

June 8, 1937.

S. R. DURAND

2,082,877

MULTIPLEX COMMUNICATION SIGNALING SYSTEM

Filed Oct. 21, 1932

3 Sheets-Sheet 1

FIG. 1

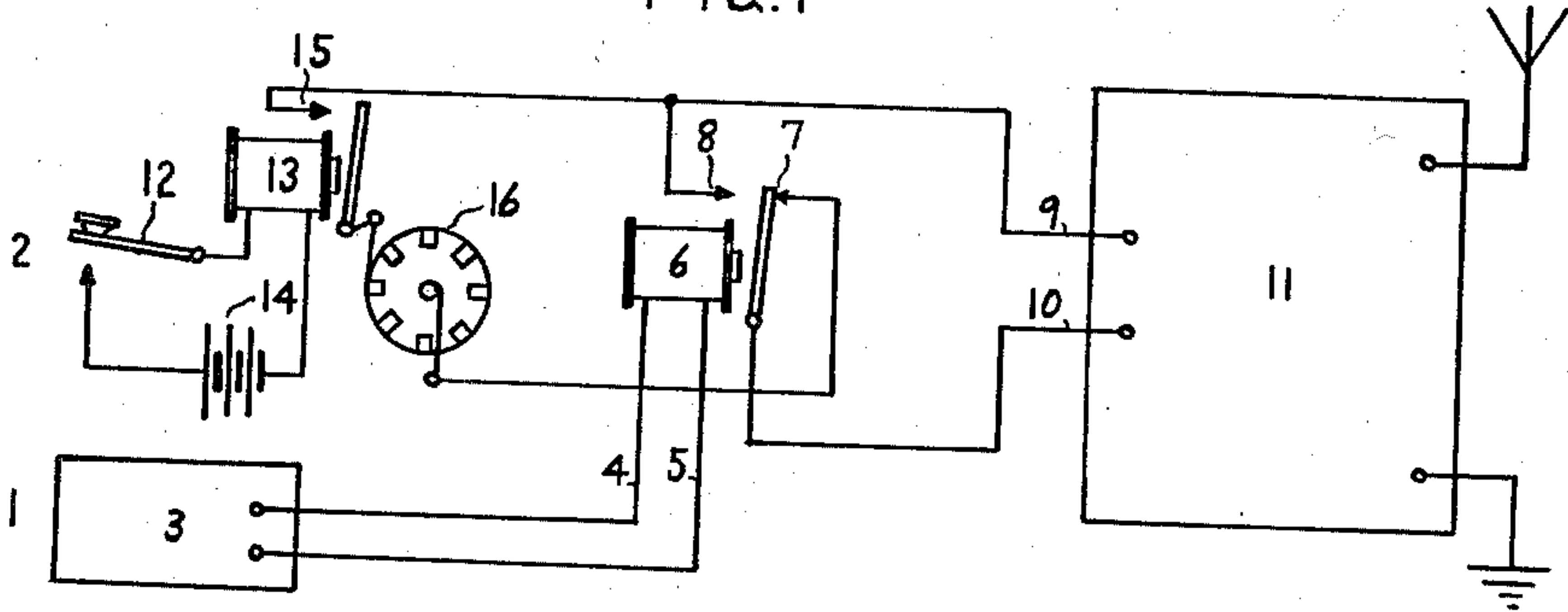


FIG. 2A

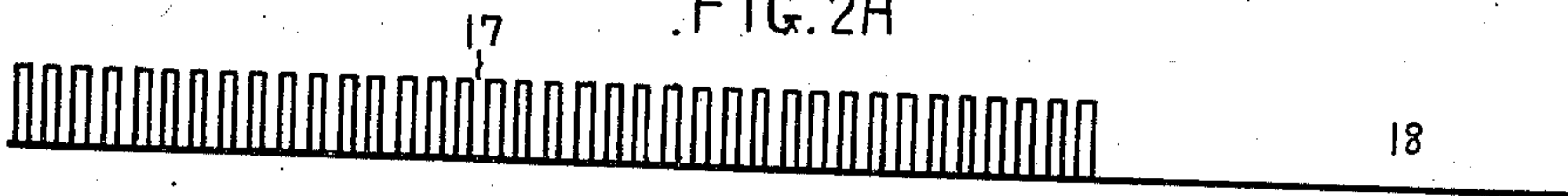


FIG. 2B

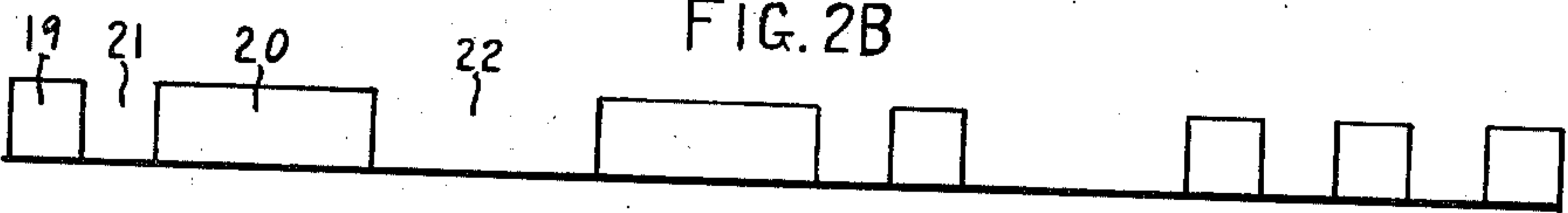


FIG. 2C

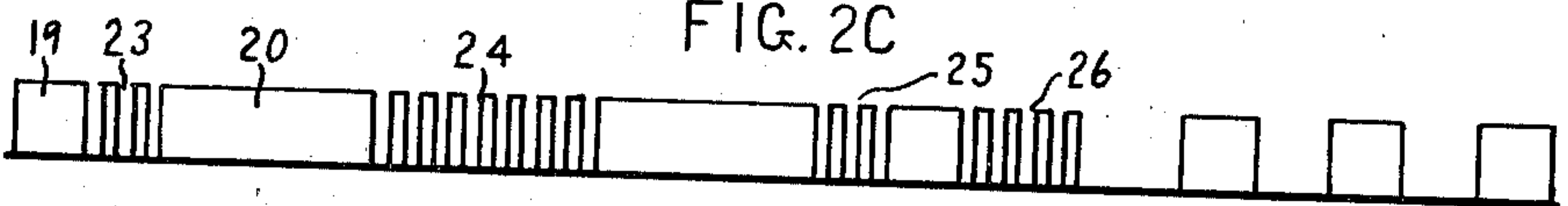


FIG. 3

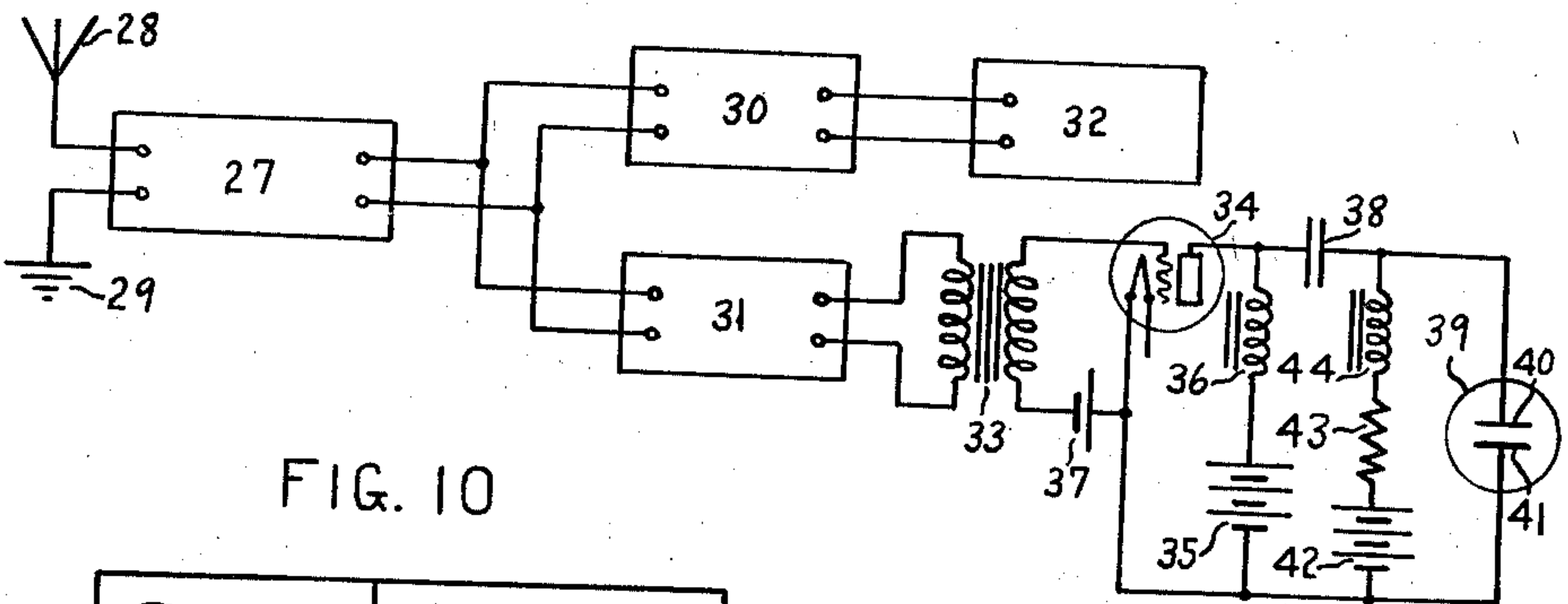
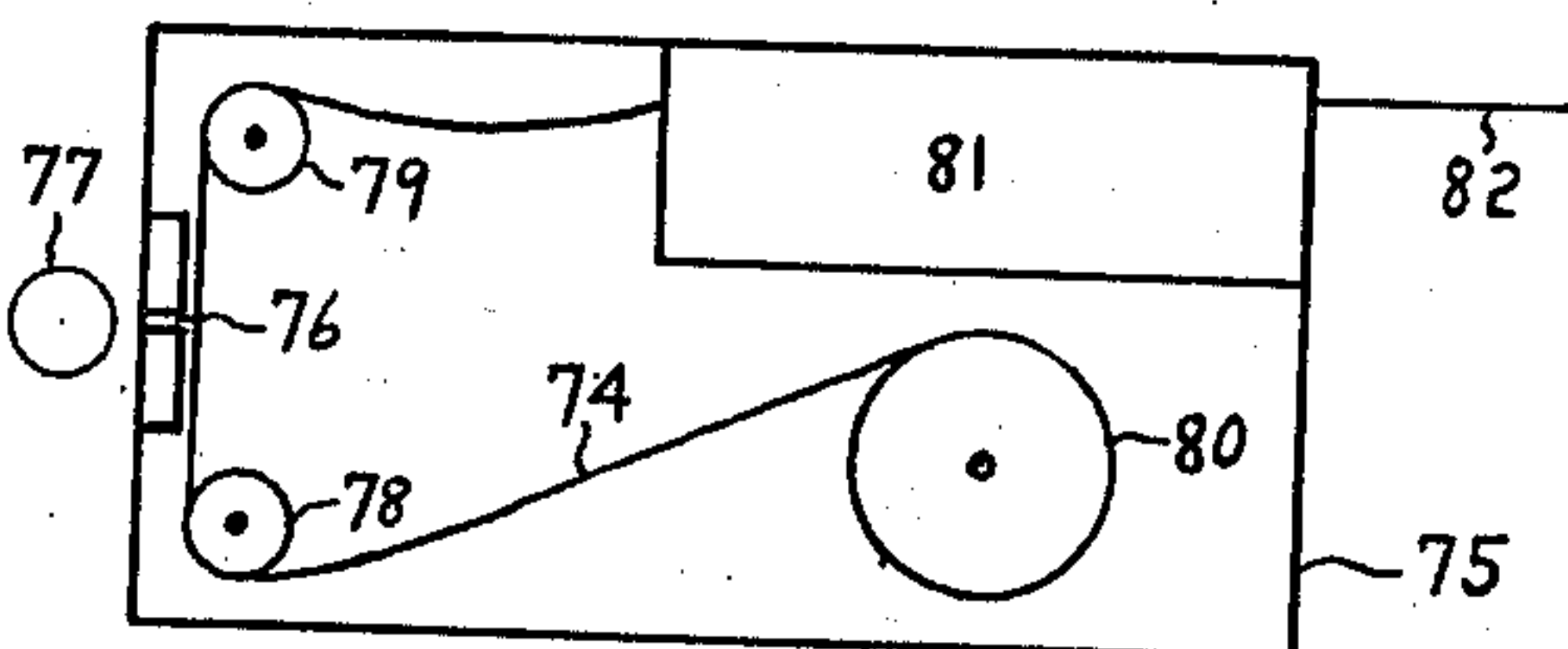


