first step in response to the first incoming impulse, the contact 30 disengages the contact 31. The opening of these contacts causes the release of relay 42. Relay 42 opens one of the energizing circuits of relay 43, but relay 43 remains energized over the circuit traceable through the back contacts of relay 51 to grounded conductor 54 until the equipment at the distant office is ready to receive the repeated impulses.

It will be recalled that the relay 44 at the distant office operates as soon as the trunk is seized and starts the movement of a switch, such as the line finder F—1, to attach a switch or a sender for receiving the repeated impulses. When the finder F—1 has found the line, a ground potential is applied over test brush 55 to operate the cut-off relay 45 and disconnect the line relay 44. At the same time, however, the trunk T is extended through the windings of the impulse receiving relay 56 associated with the switch or sender. This substitution of the relay 56 for the relay 44 causes a reversal in the direction of current flow over the trunk T, and relay 48 releases. Relay 48 closes an operating circuit for the slow operate supervisory relay 51 which may be traced from battery through the winding of relay 51, front contacts of relay 43, back contacts of relay 48 to ground on conductor 54. After an interval relay 51 operates and locks directly to conductor 54. The operation of relay 51 is a signal that the equipment at the distant office is ready to receive the repeated impulses. This signal is manifested by the opening of the second holding circuit of relay 43, the first circuit having been opened by contacts 30 and 31 in response to the first incoming series of impulses. Relay 43 now releases and closes the pulsing lead 52 so that outgoing impulses may proceed. Relay 43 also closes a short circuit around the relay 48 and coil 49 to improve the pulsing operation. Relay 51 opens one branch of the holding circuit of relay 53, and the latter relay releases un-

less the magnetic relay 16 is still closed, in which case the relay 53 remains energized.

On the first closure of interrupter 57 following the release of relay 43 a circuit is closed from ground through said interrupter, contacts of relay 41, conductor 52, back contacts of relay 43, back contacts of relay 58, through the winding of relay 59 to battery. Relay 59 operates and prepares a circuit through its own winding and the winding of relay 58 in series through contacts of relays 43 and 41 to ground. On the next opening of interrupter 57 relay 58 energizes in series with relay 59 and extends the pulsing conductor 52 to the conductor 60. For each closure of the interrupter thereafter an impulse is sent over conductor 60 to the winding of the stepping magnet 23 and impulse relay 47. Each operation of the relay 47 opens the trunk circuit T to send an impulse to the receiving relay 56 at the distant office. Each operation of the magnet 23 steps the shaft 20 and the magnetic relay 16 to the next succeeding position. On the first operation of relay 47, when the shaft 20 and relay 16 take the first step, the holding circuit of relay 53 is opened, and this relay releases, provided it had not previously released at the time relay 51 operated.

The shaft 20 continues to step in synchronism with the outgoing impulses until the magnetic relay 16 reaches the position occupied by the pin 3 that was magnetized to mark the termination of the first series of incoming impulses. Thereupon the contacts 17 and 18 are closed, and after the completion of the open pulse by the release of relay 47, a circuit is completed from battery through the winding of relay 43, back contacts of relay 53, contacts 17 and 18, back contacts of relay 47, contacts of relay 40 to the grounded conductor 54. Relay 43 reoperates and opens the pulsing conductor 52 to terminate the transmission of the outgoing impulses and to stop the stepping movement of the shaft 20. Relay 43 also releases the relays 58 and 59. If in the meantime the calling subscriber has not transmitted the next series of impulses, the contact 31 engages contact 30, and relay 42 operates to close the alternate circuit for relay 43. Relay 43 reoperates relay 53 through the closed contacts of relay 16, and relay 53 again locks through its own front contact as long as relay 16 remains operated and relay 47 released. If, however, the calling subscriber has commenced the transmission of the next series prior to the time the relay 16 reaches the marked pin, no closure results between the contacts 30 and 31; or, as soon after the relay 16 reaches the pin marked by the preceding series of impulses as the subscriber commences the transmission of the succeeding series, contacts 30 and 31 are disengaged to effect the release of relay 42. In either case the release of relay 42 on the one hand or its failure to operate on the other and the operation of relay 53 result in the release of relay 43 to reclose the pulsing conductor 52. Following the closure of conductor 52, relays 59 and 58 operate to measure the interdigital space, following which relay 47 is repeatedly operated to transmit the next outgoing series and magnet 23 is operated in synchronism to advance the shaft 20 until the relay 16 reaches the magnetized pin marking the end of the next series of incoming impulses. When this next magnetized pin is reached relay 16 reoperates and closes an energizing circuit for relay 43 as above described, and the outgoing series of impulses is terminated.

