

May 17, 1949.

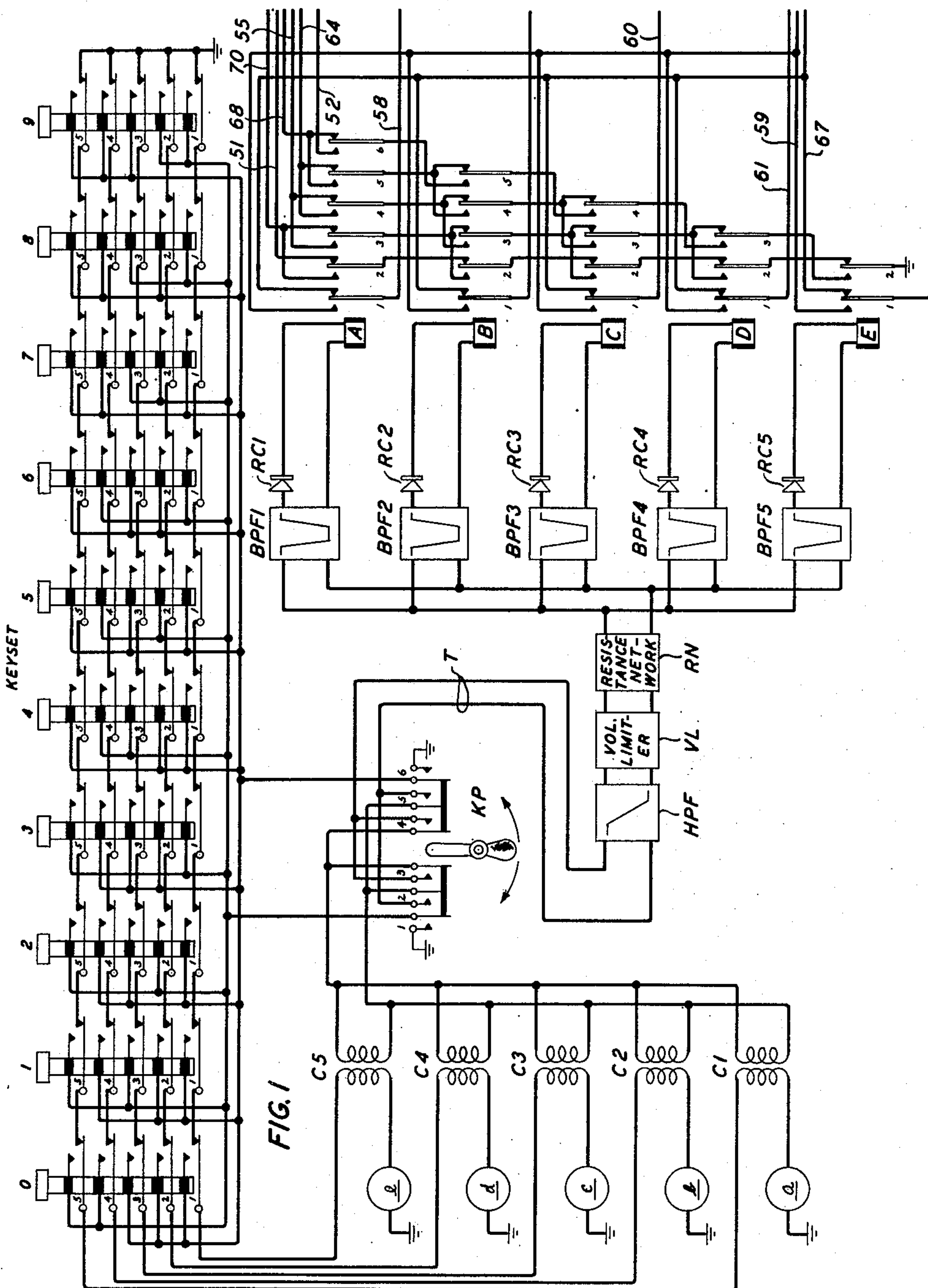
C. CLOS

2,470,145

MULTIFREQUENCY SIGNALING SYSTEM

Filed Sept. 25, 1947

3 Sheets-Sheet 1