FIG. 10



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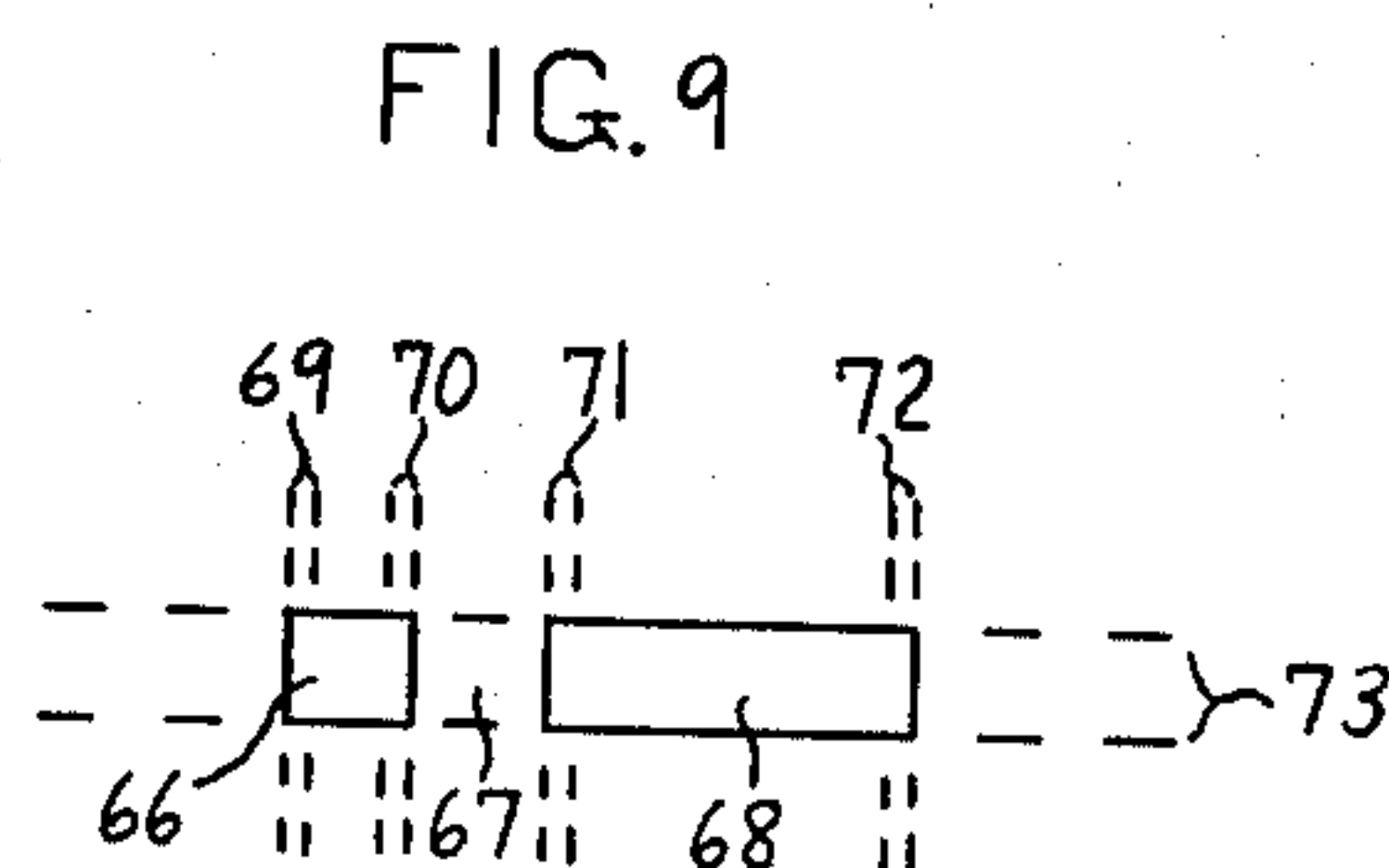
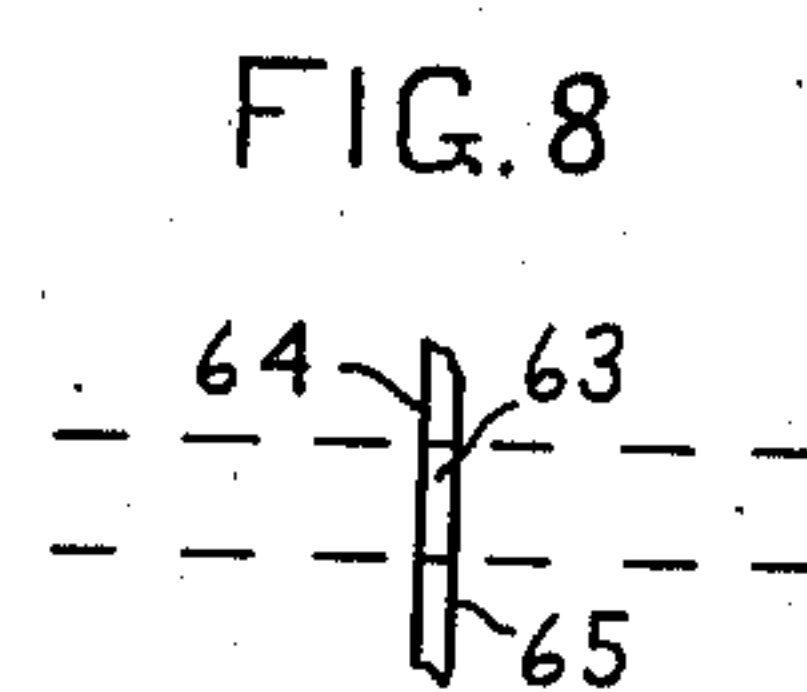
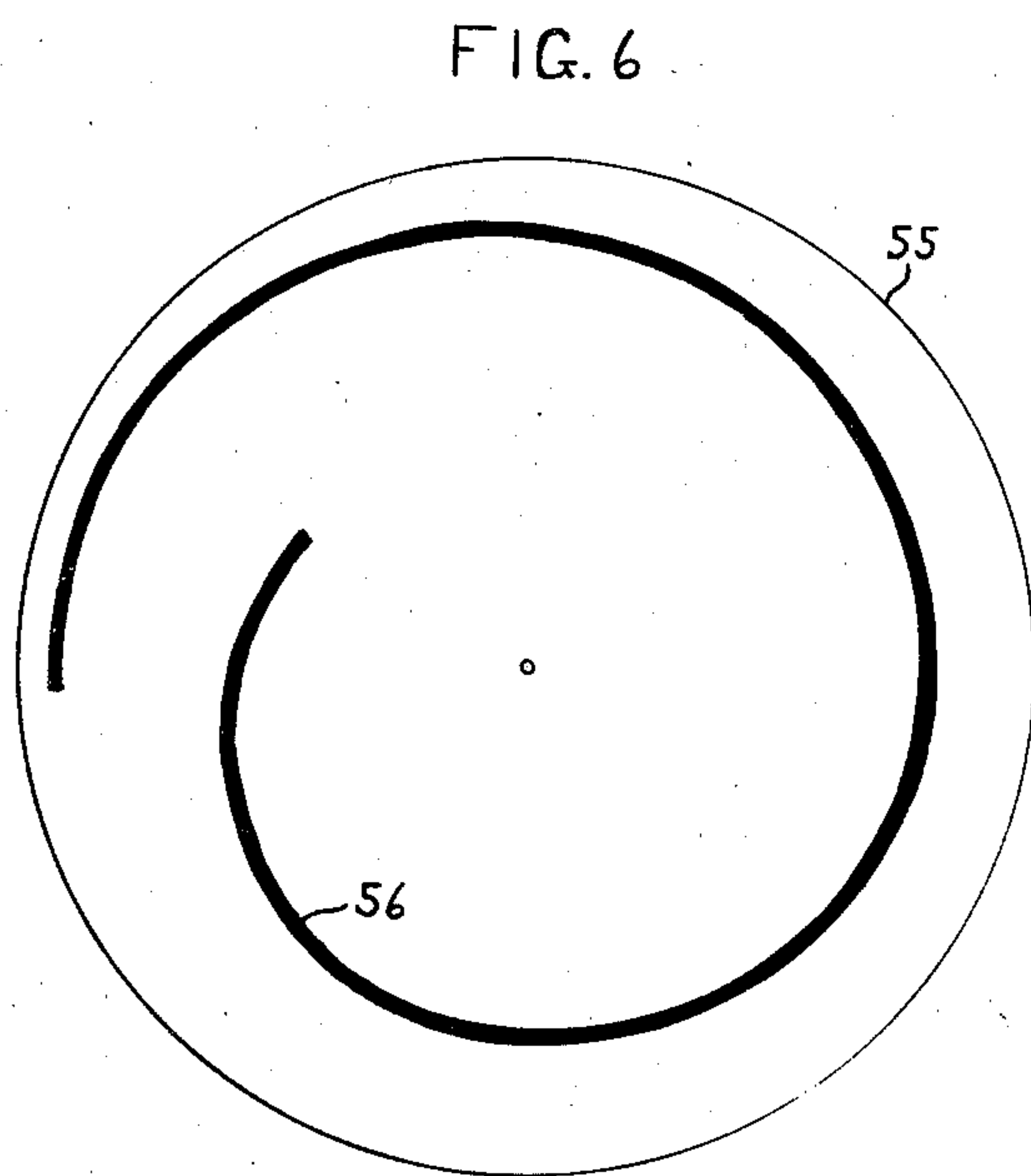