This procedure continues until all impulse series have been received and retransmitted. Upon the completion of the last series of impulses contacts 30 and 31 close, and relay 42 operates, in turn operating relay 43. Relay 43 removes the short circuit from around relay 48 and coil 49 to include them in the supervisory circuit.

When the called subscriber answers, the direction of current flow over the trunk T is again reversed, and relay 48 operates. A circuit is now closed from battery through the winding of relay 36, front contacts of relays 51 and 48 to the grounded conductor 54. Relay 36 operates and reverses the direction of current flow toward the calling subscriber's line thereby sending the usual supervisory signal.

When the calling subscriber releases, which may occur either before or after the connection has been completed relay 35 releases, operating relay 61 and magnet 10. Relay 61 causes the recharging of condenser 63, and magnet 10 prepares to advance the shaft 7 to the next position. After an interval relay 38 releases, and, following a further interval, relay 61 releases, and the condenser 63 energizes the magnetizing coil 4 to magnetize the pin 3 in the position now occupied by the magnetizing coil 4. Relay 38 removes ground potential from the hold conductor 39 to permit the release of the switches F and S and any other switches involved in the preceding train. Relay 38 releases relay 40 which extends the sleeve conductor 39 to ground on the front contact of relay 41, thus guarding the repeater against seizure. Relay 40 also opens the outgoing trunk T to permit the release of the equipment in the distant office. Relay 41 remains locked through the back contacts of relay 42, assuming that contacts 30 and 31 are separated at this time. The release of relay 40 opens the holding circuit of relay 53 and also prevents the reclosure of the circuit for relay 43. Hence relay 43 releases and recloses the pulsing conductor 52 for stepping the magnet 23 to advance the shaft 20 until contacts 30 and 31 are closed. When this occurs relay 42 operates and releases relay 41. Relay 41 in turn releases relay 42. Thus the receiving and transmitting parts of the repeater are restored to the same position, and the repeater circuits are fully restored to normal.

What is claimed is:

1. In combination, a repeater comprising a series of magnetic elements, means movable in response to a series of incoming impulses for selecting a corresponding one of said elements, means for magnetizing the selected elements, an impulse transmitter for generating and transmitting outgoing impulses, a counting mechanism including a magnetic device, means responsive to said impulse transmitter for moving said device into operative relation to the successive magnetic elements of said series, said device being operated magnetically when it moves into operative relation to said magnetized element, and means responsive to the operation of said magnetic device for terminating the transmission of the outgoing impulses.

2. In combination, a repeater comprising a series of stationary magnetic elements, a magnetizer movable into proximity with each of the successive magnetic elements in said series, means responsive to a series of incoming impulses for moving said magnetizer into proximity with the particular magnetic element representing the number of impulses received, said

magnetizer serving to magnetize the selected magnetic element to mark the number of impulses received, a transmitter for generating and transmitting outgoing impulses, a magnetic device movable into proximity with each of the successive magnetic elements of said series, means cooperating with said impulse transmitter for moving said magnetic device in synchronism with the outgoing impulses until it reaches the magnetized element, the magnetism of said element serving to operate the magnetic device, and means controlled by the operation of said magnetic device for disabling the impulse generator to determine the outgoing series of impulses.

3. In combination, an impulse repeater comprising a plurality of stationary magnetic elements arranged in a series of positions, a magnetizer movable from one position to the next and into proximity with each of the magnetic elements of the series, means responsive to the impulses of an incoming series for advancing said magnetizer into a selected position corresponding to the number of impulses in said series, means for causing said magnetizer to magnetize the element in the selected position, and impulse transmitter for generating and transmitting outgoing impulses, a counting mechanism, means for driving said mechanism through the successive positions of said series to count the outgoing impulses, a magnetic device movable with said counting mechanism and responsive to the magnetism of the magnetized element when it moves into the position occupied by said magnetized element, and means responsive to the operation of said magnetic device for terminating the outgoing series of impulses.