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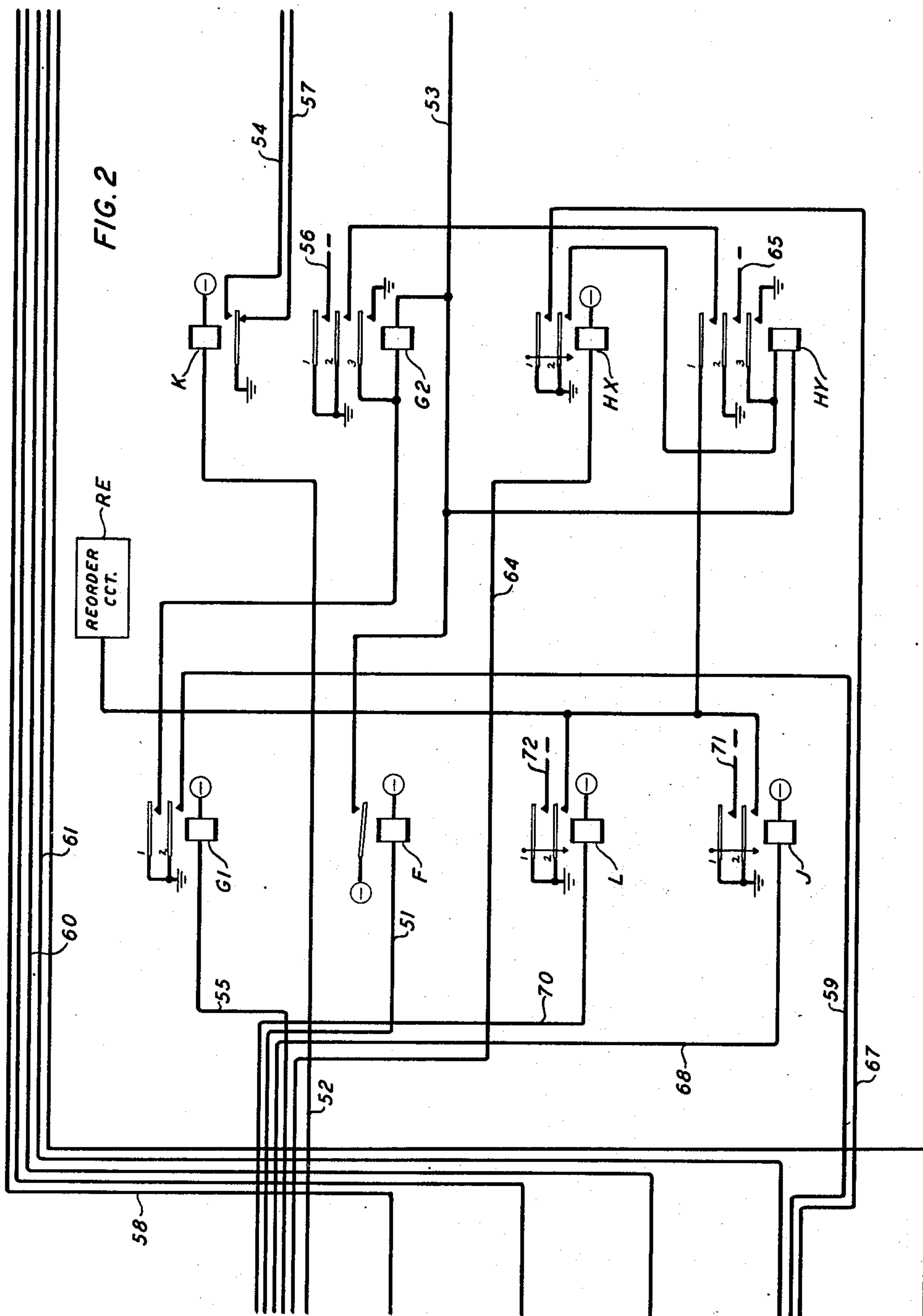
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3 Sheets-Sheet 2



