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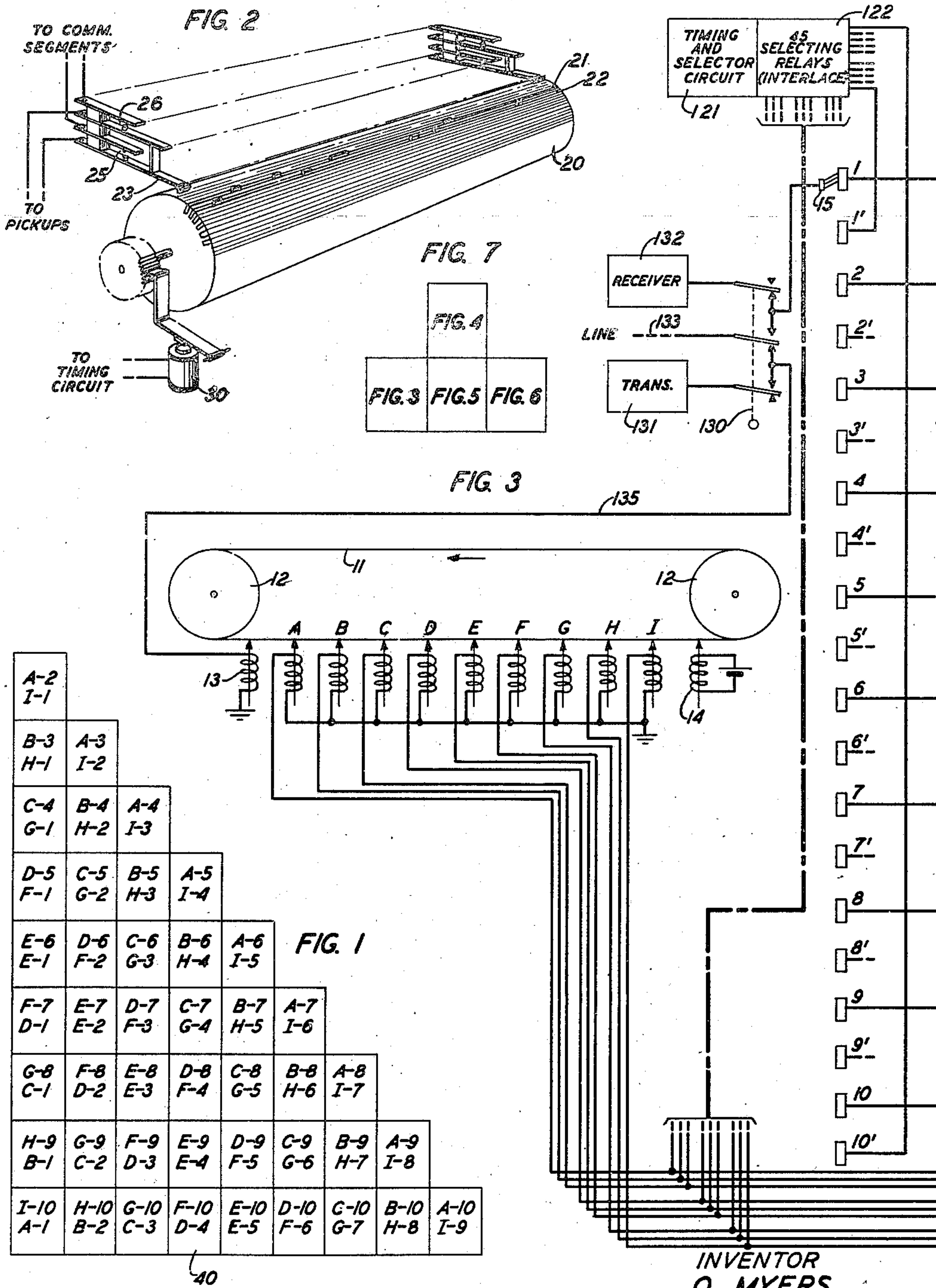
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2,406,353