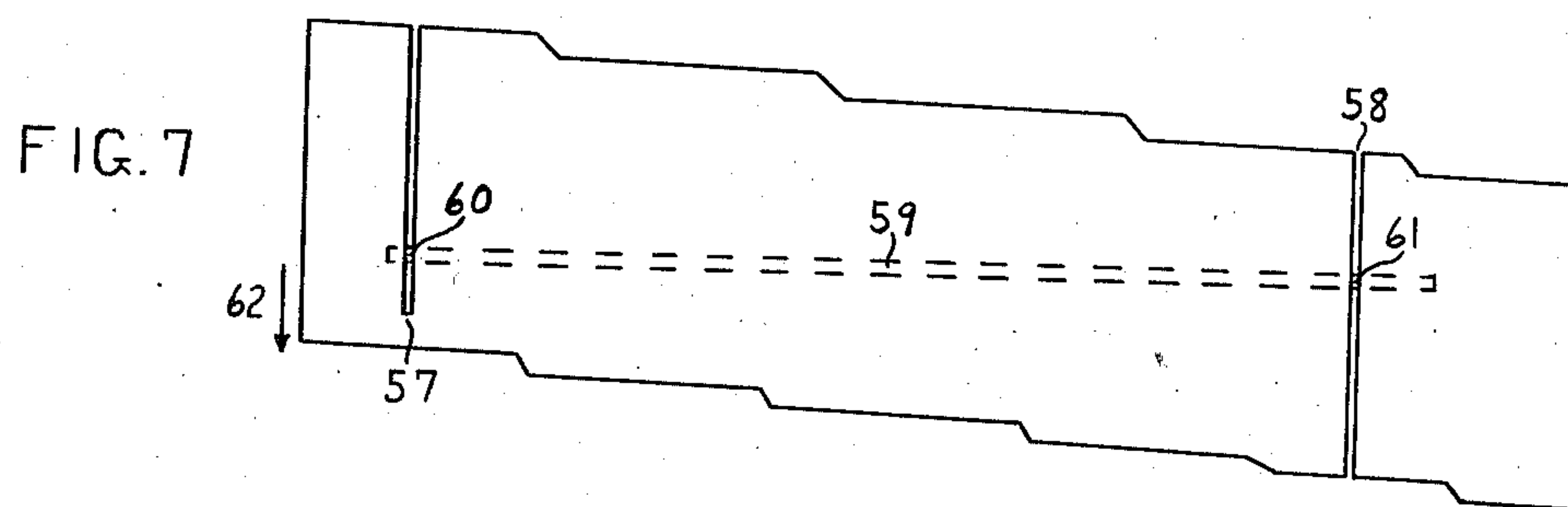
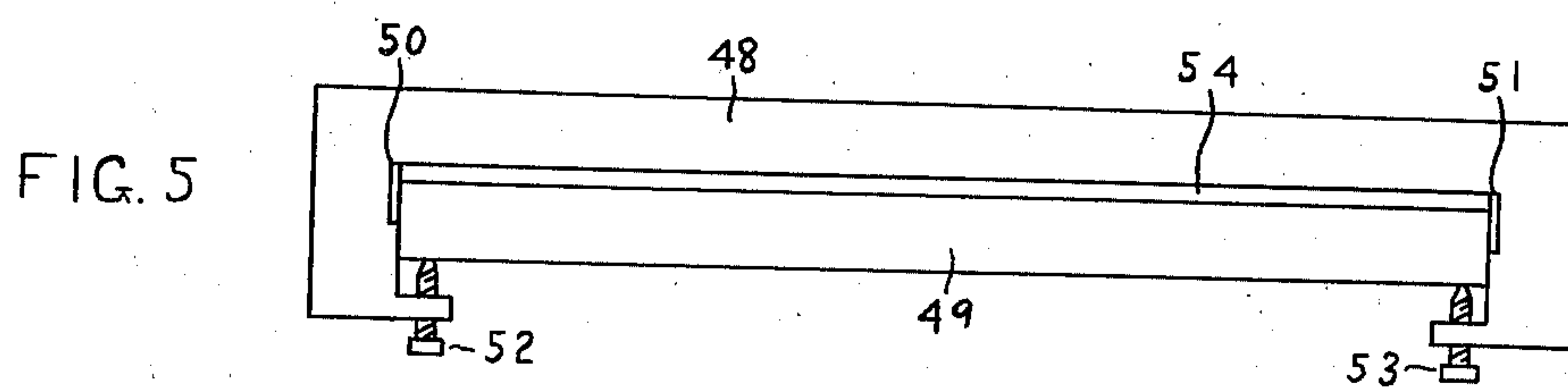
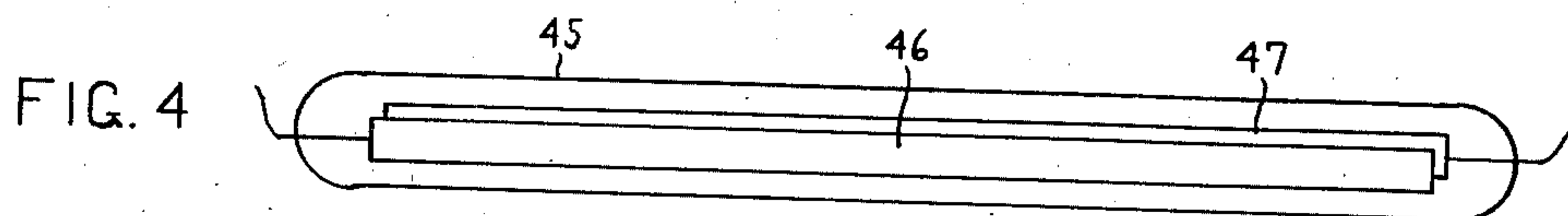
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FIG 12