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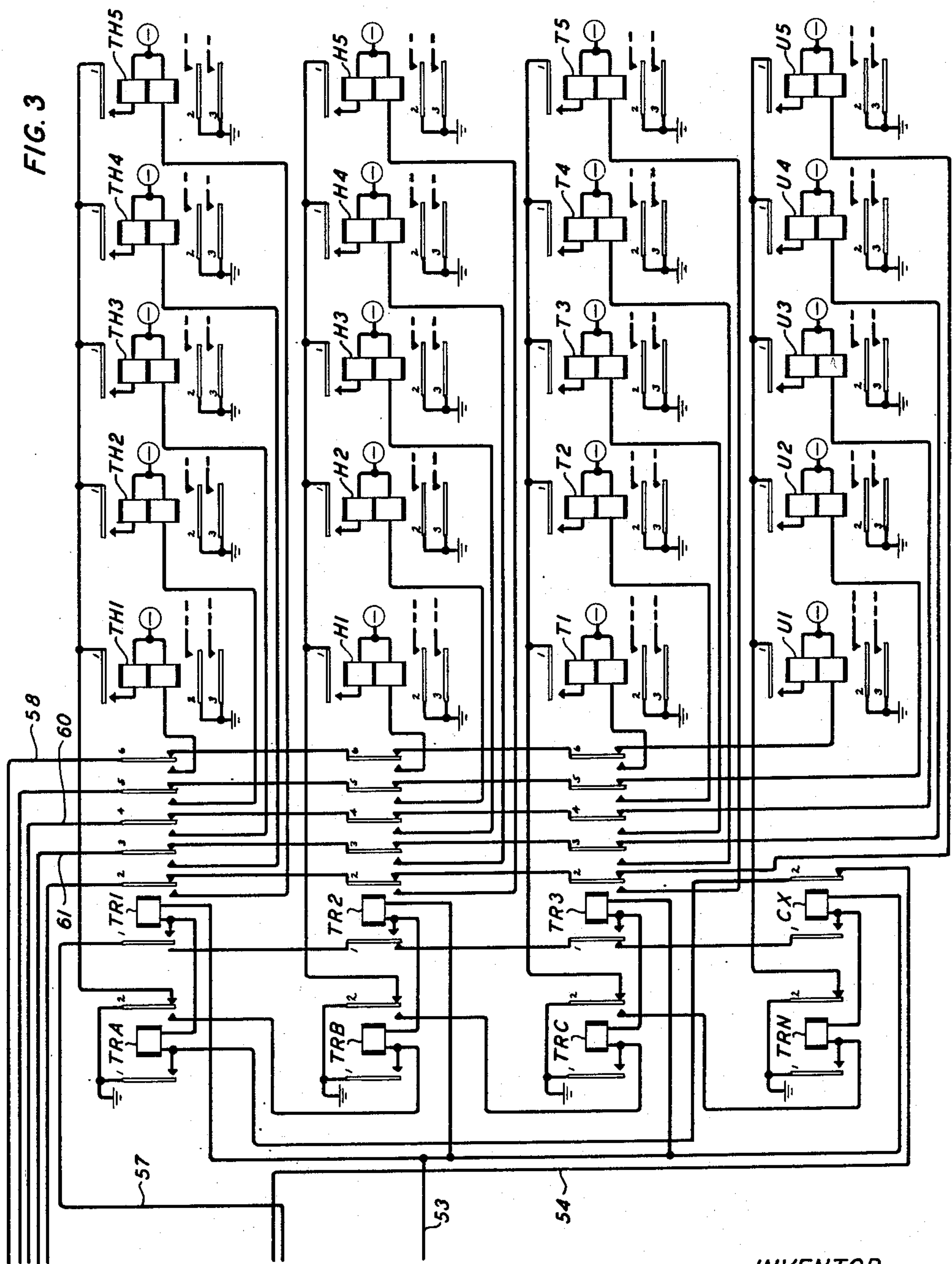
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MULTIFREQUENCY SIGNALING SYSTEM

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3 Sheets-Sheet 3



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MULTIFREQUENCY SIGNALING SYSTEM

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10 Claims. (Cl. 177-353)

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This invention relates to signaling systems and more particularly to systems in which combinations of electrical frequencies are used for signaling.

A common form of signaling system is one which employs a combination of two of five different electrical frequencies to represent each of ten characters, such as the digits "0" to "9," and a receiver responsive to said frequencies to indicate the character or digit corresponding to the combination of frequencies received. Means are usually provided to prevent false indications if, for any reason, more or less than two of the frequencies are transmitted in combination to the receiver. A system of this kind is disclosed in the patent to G. Hecht et al. 2,332,912, dated October 26, 1943.

The present invention discloses a system employing combinations of five frequencies to represent ten characters, but each character may be transmitted and received in two different ways, thus doubling the number of distinguishable codes.

A feature of the invention is a means whereby, when signals are being transmitted in one way, an indication is given of any signal accidentally transmitted in the alternate way.

Another feature of the invention is a means which may be employed, if desired, to indicate the way in which the signals are being transmitted.

These and other features of the invention will be apparent from the description, the appended claims, and the drawings, in which:

Figure 1 shows the transmitting circuits and a portion of the receiving circuits;

Fig. 2 shows another portion of the receiving circuits; and

Fig. 3 shows still another portion of the receiving circuits and also the register circuits.

To completely disclose the invention, Fig. 2 should be placed to the right of Fig. 1 and Fig. 3 to the right of Fig. 2.