SECRET SIGNALING

Filed July 17, 1943

4 Sheets-Sheet 1



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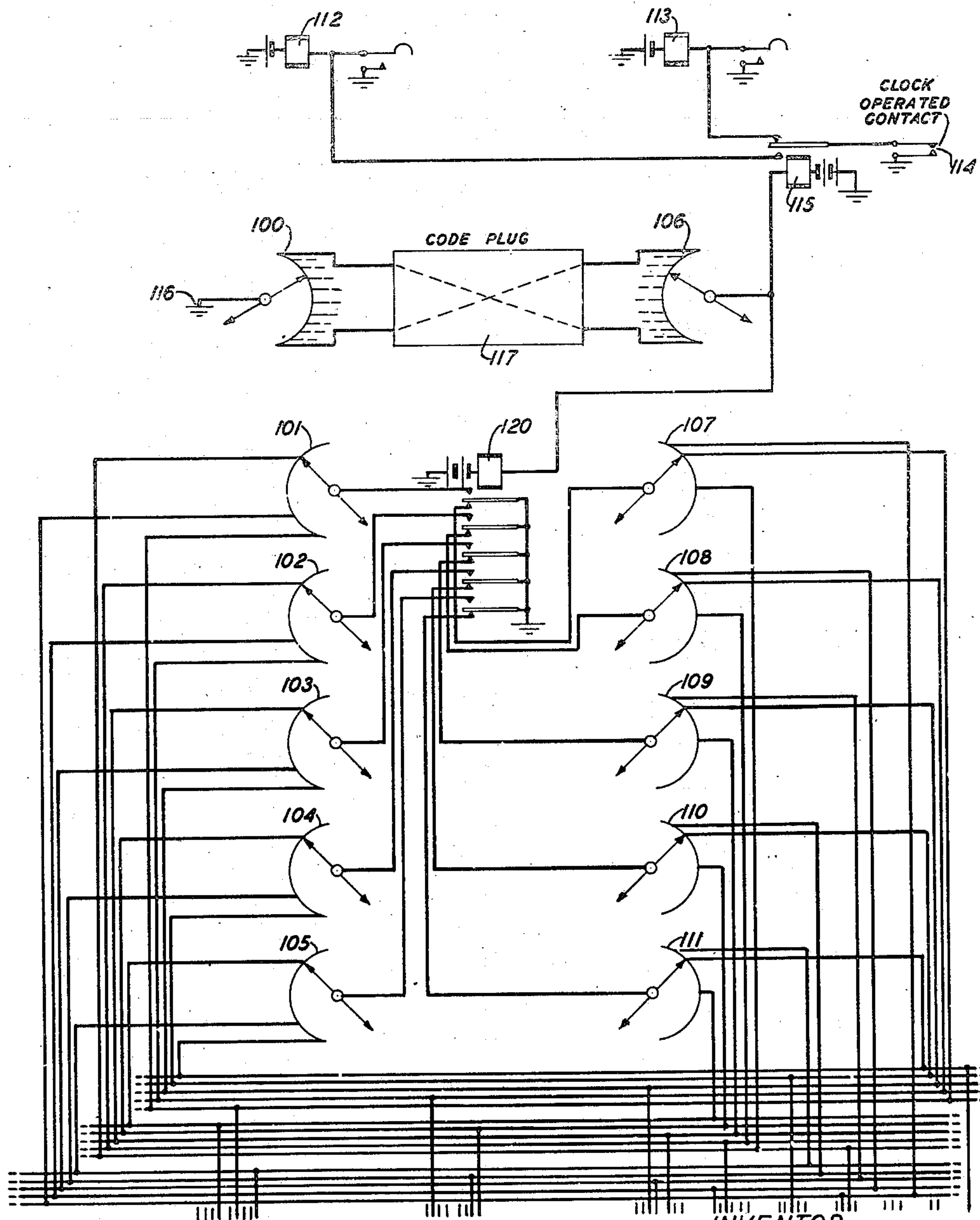
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FIG. 4