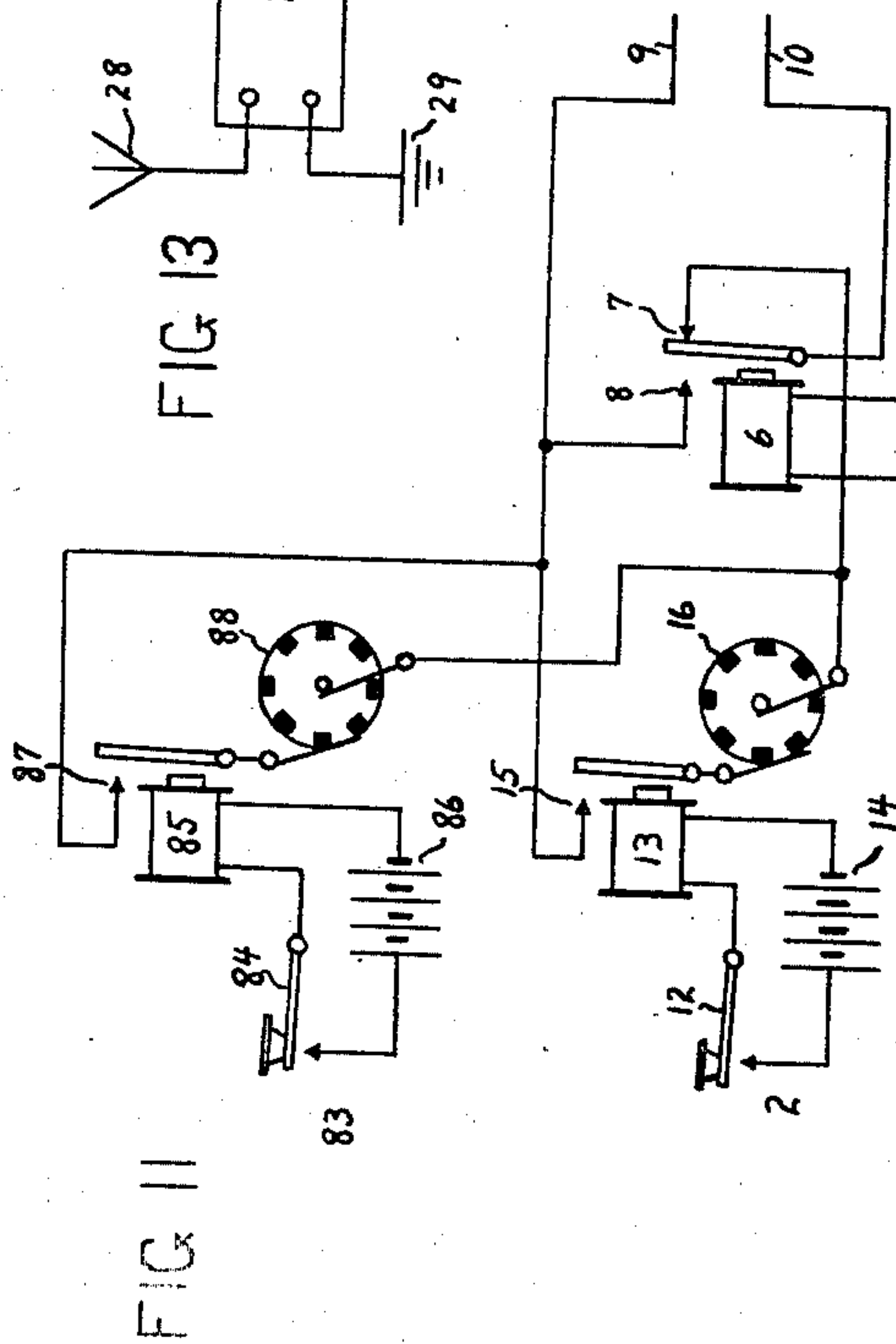
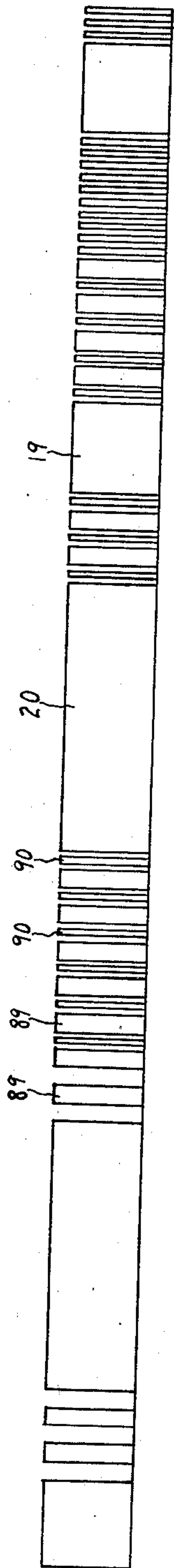


FIG 11

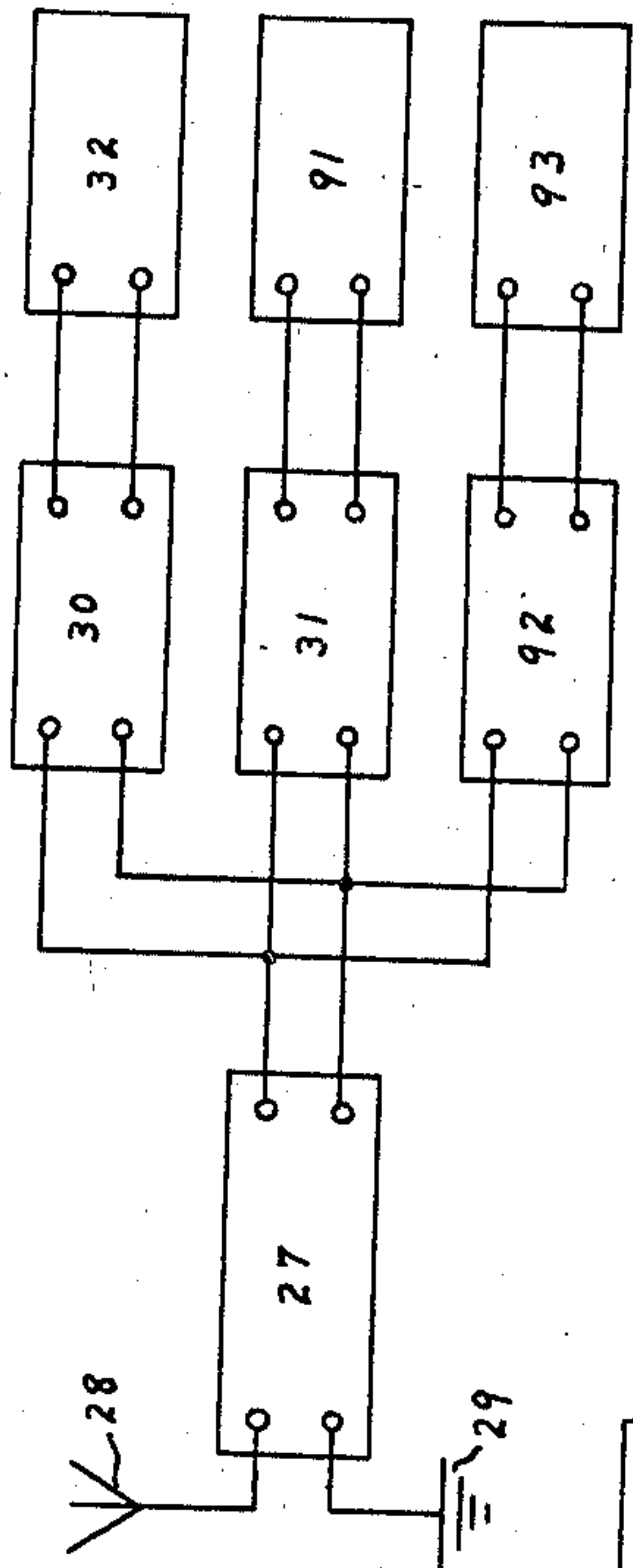
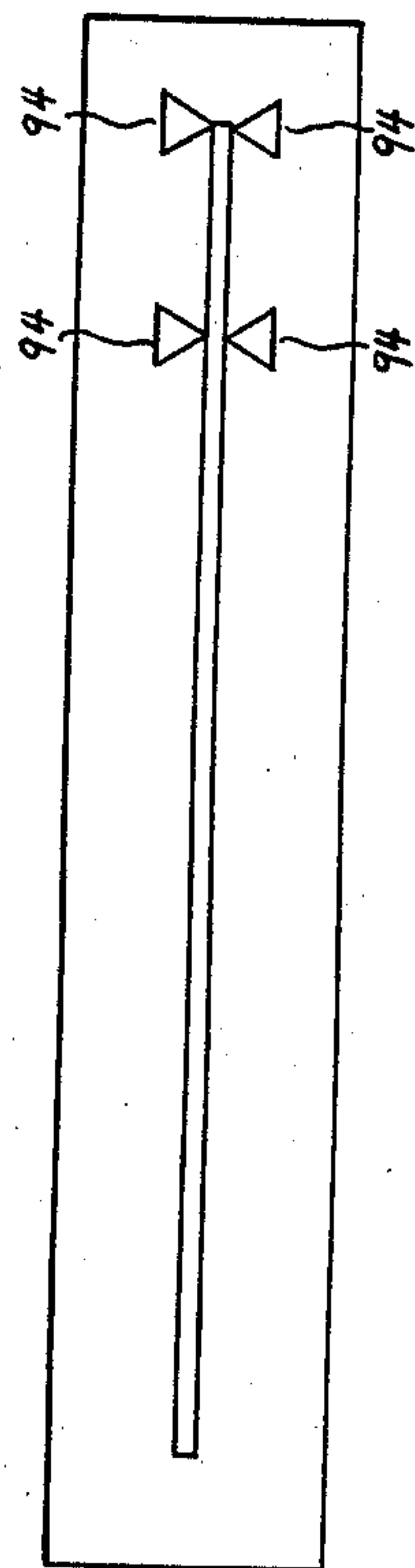