The drawings show one embodiment of the invention for the transmission, reception and registration of four signals representing digits and produced by the manual operation of keys, which is suitable, for example, for the use of operators in telephone systems. It will be obvious that signals may be initiated by other means than keys

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and may represent other characters than digits, while provision may be made for the registration at one time of any number of signals. The invention is therefore not limited in its application to telephone systems but is suitable for the transmission and reception of intelligence of any kind represented by signals initiated by any suitable means.

In the present embodiment of the invention, a keyset comprising ten keys 0-9, shown in Fig. 1, is provided, each key adapted to initiate a signal corresponding to the designation of said key by controlling five sources of frequency *a*, *b*, *c*, *d* and *e*, which may be of any suitable type, and each of which produces a frequency distinguishably different from the frequency produced by any other of said sources. A double-throw key KP is arranged to connect the output of the frequency sources through coils C1-C5 to the transmission line T.

At the receiving end of the system, the transmission line T is provided with the usual high-pass filter F, volume limiter VL, and resistance network RN, which may be of any suitable well-known type. Each of the five band-pass filters BPF1-BPF5 is responsive to the frequency of only one of the sources *a*, *b*, *c*, *d* and *e*, filter BPF1 being responsive to the frequency of source *a*, filter BPF2 being responsive to the frequency of source *b*, etc. The output of each of the band-pass filters BPF1-BPF5 through the respectively associated rectifiers RC1, RC2, RC3, RC4 or RC5, when one of said filters responds, is sufficient to operate the associated relay A, B, C, D, or E. Reference may be had to the above-mentioned patent for a more complete description of a system of this kind.

The circuits of Fig. 2 are control circuits and the reorder circuit RE, indicated but not shown, is a well-known circuit for giving a reorder signal to the operator at the keys of Fig. 1. In the present embodiment of the invention, a relay register circuit of five relays, such as the circuit comprising relays TH1-TH5, in Fig. 3, is provided for each digit to be registered and provision is made for registering four digits. Other suitable forms of registers may be used and by obvious extension or reduction of the circuits shown, provision may be made for registering any number of digits.

Signals representing digits may be transmitted

by combinations of two of the five frequencies of the sources *a*, *b*, *c*, *d* and *e* or by combinations of three of said frequencies as hereinafter described.

While the registered indications of signals received may, of course, represent any characters or intelligence of any kind, it is assumed, for the purpose of illustration, that the signals represent digits in accordance with the following code:

Combinations of Two Frequencies	Combinations of Three Frequencies	Register Relays Operated	Digits Represented
<i>a</i> , <i>b</i>	<i>c</i> , <i>d</i> , <i>e</i>	1st & 2nd	0
<i>a</i> , <i>c</i>	<i>b</i> , <i>d</i> , <i>e</i>	1st & 3rd	1
<i>a</i> , <i>d</i>	<i>b</i> , <i>c</i> , <i>e</i>	1st & 4th	2
<i>a</i> , <i>e</i>	<i>b</i> , <i>c</i> , <i>d</i>	1st & 5th	3
<i>b</i> , <i>c</i>	<i>a</i> , <i>d</i> , <i>e</i>	2nd & 3rd	4
<i>b</i> , <i>d</i>	<i>a</i> , <i>c</i> , <i>e</i>	2nd & 4th	5
<i>b</i> , <i>e</i>	<i>a</i> , <i>c</i> , <i>d</i>	2nd & 5th	6
<i>c</i> , <i>d</i>	<i>a</i> , <i>b</i> , <i>e</i>	3rd & 4th	7
<i>c</i> , <i>e</i>	<i>a</i> , <i>b</i> , <i>d</i>	3rd & 5th	8
<i>d</i> , <i>e</i>	<i>a</i> , <i>b</i> , <i>c</i>	4th & 5th	9

When it is desired to transmit signals by combinations of two frequencies, key KP is thrown to the right, closing the left-hand contacts of said key. All of the five frequencies produced by the sources *a*, *b*, *c*, *d* and *e* are thereby applied to the transmission line T. The circuit of frequency source *a*, for example is completed from ground through said source, left-hand winding of coil C1, and No. 5 normal contacts of keys 0-9 to ground. The circuits of the other sources are similarly completed through other normal contacts of keys 0-9. Frequencies induced in the right-hand winding of coils C1-C5 are then transmitted through No. 2 and No. 3 contacts of key KP to line T. Each of the band-pass filters BPF1-BPF5 responds to one of said frequencies through the high-pass filter HBF, volume limiter VL, and resistance network RN, operating the associated relays A, B, C, D, and E.