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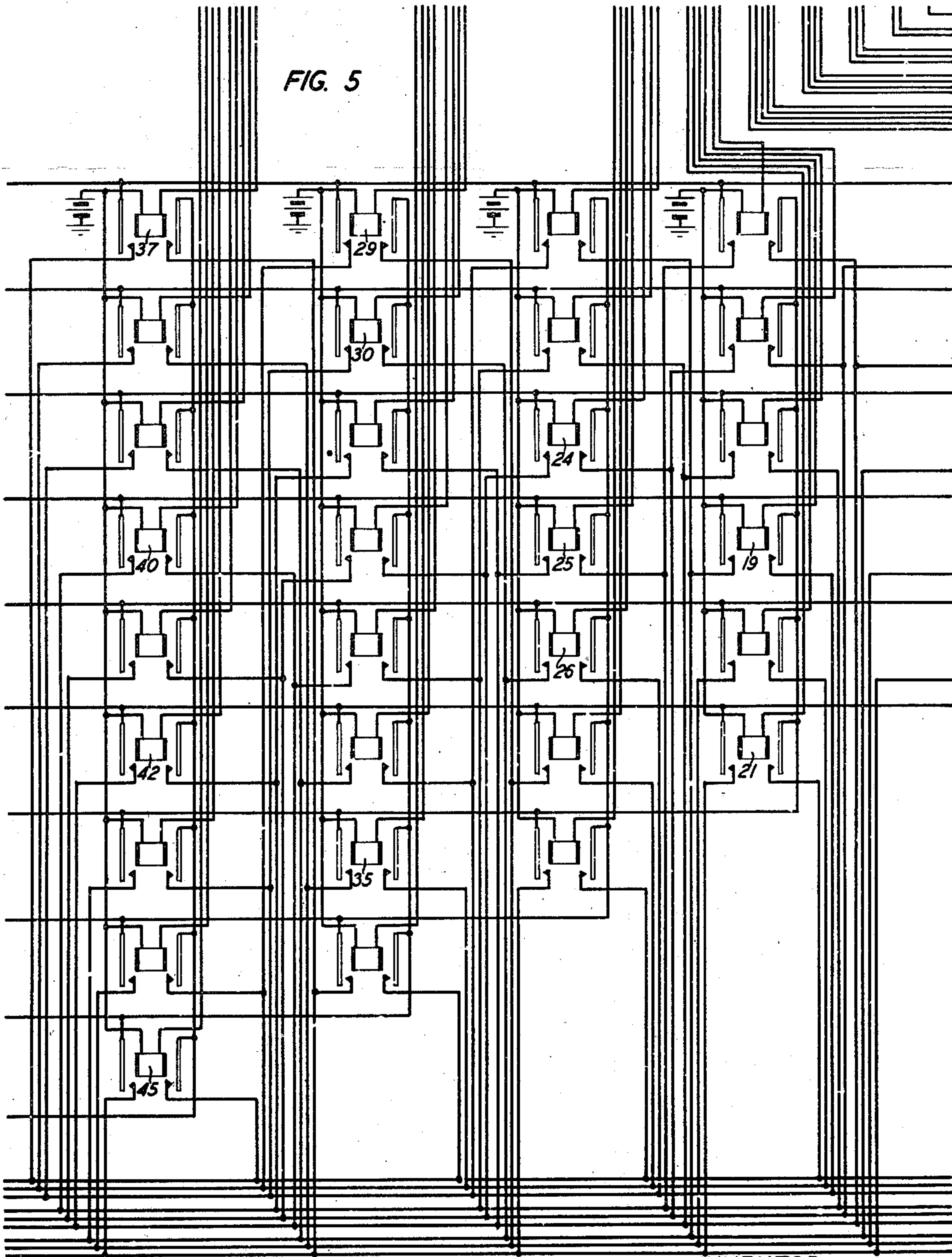
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FIG. 5