FIG 13

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FIG 14



UNITED STATES PATENT OFFICE

2,082,877

MULTIPLEX COMMUNICATION SIGNALING
SYSTEMSamuel Relf Durand, Milwaukee, Wis., assignor
to American Telephone and Telegraph Com-
pany, a corporation of New York

Application October 21, 1932, Serial No. 638,948

21 Claims. (Cl. 178—50)

My invention relates to an improved method and means for multiplex communication in which a single radio, cable or land-line telegraph communication channel is used for the simultaneous transmission and reception of signals between two or more points. The primary object of this invention is to provide a method of signaling whereby two or more messages may be transmitted simultaneously at full power by one apparatus and a transmission system without interference between the messages, and without decreasing the efficiency or materially altering the operation of existing apparatus for transmitting and receiving only one message at a time. A further object is to provide methods and means for receiving and recording the multiplex signals transmitted according to the methods of this invention.

The objects are achieved in part by controlling the energy transmitted on a time basis dependent upon the coding of the simultaneous messages. Message discrimination is also effected on a time basis, so that this system inherently provides the maximum of economy of energy and frequency range so important in multiplex radio communication.

An important feature of this invention is the utilization of the normal high-speed automatic signal transmission of a single transmitting apparatus without interference to the actual signal elements sent and received at high speed. In transmitting a second message simultaneously, rapid impulses are keyed by the transmitting apparatus only during space intervals of the normal code signals, and a combined effect produced by each such impulse in a summation of several groups of them is utilized to constitute an element of the code for the transmission and reception of an additional message. In a similar manner, by transmitting impulses at different rates of speed during space intervals of the normal high-speed code message, numerous additional messages may be sent and received simultaneously over a single circuit.

This invention may be used in connection with radio or wire-line transmission without being limited to the use of any one code, but practically all codes and conventional methods of signaling may be employed.

Various advantages and valuable features will become apparent after a reading of the following description considered in connection with the accompanying drawings, but the invention is not limited by the description and drawings, since the scope of the invention is pointed out

particularly in the claims at the end of this specification. As one embodiment for detailed description, I have chosen an arrangement for radio transmission of two simultaneous messages by means of the dot and dash combinations of the Morse code.

Figure 1 illustrates one form of transmitting apparatus.

Figures 2A, 2B, and 2C represent graphically signal elements as modified by this invention, where Figure 2A illustrates signals transmitted at one sending position of Figure 1, Figure 2B illustrates signals transmitted at the other sending position of Figure 1, and Figure 2C illustrates the combination of the signals when transmitted simultaneously.

Figure 3 illustrates one form of receiving apparatus for visual reception which may be used in connection with Figure 1.

Figure 4 shows a glow-tube suitable for recording received signals.

Figure 5 shows a light-shield with an adjustable slit suitable for use with the glow-tube of Figure 4.

Figure 6 illustrates a disc with a spiral slit for use in connection with the glow-tube of Figure 4 and the light-shield of Figure 5.

Figure 7 shows a portion of the disc of Figure 6.

Figure 8 illustrates the shape of an opening formed by the combined slits of the light-shield and the disc.

Figure 9 illustrates the visible shapes of the received signal elements.

Figure 10 shows an arrangement of a light-proof chamber for recording received signals on film.

Figure 11 illustrates a circuit for controlling the sending of three messages simultaneously.

Figure 12 illustrates graphically signal elements of three messages.

Figure 13 illustrates conventionally a receiving apparatus for use in connection with Figure 11.

Figure 14 shows a light-shield with warning markers.

Referring to Figure 1 of the drawings, 1 and 2 are two sending positions of the transmitting apparatus. At position 1, an automatic transmitter 3 is connected by wires 4 and 5 to the control relay 6, which relay when energized opens back-contact 7 and closes contact 8. Closing of this contact short-circuits wires 9 and 10 to operate the keying circuit of radio transmitter 11. Keying may be most suitably accomplished by controlling the grid bias potential applied to the

grid of a keying tube or to one of the low power amplifying tubes of the radio transmitter.

At position 2 is shown a hand key 12 connected in series with relay 13 and battery 14. Operation of the relay under control of the hand key closes contact 15 which is connected through chopper wheel 16 and contact 7 to the keying leads 9 and 10 of the radio transmitter. The chopper wheel consists of alternate insulation and interconnected metal segments with brushes arranged to bear on its surface so that the circuit is alternately made and broken at a rapid rate as the wheel revolves.

During the time back-contact 7 is closed, it is evident that when contact 15 is also closed under control of the hand key at position 2, the radio transmitter will be keyed by the short-circuiting of leads 9 and 10 through each metal segment of the chopper wheel as it rotates. During the time back-contact 7 is open and contact 8 is closed, the radio transmitter will be keyed by the automatic transmitter at position 1 independently of the chopper wheel. If each code element made at position 2 is several times longer in duration than the longest code element made at position 1, each such element will consist of several groups of short impulses occurring during space intervals of the elements of the normal code signals. In this manner it is possible to transmit two messages simultaneously in which radio frequency energy is radiated continuously by the transmitting apparatus during the integral time interval of each code element of the message keyed at position 1, and in which radio frequency energy is radiated as intermittent groups of short impulses during the time interval of each code element of a second message keyed at position 2.

A more complete understanding of the method of transmitting two messages simultaneously will be had from Figures 2A, 2B and 2C which illustrate graphically signal elements of each message. In Figure 2A is shown the signaling input to the transmitter from position 2 when position 1 is not being operated. The total time of all the successive impulses at 17 represents the duration of a dot as made by the hand key, and the space 18 represents an interval when the hand key is released. In Figure 2B is shown the signaling input to the transmitter from position 1 when position 2 is not being operated. 19 represents the duration of a dot and 20 of a dash as made by the automatic transmitter; 21 is a space interval equal in length to a dot, and 22 is a space interval equal in length to a dash occurring between the signal elements. In Figure 2C is shown the combined signaling input to the transmitter when both positions are being operated simultaneously. It is evident that the actual dot and dash signal elements of Figure 2B are not interfered with by the impulses of Figure 2A, but that these signaling input impulses only control the keying of the radio transmitter when they occur during space intervals between dots and dashes. The dot 17 of Figure 2A is thus altered to consist of groups of impulses 23, 24, 25, and 26, as shown in Figure 2C.

Referring to Figure 3, a receiving system is shown for the reception of signals transmitted by radio in the manner illustrated by Figure 1. The receiver 27 is connected to an antenna system 28 grounded at 29. It may be of any desired and appropriate character which may include radio frequency amplifiers, a detector, and audio frequency amplifiers, or, if desired, may be of the heterodyne type. The receiving system may also

consist of the combined use of several receivers with automatic volume control devices for regulating the output energy.