4. The combination in an impulse repeater of a plurality of magnetic elements arranged in a series of positions, a magnetizer movable from position to position and into proximity with each of said magnetic elements, means responsive to the impulses of an incoming series for advancing said magnetizer from any one of said positions to a succeeding position representing the number of impulses received, means for energizing said magnetizer to magnetize the magnetic element in said succeeding position, a counting mechanism including a magnetic device movable from position to position and into proximity with each of said magnetic elements, a transmitter for generating and transmitting outgoing impulses, means responsive to the incoming impulses for rendering said impulse transmitter effective to transmit the outgoing impulses, means controlled by said impulse transmitter for advancing said counting mechanism through successive positions to bring said magnetic device into proximity with the magnetized element, the magnetism of said element serving to operate said magnetic device, and means controlled by said magnetic device for terminating the transmission of the outgoing impulses.

5. The combination in an impulse repeater of a plurality of stationary magnetic elements arranged in a series of positions, a magnetizer movable from one position to another and into operative relation to each of said magnetic elements, means responsive to incoming impulses for advancing said magnetizer in a stepping movement from any position to a succeeding position representing the number of incoming impulses, means for energizing said magnetizer to magnetize the element in said succeeding position, a transmitter for generating and transmit-

ting outgoing impulses, means responsive to the incoming impulses for rendering said transmitter effective to transmit outgoing impulses, means including a magnetic relay movable through said series of positions and into operative relation with each one of said magnetic elements, means controlled by said impulse transmitter for driving said relay in a stepping movement through a number of positions corresponding to the number of outgoing impulses transmitted, said magnetic relay being operated when it moves into a position occupied by a magnetized magnetic element, and means controlled by the operation of said relay for terminating the transmission of the outgoing impulses.

6. The combination in an impulse repeater of a plurality of magnetic elements arranged in a series of positions, a magnetizer movable through positions of said series and into operative relation to each of said magnetic elements, means responsive to successive series of impulses for moving said magnetizer from any position to succeeding positions, each of which corresponds to the number of impulses in each of the successive incoming series, means for causing said magnetizer to magnetize the elements in the positions corresponding respectively to each of said impulse series, means for detecting the magnetized elements, means for transmitting series of outgoing impulses, and means controlled by said detecting means for determining the number of impulses in each of said outgoing series.

7. In combination, an impulse repeater, means for seizing said repeater to repeat a series of incoming impulses, said repeater including a plurality of magnetic elements arranged in a series of positions, a magnetizer responsive to said incoming impulses for selecting the magnetic element in the position corresponding to

the number of impulses in said incoming series, means for causing said magnetizer to magnetize the selected magnetic element, transmitting means for generating and transmitting a series of outgoing impulses corresponding to said incoming impulses, a magnetic relay movable from one position to the next and into operative relation with each of said magnetic elements, means responsive to the incoming impulses after the seizure of said repeater for rendering said impulse transmitting means effective to transmit outgoing impulses, means controlled by said impulse transmitting means for advancing said magnetic relay into the position selected by said magnetizer in response to the incoming impulses, said magnetic relay being operated by the magnetized element in the selected position, and means controlled by said relay when operated for terminating the transmission of the outgoing impulses.

8. In combination, a repeater comprising a series of magnetic elements, means movable in response to a series of incoming impulses for selecting a corresponding one of said elements, means for magnetizing the selected element, an impulse transmitter for generating and transmitting outgoing impulses, a counting mechanism including a magnetic device, means responsive to said impulse transmitter for moving said device into operative relation to the successive magnetic elements of said series, said device being operated magnetically when it moves into operative relation to said magnetized element, means responsive to the operation of said magnetic device for terminating the transmission of the outgoing impulses, and means for demagnetizing said magnetized element.

THOMAS L. DIMOND.