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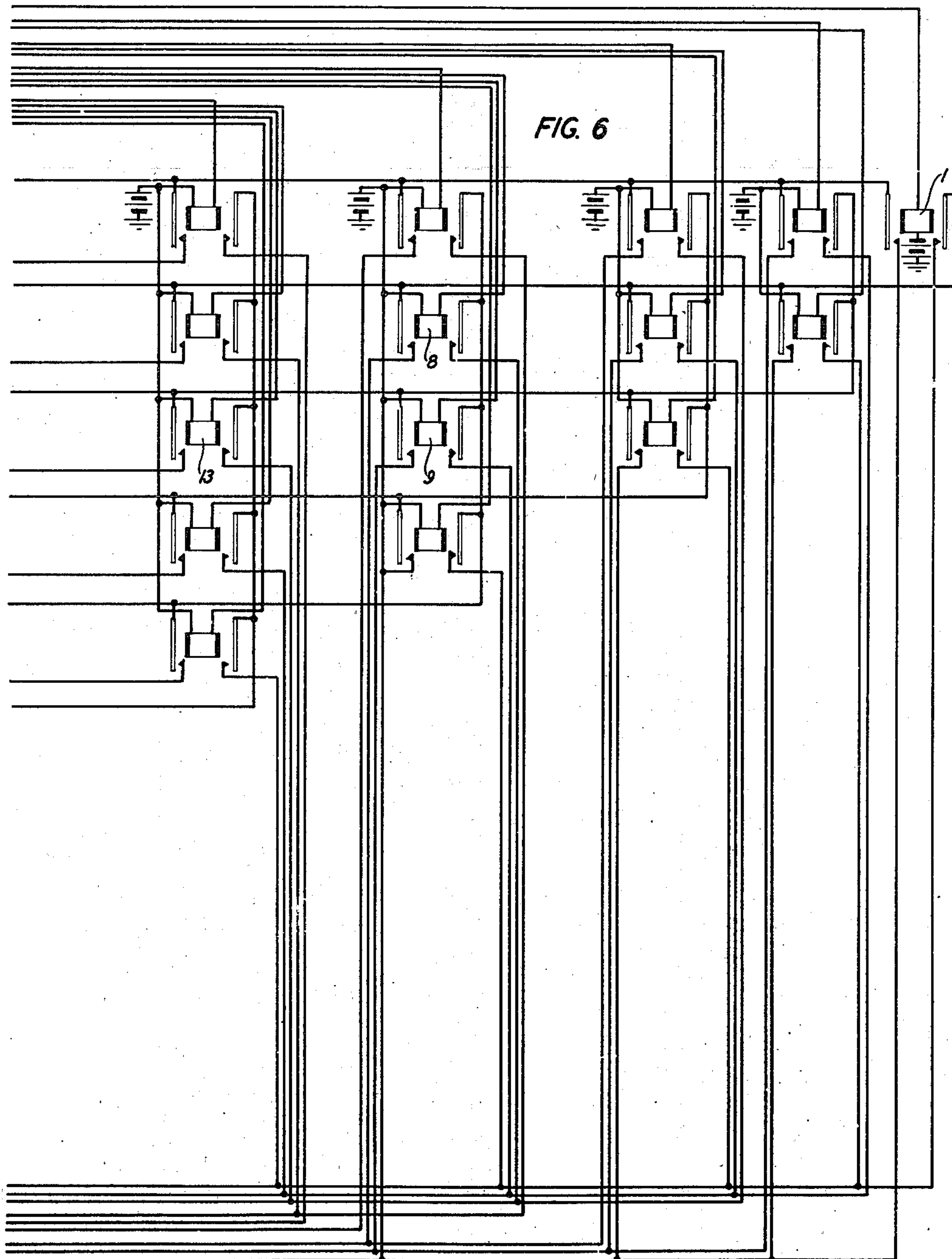
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SECRET SIGNALING

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The present invention relates to the transmission of speech or other types of signals with privacy. The invention is based upon the use of variable time delay in transmission of signal elements to render reception of the message difficult.

A known type of privacy uses a moving magnetic tape with cooperating electromagnets spaced along the tape at equal intervals as a means of producing unequal time delay in the transmission of signal elements. A commutator or equivalent is used to switch electromagnets, serving as individual recorders or pick-ups, into circuit with the line in definitely timed short intervals. A similar arrangement is used at the receiver to decode the message. In such a system the sum of the delay introduced at the transmitter plus that introduced at the receiver is the same for all signal elements. For illustration, assuming a commutator of ten segments individually wired to the electromagnets, the total delay at both transmitter and receiver is ten units (a unit being in this case one tenth the rotational period of the commutator) so that if a delay of three units is introduced in transmitting a given signal element, a delay of seven units must be introduced for that element in the receiving and decoding process. With a given wiring between commutator segments and electromagnets the code is repeated in each rotation of the commutator, "code" here being used to indicate the scheme of time delays introduced in the ten individual signal elements sent in commutator times 1 to 10, inclusive. This can conveniently be expressed as a series of ten numbers, for example, 1 3 7 6 8 3 6 4 7 5 to indicate the delays of the respective elements. In view of the fact that each element must experience a total delay of ten units at transmitter and receiver together, if the message is to be successfully decoded, the time delays introduced at the receiver in order to decode the message sent by this code would have to be 9 7 3 4 2 7 4 6 3 5 for the respective signal elements considered above, but since these elements are variably delayed they are actually received in a different order from that which they originally had, the received order being 3 5 4 2 1 7 9 6 8 10 on the basis of an original order of 1, 2, 3, etc. If the receiver delays given above are identified with the individual signal elements the receiver code expressed in terms of delay to be introduced into the signal elements as received would be 3 2 4 7 9 4 3 7 6 5.