The output energy of the receiver is directed to two electrical filters, 30 and 31. Filter 30 may consist of a network of inductances and capacitances constituting a low-pass filter or it may consist of rejector circuits tuned to the same frequency as that of the impulse signals made by the chopper wheel of position 2, so that the received energy of the impulse signals is prevented from passing through this filter whereas the received energy of the signals transmitted from position 1 is permitted to pass through and operate a siphon recorder 32. A repeater relay, printing machine, chemical recorder, or any other means of relaying or recording the signals may be substituted for the siphon recorder.

Filter 31 is a high-pass filter designed to readily pass energy of the frequency of the impulse signals, but to completely attenuate the low frequency energy of the automatic signals made at position 1. This filter may be particularly selective to the frequency of the impulse signals, or it may be particularly rejective throughout the range of frequencies at which the automatic transmitter of position 1 operates.

The energy passed by filter 31 is directed through a coupling impedance 33 to a vacuum tube amplifier 34. Plate potential is supplied to the vacuum tube by battery 35 through choke coil impedance 36, and negative biasing potential is supplied to the control grid of the vacuum tube by battery 37. Condenser 38 is of a relatively large capacity so as to readily pass current of the frequency of the impulse signals, but to block the passage of direct current. A glow-tube 39 having two electrodes 40 and 41 is connected in the output circuit of the vacuum tube amplifier. Positive potential is supplied to electrode 40 by battery 42 through series resistance 43 and the choke coil impedance 44. This potential is adjusted to a value just below that at which a glow-discharge will take place in the tube, so that the tube remains inoperative except during the time that amplified energy of each received impulse signal causes a glow-discharge to occur. Of course, conveniently designed Kerr cells or other light valves may be used in lieu of the glow-tube, or audible or chemical means capable of responding to the impulse signals may be employed.

It is apparent that each distinct impulse signal transmitted from position 2 will cause a glow-discharge to occur in the glow-tube at the receiving station. The human eye will respond to each one of the distinct flashes of the glow-tube, but it cannot transmit to the brain a sensation of having responded to each separate flash, if succeeding flashes occur within the interval during which previous ones appear to persist in vision. By transmitting the impulse signals with sufficient rapidity, it is therefore possible to make each group of them appear as a single flash to an observer of the glow-tube at the receiving station. Furthermore, if the longest time interval of a signal element of position 1 which can occur between groups of impulses in an element of the code of position 2 is somewhat less in duration than the time during which vision of the resulting flashes at the receiver will appear to persist from one group to the next succeeding one, all of the groups of flashes constituting a signal element of position 2 will appear to be merged into but a single flash of the glow-tube. If, following this apparent single flash, a sufficient time in excess of the dura-

tion of persistence of vision is allowed to elapse, an observer will be aware of an interval in which the glow-tube remains inoperative. In this manner, it is apparent that each signal element and subsequent space interval as made at position 2 will appear to an observer of the glow-tube at the receiving station as a flash of light of apparent continuity followed by an interval of no flashing, respectively, in which the relative length of the signal element and of the space interval as perceived are approximately the same as made at the transmitter. It is therefore possible to receive and record a message keyed at position 2 simultaneously to receiving and automatically recording the normal high-speed message keyed at position 1.

Because of the necessity for allowing an interval to elapse between signal elements at position 2 somewhat longer than that in which persistence of vision may endure, the speed at which a message may be transmitted for reception by the apparatus of Figure 3 is limited no matter how much the speed of the message keyed at position 1 may be increased. However, if instead of employing any suitable light valve in the circuit of Figure 3, one of special construction is used associated with additional apparatus, messages may be transmitted and received from position 2 at relatively high speeds. The construction of the glow-tube is shown, though only schematically, in Figure 4, without it being intended to show dimensional relations and details of the arrangement. In the interior of the bulb 45 there are two electrodes, one thereof being the cathode 46 having the form of a flat rectangular strip and being insulated against the starting of glow-discharge currents upon the inner side thereof, while the other is the anode 47 of the same shape and size and mounted parallel to the former. This glow-tube, connected in the circuit of Figure 3, is mounted so that the greatest length of the electrodes is in a horizontal position with the cathode in front of the anode as seen by an observer.

Placed immediately in front of the glow-tube is a light-shield illustrated in Figure 5 having a stationary plate 48 and a movable plate 49 adapted to grooves 50 and 51 in the stationary plate. The lower extension parts of the stationary plate are threaded to receive screws 52 and 53 by means of which the width of a slit 54 between the two plates may be adjusted. The length of this slit is slightly less than that of the cathode of the glow-tube.

Figure 6 illustrates a flat, light opaque disc 55 having a narrow slit 56 near its periphery in the form of a spiral completing a small fraction more than one revolution of the disc. The slit need not be continuous throughout its length, but may have several cross pieces to reinforce the disc providing each one is of a small width comparable to that of the slit. The disc is arranged to be rotated about its center by means of an axle attached directly or geared to a motor, and it is placed with the slit on one side immediately in front of the stationary slit in the light-shield.

Figure 7 shows an enlarged view of a portion of the left hand edge of the disc 55 drawn to the same relative scale as Figures 4 and 5. The outside end of the spiral slit in the disc is shown at 57, and a portion of the overlapping part of the spiral slit is shown at 58. The slit in the light-shield behind the disc is shown in the outline at 59. The projected distance from one end of the spiral slit to the other end measured on a radius of the disc is slightly less than the length of the

stationary slit, so that at every instant as the disc revolves there is either one or two openings, 60 and 61, through both slits for light to pass from the cathode of the glow-tube. These openings progress across the stationary slit from left to right in a constantly repeated cycle when the disc is rotated about its center in the direction of the arrow 62.

Figure 8 shows an enlarged view of the instantaneous shape 63 of an opening formed by the intersection of the stationary and movable slits. When the glow-tube of Figure 4 connected in the circuit of Figure 3 responds to a signal impulse as transmitted at position 2 by flashing during the time interval of the received impulse, a spot of light of substantially this shape is impressed upon the retina of the eye of an observer. If the signals are transmitted and the disc revolved at such a speed that during the longest interval occurring between successive groups of impulses in one signal element, the left hand edge 64 of the spiral slit does not progress as far to the right before the first flash of the succeeding group as the point at which the right hand edge 65 was at the last flash of the previous group, the images of all of the flashes in each group occurring before and after this interval will be partially merged together into the sensation of seeing but a single unbroken spot of light. In this manner, by regulating the speed of the revolving disc within limits, an observer receives the sensation of seeing a single spot of light for each complete signal element as transmitted at position 2.

Figure 9 illustrates the relative visible shapes of such apparent signal elements. A dot is shown at 66 followed by a dark spacing interval 67, and then another apparent flash of light representing a dash 68. The broken lines 69 show the instantaneous position of the rotating spiral slit at the first flash of the glow-tube, and the broken lines 70 show the instantaneous position of this slit at the end of the final flash in the groups of flashes constituting the dot. During the time the spiral slit is revolving past the space 67, no flashes of the glow-tube occur so that an observer would be conscious of seeing a dark space in this area. The broken lines 71 and 72 show, respectively, the first and last instantaneous positions of the revolving slit for the groups of flashes constituting the dash 68. The width of the stationary slit is represented by the broken lines 73, and it is evident that the edges of this adjustable slit limit the vertical height of the apparent spots of light. The visible length of each signal element depends within limits upon the width of the spiral slit and the speed of rotation of the disc.

The component elements of each successive code letter in the message appear progressively along the line of the stationary slit from left to right for interpretation by the eye, and disappear thereafter. Within a specific distance of the end of the line, the continued rotation of the disc causes succeeding signal elements to appear in order at the beginning of the line. However, since the spiral slit is caused to complete a small fraction more than one revolution of the disc, duplicate signal elements will appear simultaneously for a short continued distance at the right hand end of the line. This enables an observer to shift the concentration of his gaze from right to left across the intervening area each time of the completion of a line without the loss of the relative length of any code element or space interval. It is advantageous to provide markers to indicate at the end of the line the limits within which the

signal elements are simultaneously duplicating the elements at the beginning of the line. In an arrangement found to be particularly suitable, warning markers in the shape of arrows painted white on the dark background of the light-shield were used, and the relative positions of the light-shield and the rotating disc were interchanged in front of the glow-tube.

Figure 14 illustrates such a light-shield with warning markers 94 to indicate the limits within which duplicate signals appear.