In the known type of privacy system referred to there are nine electromagnets spaced along

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the record tape and these are designated A, B, C, D, E, F, G, H and I. If magnet A is used, since it is situated nearest to the recording magnet, a delay of one unit is introduced. Magnet B introduces two units delay, etc. The above code, together with its decoding sequence, could be expressed in terms of the electromagnets that are used in successive commutator times, the transmitting code then being A B C G F H C F D G E and the decode sequence being C B D G I D C G F E. The connections between the commutator segments and electromagnets at the transmitter would have to be different from those at the receiver if this code were used. This would be satisfactory in the case of one-way transmission or two-way transmission on a four-wire basis using four machines. Two-way transmission with two machines each serving alternately to receive and transmit would also be possible with different codes used for opposite directions provided the necessary switch-overs were made at both stations whenever the direction of transmission is reversed. In order to avoid the rather complicated switching that would be involved it has been proposed to use self-converse codes, meaning that if one machine is set to code a message for transmission with a self-converse code, it can without switch-over decode a received message sent with the same code. This imposes the limitation that the delays introduced into the individual signal elements as transmitted must be the same as the delays introduced into the elements as received, and that as before the sum of the delays introduced into the same signal element at both transmitter and receiver must be equal to that for each of the other elements. One such code, for illustration, might be B G E G C F C E H D.

Applicant has found that for every self-converse code a pair of electromagnets must be used, one giving a delay complementary to the other, and that the commutator segments to which these pairs are connectable also fall into pairs. In the case of a ten-element code, the electromagnets and commutator segments can be arranged in a table comprising forty-five possible pairs of electromagnets and commutator segments. This fact enables a straightforward type of selection to be made for setting up all possible self-converse codes and gives the general pattern of a switching circuit for selecting the codes.

An object of the invention is to facilitate selection of different codes for both transmitting and receiving and especially to provide for quickly and automatically changing codes.

The nature of the invention and its various objects and features will be better understood from the following detailed description in connection with the accompanying drawings in which Fig. 1 is a table from which to determine interconnections between reproducer magnets and commutator segments in making up self-converse codes;

Fig. 2 is a partial view in perspective of one type of code selector according to the invention; and

Figs. 3, 4, 5 and 6 when placed together in the manner shown in Fig. 7 show in schematic diagram form the circuit of a complete two-way privacy system in accordance with the invention.

In Fig. 3, the magnetic tape is shown at 11 passing over pulleys 12 for driving it and the electromagnets are shown below the tape, there being nine reproducer magnets lettered A, B . . . I, a recording magnet 13 and an eraser magnet 14. Each of the reproducer magnets is adapted, by switching devices to be described, to be connected to an individual segment of the commutator shown in developed form at the right of Fig. 3 with the segments in a vertical line. These segments are numbered 1 to 10 and 1' to 10', the latter being interlaced with the former. In the drawings, these segments are shown widely separated but in practice it will be understood that they would be situated as closely together as feasible in accordance with usual commutator design. It will be understood that in practice the tape 11 may be mounted on the rim of a disc and that the commutator may be circular and mounted so that the same shaft rotates the tape disc and the commutator brush 15 over the segments.

Reference will now be made to Fig. 1 which consists of forty-five boxes in each of which appears a pair of letters designating reproducer magnets and an associated pair of numbers designating commutator segments. Thus, in the single box appearing at the top of the figure, the notation indicates that if reproducer A is connected to commutator segment 2 and if reproducer I is connected to segment 1, two of the signal elements of a ten-unit section of signal will be coded in a self-converse code. The two signal elements sent by such arrangement will be correctly decoded at the receiver with identical connection of reproducers A and I to the commutator segments 2 and 1 thereat, assuming, of course, synchronous operation of the machines. A complete ten-element self-converse code can be built up by choosing any five boxes that result in a connection to each of the ten commutator segments with only one connection to each segment. There may and usually will be more than one connection to the same reproducer. It will be noted that in any self-converse code, such as that given earlier in this description by way of illustration, the letters representing the amount of delay given to a signal element appear in pairs such that the sum of the delays is the same for all pairs. Moreover, the letters correspond in their position in the code to commutator segments and, in the case of each pair, are separated by a number of segments equal to the number of delay units represented by one of the pairs, counting around the commutator regarded as a closed ring.

Since these forty-five sets of connections represent all of the possible self-converse codes when taken five at a time as explained, it becomes a

relatively simple matter to arrange switching mechanism to select the codes one after another in any desired sequence.

One such switch mechanism is shown in Fig. 2 and comprises a rotating cylinder 20 with insets, two of which are shown at 21 and 22, extending the length of the cylinder and situated close together entirely around the cylinder. Each inset has five raised portions, which when directly underneath corresponding springs 23, raise the springs and cause two pairs of contacts per spring to be closed, as indicated, for example, at 25 and 26. There would be forty-five such springs 23 any five of which are operated at a time as determined by the positions of the lugs on any one inset 21 or 22, etc. One set of contacts, 25, would connect a particular reproducer pick-up coil with a particular commutator segment 1, 2, 3, etc., of the regular set. The other set of contacts, 26, would connect a particular pick-up coil with a particular commutator segment 1', 2', 3', etc., of the interlace set.

The insets 21, 22, etc., can be made of metal, plastic, fiber or other suitable material and they can be inserted in slots in the cylinder and can be readily interchanged among themselves by simply withdrawing them and reinserting them in different order.

The cylinder 20 can be stepped to bring the next inset underneath the row of forty-five switch springs 23 by means of a pawl and ratchet operated by stepping magnet 30 which can be actuated at timed intervals by a clock-operated contact or from the commutator drive, as for instance, after each rotation of the commutator or after a given number of commutator rotations.

It will be understood that the insets are cut so as to select five pairs of magnets, and accompanying commutator segments from those given in the table of Fig. 1 to provide self-converse codes as previously explained, each strip with its lugs representing one code. The interlace code can be entirely independent of the regular code.

Reference will now be made to Figs. 3, 4, 5 and 6 arranged as shown in key Fig. 7. It will be noted that forty-five relays are shown in Figs. 5 and 6 arranged in the same manner as the boxes in Fig. 1, except that for convenience of arrangement on the sheet the table is turned on its side in Figs. 5 and 6 with the relay corresponding to the uppermost box in Fig. 1 shown at the extreme right in Fig. 6. The bottom row of boxes of Fig. 1, therefore, corresponds to the vertical column of relays at the left side of Fig. 5. Each relay has two armatures and it will be observed that the armatures are permanently connected to commutator segments and when attracted close contacts leading to the pick-ups. Taking the left-hand column of relays of Fig. 5, for example, and reading from the top down, the left armatures are connected to respective commutator segments 1, 2, 3, 4, 5, 6, 7, 8 and 9 while the right-hand armatures are all connected to segment 10. A corresponding rule with one less total number is followed in each of the other columns of relays. Again considering the left-hand column, the left armatures can be closed to connect individually to reproducers A, B, C, etc., reading from the top relay down, while the right-hand armatures have an opposite order of connection, that is, they can be closed to connect individually to reproducers I, H, G, F, E, D, C, B and A. A similar scheme is followed in the case of the other columns except displaced one

reproducer element since the number of relays decreases by one per column.

It will be seen by tracing out the wiring that whenever a particular relay is energized it connects the pair of pick-ups to the pair of commutator segments that are given in the corresponding box in Fig. 1. Taking relay 40 (Fig. 5), for example, which corresponds to the box marked 40 in Fig. 1, this relay when energized closes both its armature contacts, the left armature connecting commutator segment 4 to reproducer D and the right armature connecting commutator segment 10 to reproducer F. It is merely necessary, therefore, to energize five relays to provide a self-converse code, these relays corresponding to any suitable five boxes in the diagram of Fig. 1.

Each relay in Figs. 5 and 6 has an individual energizing conductor extending off the top of Fig. 5 to the selecting circuit in Fig. 4 where a ground can be applied to any of these leads, the opposite side of each relay being permanently connected to battery as shown in Figs. 5 and 6.