Figure 10 shows a schematic arrangement for recording the received signals by means of photographic or chemical methods, which offers the advantage of being able to automatically receive signals transmitted at much greater speeds than an operator can record by eye alone. A light-sensitive tape or film 74 is enclosed in a light-proof chamber 75 having a small rectangular opening to the interior of the chamber at 76. Mounted in front of this opening is a glow-tube 77 connected in the circuit of Figure 3. The tape travels over pulleys 78 and 79 past the opening, being unwound from spool 80 within the light-proof chamber. By adjusting the speed within limits at which the tape travels, the successive component flashes in each signal element are made to partially overlap each other in reacting on the light-sensitive surface of the tape, and thus each signal element is recorded as a single distinct mark. The tape may either be rewound on a spool within the light-proof chamber after being exposed, or it may be passed through a section 81 wherein chemical solutions or other means make it further insensitive to light, thus enabling it to be passed immediately through a position 82 outside of the light-proof chamber where the recorded signals may be observed.

In transmitting simultaneously more than one additional message to the normal high-speed automatic code transmission, short impulses are sent at different rates of speed for each one of the additional messages, and summations of the impulses transmitted at each rate constitute separate signaling elements of each distinctive message. For example, Figure 11 illustrates a circuit for controlling the sending of three messages simultaneously according to the method of this invention. This circuit is similar to that shown in Figure 1, with the exception that a third signaling position designated 83 with its associated apparatus is connected in parallel with the keying circuit of position 2. At position 83, a hand key 84 in series with relay 85 and battery 86 controls the operation of the relay to close contact 87. Closing of this contact completes the circuit through chopper wheel 88 and contact 7 to the keying leads 9 and 10 of the radio transmitter, and the radio transmitter is thus keyed by the impulses produced at chopper wheel 88. This chopper wheel may be similar to chopper wheel 16 but revolved at a higher speed, or it may have two or more times the number of insulation and interconnected metal segments. It may be rotated by the same motor used to revolve chopper wheel 16 either by being coupled directly or geared to the motor shaft.

The most efficient method of operation results when the brush bearing on chopper wheel 88 makes contact with the metal segments of the wheel during intervals when insulation segments of chopper wheel 16 are in contact with the brush bearing on that wheel. This is accomplished by controlling the relative speed of rotation of each chopper wheel and adjusting the position of the

brushes bearing on their surfaces. In this manner impulses produced by chopper wheel 88 occur within intervals between impulses produced by chopper wheel 16. In the practical operation of a multiplex circuit of the invention, it is generally found desirable to produce the impulses of each successive message at a rate several times faster than that of the next previous message.

A more complete understanding of the method of transmitting three messages simultaneously will be had from Figure 12 which illustrates graphically signal elements of each message. The duration of a dot made by automatic transmitter 3 at sending position 1 is represented at 19, and the duration of a dash is represented at 20. The duration of each impulse made by chopper wheel 16 when key 12 is closed at position 2 is represented at 89; these impulses are transmitted only during space intervals between dot and dash elements of the signals made at position 1. The duration of each impulse made by chopper wheel 88 when key 84 is closed at sending position 83 is represented at 90; these impulses are transmitted only during space intervals between dot and dash elements of the signals made at position 1, and also only during space intervals between impulses made at position 2. It is evident that a summation of all such impulses 90 as may be transmitted during the time key 84 is closed constitutes a signaling element sent from position 83, in the same way that a summation of all such impulses 89 as may be transmitted during the time key 12 is closed constitutes a signaling element sent from position 2.

Figure 13 illustrates conventionally a receiving system adapted to effect separation of the three messages transmitted simultaneously from sending positions 1, 2, and 83 in Figure 11. The output energy of the receiver 27 is directed to three electrical filters 30, 31, and 92. Filter 30 is designed to pass only energy of the frequencies of the high-speed automatic signals sent from sending position 1 of Figure 11; these signals are recorded by an indicator 32. Filter 31 is designed to pass only energy of the frequency of the impulse signals sent by chopper wheel 16 from sending position 2 of Figure 11; these impulse signals are recorded by means of an apparatus indicated conventionally at 91 which is arranged for visibly representing the signal elements according to the method of this invention previously described. Filter 92 is designed to pass only energy of the frequency of the impulse signals sent by chopper wheel 88 from sending position 83 of Figure 11; these impulse signals are recorded by means of an apparatus indicated conventionally at 93 which is arranged for visibly representing the signal elements according to the method of this invention previously described.

It is apparent also that more than three messages may be transmitted and received over a single communication circuit by the method of this invention. Each impulse and signaling element may be sent at full power by the transmitting apparatus, since each one in itself occupies a distinct period of time.

Various modifications may be made in the precise details and arrangements of the apparatus used in different adaptations of this invention. For example, light choppers making use of photoelectric cells and glow-tubes may be used, and automatic transmitters may be employed to control the transmission of impulse signals. Various types of scanning systems may be used in

place of a disc scanner, and an optical system may be employed to spread light across the slit in a stationary light-shield instead of using a glow-tube extending the length of this slit.

5 An advantage innately offered by this invention is that the method of receiving the signals of messages subordinate to the normal high-speed code transmission is comparatively insensitive to static interference. This is due to the fact that
10 each signal element as received is effectively composed of many partially superimposed component parts occurring at time-separated intervals, so that interference to some of these parts within a signal element does not effect the fabrication of
15 a visible signal element having the same apparent characteristics as one in which no interference takes place.

It is evident that I have provided a new method and means for efficiently transmitting and re-
20 ceiving multiplex signals over a single communication channel. Whereas I have described in the foregoing drawings and descriptions a specific embodiment of my invention, it is understood that the arrangements may be varied as desired and substitutions of equivalent forms made
25 without departing from the spirit and scope of my invention, and I therefore desire to be limited in the modifications of the invention only in so far as the scope of the hereinafter appended claims necessitates.

What I claim is:

1. The method of transmitting a secondary code message during the transmission of a primary code message which comprises transmitting
35 a primary code message having integral signal elements and spacing intervals therebetween, and transmitting electrical impulses during the spacing intervals of the primary code, aggregate summations of the impulses constituting signal ele-
40 ments of the secondary code message such that each secondary element endures several times longer than the longest primary element.

2. The method of transmitting a plurality of secondary code messages during the transmission
45 of a primary code message which consists in transmitting a primary code message having integral signal elements and spacing intervals therebetween, and transmitting a plurality of impulses at different predetermined rates dur-
50 ing the spacing intervals of the primary code, aggregate summations of the impulses of each predetermined rate constituting separate signaling elements of the secondary code messages such that each secondary element endures several
55 times longer than the longest primary element.

3. In a telegraphy system, means for producing integral signaling elements of a primary code message; means for producing successive im-
60 pulses in which summations of said impulses constitute signaling elements of a secondary code message, each of said elements enduring several times longer than the duration of the longest integral signaling element of the primary code message; simultaneously supplying all of said
65 integral signaling elements and such of said impulses as may occur within time intervals between integral signaling elements to a transmitting system; means for successively keying said transmitting system to control the transmission of energy during the duration of each integral sig-
70 naling element and during the duration of each of such impulses as may be supplied to the transmitting system; receiving transmitted energy as a series of electrical pulses of varying duration; filtering the received pulses to direct into one circuit

electrical energy in which the duration of the pulses corresponds to that of the integral signaling elements, and to direct into another circuit electrical energy in which the duration of the pulses corresponds to that of the impulse signals; recording the separated integral signaling elements; and providing means for controlling the response of a light valve to each separated impulse signal whereby said impulse signals are evaluated
5 to represent single distinct visible sensations, each of which appears to endure for a period of time
10 corresponding approximately to that of the summation of impulses constituting distinct signaling elements as produced at the transmitting end of the system.

4. In a telegraphy system, means for producing integral signaling elements of a primary code message; means for producing a plurality of rapid impulses at different predetermined rates in which summations of such impulses at each
20 predetermined rate constitute signaling elements of other code messages, each of said elements enduring several times longer than the duration of the longest integral signaling element of the primary code message; simultaneously supplying
25 all of said integral signaling elements and such of said impulses as may occur within time intervals between integral signaling elements to a transmitting system; means for successively key-
30 ing said transmitting system to control the transmission of energy during the duration of each integral signaling element and during the duration of each of such impulses as may be supplied to the transmitting system; receiving trans-
35 mitted energy as a series of electric pulses of varying duration; filtering these received pulses to direct into one circuit electrical energy in which the duration of the pulses corresponds to that of the integral signaling elements of the primary code message, and to direct into each one of sev-
40 eral other circuits electrical energy in which the duration of the pulses corresponds in separate circuits to that of each one of the predetermined rates of transmission of impulses of the other code messages; recording the separated integral
45 signaling elements; and providing means in each one of said other circuits for controlling the response of light valves from the separated impulse signals whereby said impulse signals are evalu-
50 ated to represent distinct visible sensations, which appear to endure for periods of time approximately that of the duration of each summation of impulses constituting separate signaling elements produced at the transmitting end of the system.