Referring to Fig. 4, two banks of selector switches are shown, those at the left being numbered 100 to 105 and those at the right being numbered 106 to 111. The switches 100 to 105 are stepped by stepping magnet 112 and switches 106 to 111 are stepped by magnet 113. These switches are stepped under control of clock-operated contacts 114 which when closed energize either stepping magnet 112 or 113 depending upon whether or not the transfer relay 115 is energized or deenergized. This relay is, in turn, controlled by the two selector switches 106 and 107 in tandem from ground 116 through contact of selector 100 through conductor leading through the code plug 117, contact of selector 106 and winding of relay 115 to battery. It is to be understood that a number of conductors extend between the sector of selector 100 and that of selector 106 and that the code plug provides cross-connections between these conductors as may be desired to introduce a variable operation into relay 115. For example, with the relay 115 in the condition shown the next time contacts 114 are closed stepping magnet 113 is energized causing switches 100 to 111 to take an additional step. If after such step is taken switches 100 and 106 find a closed circuit to ground, relay 115 is energized but if no circuit to ground is closed in this position of switches 100 and 106, relay 115 remains unenergized. The wiring between switches 100 and 106, together with that inside the code plug, may be such as to cause relay 115 to be operated or unoperated for varying lengths of time.

Another transfer relay 120 is also operated in parallel with transfer relay 115. The purpose of relay 120 is to furnish grounds to the movable arms of either the selector switches 100 to 105 or 107 to 111. With relay 120 unoperated as shown grounds are supplied to the wipers of selectors 107 to 111. With the wipers in the positions shown these grounds cause energization of the following relays on Figs. 5 and 6: 1, 13, 26, 35 and 40. These relays, in turn, set up the following code using the notation given in Fig. 1: A-2 I-1, C-6 G-3, C-8 G-5, B-9 H-7, F-10 D-4.

If with the switches in the position shown the relay 120 were energized supplying grounds to the selectors on the left, the following relays in Figs. 5 and 6 would have been operated: 8, 19, 24, 29 and 42 and the following code would have

been set up: C-5 G-2, C-7 G-4, E-8 E-3, H-9 B-1, F-6 D-10.

For simplicity of drawing only a few connections are shown in Fig. 4 between the energizing leads for the relays in Figs. 5 and 6 and the selector banks. It will be obvious, however, how all of the connections indicated in the diagram of Fig. 1 can be provided for by merely connecting the individual leads from the code relays to proper chosen points of the selectors. A great variety of connections is possible since the codes can be set up in any desired sequence and the same code can be used over and over again in different sequences.

The selecting circuit of Fig. 4 and the relays on Figs. 5 and 6 determine the coding to be used for the normal commutator segments 1, 2, 3 . . . 10. A duplicate set of equipment is indicated in the upper part of Fig. 3 to determine the coding to be used for the interlace set of segments 1', 2', 3' . . . 10', this equipment consisting of a timing and selector circuit 121, which may be entirely similar to that shown on Fig. 4, and forty-five selecting relays (interlace set) 122 which may be similar to those shown in Figs. 5 and 6. The wiring between the relays and selectors and the wiring within the timing and selector circuit in the case of this interlace equipment 121, 122 may be different from that used in the normal set of equipment of Figs. 4, 5 and 6; since the normal and interlace codes can be entirely independent of each other. Also the wiring between the relays and commutator segments may be different in the two cases.

In the use of this equipment to transmit and receive, the telephone or other signal generating means 131 and the telephone or other signal receiving means 132 are arranged as in Fig. 3 to be connected into the system by the two-position three-spring switch 130, which is shown in normal or receiving position. The "line" 133 may be the audio input to a radio or other signal transmitter and the audio output of a radio or other receiver, or it may be one side of an ordinary telephone or other signal line the opposite side of which in any case is assumed to consist, in this figure, of grounded terminal of recorder coil 13 but may, if desired, be metallic.

With switch 130 in the position shown, coded speech or other signal received over line 133 is sent through central switch spring of switch 130 and conductor 135 to the recorder coil 13 and makes a record of coded speech or signal on the tape 11. As different parts of the coded material is picked up by the coils A, B, C, etc. the brush 15 is passing over the commutator segments and momentarily connecting these individual coils in proper order to the receiver 132, through the upper spring of switch 130, to decode the message, the order of connection being determined by the relays in the regular and interlace sets of selecting relays as previously described.

In transmitting, the talker or user pushes switch 130 to its upper position so that the transmitter 131 is connected to recorder coil 13 and the message is recorded on the tape 11 in normal form, the coding taking place by the relays connecting various ones of the pick-up coils A, B, C, etc. individually to the commutator segments and thence via brush 15 and middle switch spring of switch 130 to the line 133.

It is to be understood that various substitutions, alterations and modifications may be made

within the spirit and scope of the claims, which follow.

What is claimed is:

1. In a speech privacy system in which different speech fragments are delayed in transmission by different amounts of time, a plurality of individually actuable devices each determining a different transmission delay time, a circuit and circuit contact for actuating each device, said contacts being arranged in pairs, the devices controlled by the contacts constituting any one pair determining respective transmission delays the sum of which is a constant, and means selectively operating said pairs of contacts.

2. In a privacy system in which a succession of delay elements is used to introduce successive equal units of delay into signals together with means for allotting time periods to said elements for individual operation, means to code or decode the signal comprising switches associated to be always operated in definite pairs, each pair of switches when operated determining a particular pair of delay elements to be used and particular time periods allotted to them for operation such that the sum of the delays introduced into signals by the two elements of the pair is a constant for all pairs and the time periods allotted to the elements of a pair for operation are always separated in time by a number of time periods corresponding to the number of units of delay introduced by one of the elements of the pair.

3. The invention claimed in claim 2 in which said switches comprise pairs of double contact switch springs and cams for operating said pairs individually and selectively.

4. The invention claimed in claim 2 in which said switches comprise sets of switch spring pile-ups, each pile-up comprising two switch elements, and means for actuating said switches comprising a rotating drum and code strips removably mounted on said drum, each code strip having raised lugs for passing under and lifting a selected spring pile-up to close the pair of switch elements thereof.

5. The invention claimed in claim 2 in which said switches comprise relays each when operated closing two circuits for selecting the two elements of a pair, and means for selectively operating said relays.

6. In a privacy system in which message currents are divided on a time basis into short fragments and the fragments are transposed in time in irregular manner in recurrent cycles and in which the number of fragments in each cycle is an even number, the method of building up self-converse codes comprising conditioning in advance the fragment transposing means to transpose the signal fragments in pairs such that the time shift in one of the two fragments of the pair is the converse of that in the other and selecting and operating enough of said transposing means to provide the proper number of pairs of fragments to fill up one cycle.

7. In a privacy system including a moving record medium for signals and reproducers spaced along said medium, and timing means for dividing the signals on a time basis, means to provide a plurality of paths between said reproducers and said timing means, switching means for closing said paths in predetermined pairs to produce time shifts in a pair of signal fragments such that the time shift in one fragment is the converse of that in the other, and means to select groups of said switching means.

8. In a signal privacy system using a moving magnetic tape, electromagnets spaced therealong and a commutator having segments, for arranging signal elements in different time sequences in cycles, switches associated in inseparable pairs, one switch of a pair when operated closing a circuit from one of said electromagnets to one of said segments and the other switch of the pair when operated closing a circuit from one of said electromagnets to a different one of said segments such that the time sequence, within a cycle, given to a signal element by closure of one of said circuits is the converse of that given by closure of the other circuit, and means for selectively operating said pairs of switches in groups simultaneously.

9. The invention claimed in claim 8 in which said switches comprise electromagnetic relays, a selector circuit having successive positions, means in each position of said selector circuit for operating a group of said relays, and means to move said selector circuit from one position to another.

10. The invention claimed in claim 8 in which said switches comprise pile-ups of pairs of springs and said means for selectively operating said pairs of switches comprises a rotatable cylinder containing projecting lugs on its surface for lifting selected groups of spring pile-ups when said lugs pass underneath said pile-ups.

11. In a signal privacy system having a traveling record medium and N reproducers spaced along said medium and including a distributor of P segments for dividing the signal into fragments in time, paths extending between each reproducer and each segment, said paths being NP in number,

$$\frac{NP}{2}$$

switches each controlling closure of a definite pair of said paths such that one signal fragment is coded in converse relation to the other, and means to select and operate said switches in groups of

$$\frac{P}{2}$$

to the group to build up a self-converse code.

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