5. The method of duplex signaling which includes signaling simultaneously on a single channel by utilizing the spacing time between integral signal elements of a primary high-speed code message for transmitting signals of a secondary
60 code message composed of elements, each element comprising a number of groups of impulses, and each impulse comprising a number of high frequency oscillations, receiving the transmitted frequencies as a series of high frequency oscillations, demodulating the received energy into pulses of electrical energy corresponding to all the successive signaling frequencies, separating the groups of time-separated impulses constituting elements of the secondary message from
70 the integral signal elements of the primary message, recording the high-speed integral signal elements of the primary code message, and providing a method for recording the elements of the secondary message by producing for each 75

separated impulse signal a small area of light, the combination of said small areas of light forming a composite area of light representing by its apparent physical dimensions the corresponding time dimension of duration of the signal element made at the transmitting end of the system, each of said composite areas of light being separated by an area of no illumination representing by its apparent physical dimensions the corresponding time dimension of duration of the space interval between the signal elements.

6. The method of multiplex signaling which includes signaling simultaneously on a single channel by utilizing the spacing time between integral signal elements of a primary high-speed code message for transmitting signals of two or more subordinate code messages composed of elements, each element comprising a number of groups of impulses produced at different rates of speed in each message, and each impulse comprising a number of high frequency oscillations, receiving the transmitted frequencies as a series of high frequency oscillations, demodulating the received energy into pulses of electrical energy corresponding to all of the successive signaling frequencies, separating according to the different rates of speed the groups of impulses and the integral signal elements, recording the integral signal elements of the primary code message, and providing a method for recording separately the elements of each of the subordinate messages by producing for every impulse signal in the respective messages a small area of light, the separate combinations of said small areas of light in each message forming composite areas of light representing by their apparent physical dimensions the corresponding time dimension of duration of the signal elements made at the transmitting end of the system, each of said composite areas of light being separated by areas of no illumination representing by their apparent physical dimensions the corresponding time dimension of duration of the space intervals between the signal elements.

7. In a system for receiving composite signaling elements of a code message each one composed of a summation of time-separated impulses occurring during spacing intervals between integral signaling elements of another code message, the method of visibly registering said composite signaling elements independently of said integral signaling elements which consists in controlling the scanning of a modulated light source adapted to respond only to said time-separated impulses so as to form therewith for each of said composite signaling elements an area of light elongated so as to be readable.

8. A signaling circuit comprising a single communication channel, transmitting and receiving apparatus connected to said circuit to provide duplex operation thereover, said transmitting apparatus including two keying positions for controlling the transmission of energy, one of said keying positions adapted to control the transmission of integral signaling elements of a primary code message and the other of said keying positions adapted to control the transmission of signaling elements of a secondary code message composed of rapid impulses occurring during space intervals between said integral signaling elements of the primary code message, a receiver responsive to all of the signaling frequencies transmitted over the circuit, a filter adapted to separate the integral signaling elements of the primary code message from the rapid impulses of the secondary

code message, an indicator adapted to record the integral signaling elements of the primary code message, a light valve adapted to respond to the rapid impulses of the secondary code message, means for scanning said light valve to restrict each visible response to an elementary unit of illuminated area, and means for utilizing said elementary units of illuminated area to represent in a visible manner signal elements of the secondary code message.

9. In a scanning system for use with a modulated light source responsive to electrical impulses of code signals, the method which comprises regulating the rate of scanning in accordance with the rate of transmission of said electrical impulses to form in successive order across a transverse line momentarily visible areas of light representing a summation of the electrical impulses contained in said code signals, each area being elongated so as to be readable as a discrete signal element and separated by areas of no illumination representing code spacing intervals occurring between said code signals.

10. In a receiving system for continuously repeating across a transverse line the registering of momentarily visible areas of light representing signaling elements of a code message, means for coordinating the continuous interpretation of said code message at the start of each successive repetition of said transverse line which consists of the combination of a modulated light source adapted to respond to electrical energy of said signaling elements, a light-shield in effective position before said modulated light source and having a transverse slit therein, a scanning device in position before said light-shield and having an overlapping spiral slit therein whereby a light aperture is formed by the intersection of said transverse slit in said light-shield and said slit in said scanning device, and means for regulating the rate of transverse movement of said light aperture corresponding to the rate of transmission of said signaling elements, an overlapping portion of the spiral slit serving to form an identical light aperture at the beginning of said transverse slit when said aforementioned light aperture has progressed to a distance near the opposite end thereof whereby identical areas of light representing said signaling elements are formed simultaneously near each end of said transverse slit.

11. In a scanning system for the momentary visible portrayal across a transverse line of areas of light representing code signaling elements, the method of simultaneously duplicating identical elements for a short period of time at each end of said transverse line in each successive rescanning in order to coordinate the continued interpretation of a code message at the beginning of said transverse line.

12. In a system for scanning successively a single area formed by a slit in a light-shield, a light-opaque disc placed with a sector on one side immediately in front or immediately in back of said light-shield; a spiral slit in said disc completing a fraction more than one helical revolution of the disc near its periphery, said spiral slit intersecting said slit in said light-shield whereby an elementary area is formed; means for rotating said disc about its center whereby said elementary area is caused to progress across the stationary slit of the light-shield; and means for indicating by some form of marker the place attained by said elementary area near one end

of said stationary slit when a corresponding area is formed by the intersection of the spiral slit with the stationary slit at its opposite end.

13. In a system for visibly portraying signal elements separated by space intervals and formed with a plurality of electrical impulses, the method which consists in forming across a transverse line momentarily visible areas of light representing a summation of the impulses contained in each of said signal elements, each area elongated so as to be readable as a discrete signal element and having a light reactive value different from that of the intervening units of area representing space intervals, and continuously retracing said transverse line in one direction with momentarily visible representations of successive signal elements separated by space intervals.

14. In a system for recording signaling elements of a code message upon a light-sensitive film in which each signaling element consists of a series of time-separated impulses produced at a uniform rate of occurrence followed by a no-impulse spacing interval, the combination of a modulated light source responsive to each of said impulses, a camera inclosing a light-sensitive film and having an aperture in effective position before said modulated light source, means for continuously moving said light-sensitive film past said aperture whereby limited portions thereof are exposed to light from said modulated light source in response to said series of impulses and said no-impulse interval, means for forming upon said light-sensitive film in successive order composite representations of each of said series of impulses followed by said no-impulse spacing interval, and means for controlling the rate of movement of said light-sensitive film past said aperture in accordance with said uniform rate of occurrence of said time-separated impulses.

15. In a multiplex communication system the method which consists in transmitting electrical impulses during space intervals between integral signaling elements of a primary code message such that aggregate summations of such recurring electrical impulses constitute signaling elements of a secondary code message, each of said elements enduring several times longer than the duration of the longest integral signaling element of the primary code message, and directly converting electrical energy of said impulses at the receiving end of said communication system into light.

16. A duplex telegraphy system comprising a transmitting and a receiving station, apparatus at said transmitting station for sending simultaneously two code messages, the integral signaling elements of a primary code message being transmitted at high speed and each composite signaling element of a secondary code message being formed of an aggregate summation of time-separated impulses transmitted during spacing intervals occurring between said integral signaling elements of said primary code message, apparatus at said receiving station for receiving the transmitted signals, and means for independently recording the composite signaling elements of said secondary code message whereby the time-separated impulses corresponding to the parts of each of said composite signaling elements produce an aggregate record of the signaling element.

17. The method of visibly displaying signaling elements of a code message each one composed of impulses occurring between integral signaling elements of another code message which consists in modulating a light source to flash only in response to each of said impulses, and controlling the continuous scanning of said light source to display said flashes as momentarily readable areas of light independently of said integral signaling elements.

18. The method of registering upon a light-sensitive film only the signaling elements of a code message composed of impulses occurring between the integral signaling elements of another code message which consists in modulating a light source to flash only in response to each of said impulses, causing said flashes from said light source to be impinged upon a limited portion of said light-sensitive film, and controlling the continuous movement of said film past the point of impingement of said light thereon whereby the signaling elements composed of said impulses are registered as composite shaded portions upon said light-sensitive film.

19. In a communication system, the method of receiving electrical impulses transmitted during spacing intervals between integral signaling elements of a primary code message which consists in effecting aggregate summations of said electrical impulses to constitute signaling elements of a secondary code message, each of said signaling elements enduring several times longer than the duration of said integral signaling elements, and visibly recording said signaling elements independently of said integral signaling elements by separating said electrical impulses from said integral signaling elements and modulating and scanning a light source therewith to form each of said aggregate summations of electrical impulses into a composite area of light elongated so as to be readable.

20. The method of receiving a secondary code message simultaneously with a primary code message which comprises receiving a primary code message having integral signal elements and spacing intervals therebetween, and receiving impulses during the spacing intervals of the primary code such that aggregate summations of the received impulses constitute signaling elements of the secondary code, each secondary code element enduring several times longer than the longest primary code element.

21. In a system for independently recording signaling elements of a code message upon a light sensitive film in which each signaling element consists of an aggregate summation of time-separated impulses occurring during spacing intervals between integral signaling elements of another code message, the method which consists in modulating a light source with said time-separated impulses, and impinging light flashes from said modulated light source upon a limited portion of a moving light-sensitive film whereby each of said aggregate summations of time-separated impulses is recorded as a composite shaded portion on said film independently of said integral signaling elements.