By the operation of relays A, B, C, D and E the circuit of the normally-operated relay F, which extends from battery through the winding of said relay, conductor 51 and No. 2 back contacts of relays A, B, C, D and E in series to ground, is opened and relay F released. A circuit is also completed from battery through the winding of relay K, conductor 52, No. 6 front contacts of relay A, No. 5 front contacts of relay B, No. 4 front contacts of relay C, No. 3 front contacts of relay D, and No. 2 front contacts of relay E to ground, over which relay K operates. Relays TRA and TR1 then operate in series over a circuit extending from battery through the contacts of relay F, conductor 53, winding of relay TR1, winding of relay TRA, No. 2 contacts of relay CX, conductor 54, and front contacts of relay K to ground, and lockup through No. 1 contacts of relay TRA to ground. Relays TRB and TR2 operate in series over a circuit extending from battery through contacts of relay F, conductor 53, winding of relay TR2, winding of relay TRB, and No. 2 front contacts of relay TRA to ground, and lock up through No. 1 contacts of relay TRB to ground. Relays TRC and TR3 operate in series over a circuit extending from battery through the contacts of relay F, conductor 53, winding of relay TR3, winding of relay TRC, and No. 2 front contacts of relay TRB to ground, and lock up through No. 1 contacts of relay TRC to ground. Relays TRN and CX operate in series over a circuit extending from battery through the contacts of relay F, conductor 53, winding of relay CX, winding of relay TRN, and No. 2 front contacts of re-

lay TRC to ground, and lock up through No. 1 contacts of relay TRN to ground.

The receiving circuits are thereby prepared for receiving signals which are initiated by the depression of the keys 0-9. Assuming that the number "1234" is to be transmitted, keys 1, 2, 3 and 4 are successively depressed and released, in that order. Upon the depression of key 1, a circuit for frequency source *a* is closed through No. 5 normal contacts of key 0, No. 5 front contacts of key 1 and No. 1 contacts of key KP to ground and a circuit for frequency source *c* is closed through No. 3 normal contacts of key 0, No. 3 front contacts of key 1 and No. 1 contacts of key KP to ground. Since key KP is operated to the right, the circuits of frequency sources *b*, *d* and *e* are opened at No. 4, No. 2 and No. 1 normal contacts, respectively, of key 1. Only the frequencies of sources *a* and *c* are now transmitted over line T. Relays A and C therefore remain operated and relays B, D and E release.

By the release of relays B, D and E, a circuit is completed from battery through the winding of relay G1, conductor 55, No. 3 front contacts of relay A, No. 3 back contacts of relay B, No. 2 front contacts of relay C, No. 2 back contacts of relay D, and No. 2 back contacts of relay E to ground, operating relay G1. Relay G2 then operates over a circuit extending from battery through the contacts of relay F, winding of relay G2, and No. 1 contacts of relay G1 to ground and locks up through its own No. 3, contacts to ground. The No. 1 contacts of relay G2 apply ground to conductor 56 as an indication that signals will be received in combinations of two frequencies. By the release of relays B, D and E, the circuit, previously traced, of relay K is opened and said relay released. The winding of relay TRA is thereby short-circuited, the left-hand end of said winding being connected to ground through No. 1 contacts of said relay and the right-hand end of said winding being connected through No. 1 front contacts of relay TR1, conductor 57, and back contacts of relay K to ground. Relay TRA is thereby released.

Upon the operation of relay G1, as described above, circuits are completed from battery through the lower winding of relay TH1, No. 6 front contacts of relay TR1, conductor 58, No. 1 front contacts of relay A, conductor 59, and No. 2 contacts of relay G1 to ground, and from battery through the winding of relay TH3, No. 4 front contacts of relay TR1, conductor 60, No. 1 front contacts of relay C, conductor 59, and No. 2 contacts of relay G1 to ground, over which relays TH1 and TH3 operate, said relays locking up over circuits extending from battery through their respective upper windings and No. 1 contacts, and No. 2 back contacts of relay TRA to ground. Relays TH1 and TH3 operated indicate the first digit received to be "1" in accordance with the code previously given.

Upon the release of key 1, the circuits of the frequency sources *b*, *d* and *e* are restored, all five frequencies being now transmitted over line T. In consequence, relays B, D and E reoperate. The circuit, previously traced, of relay G1 is thereby opened and said relay released. The circuit, previously traced, of relay K is restored, operating said relay which opens the locking circuit of and releases relay TR1. Relays TR1 and TRA do not reoperate, their operating circuit being now open at No. 2 contacts of relay CX.

When key 2 is now depressed, the circuits of frequency sources *a* and *d* are maintained through

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No. 5 and No. 2 front contacts, respectively, of said key and No. 1 contacts of key KP to ground, while the circuits of frequency sources *b*, *c* and *e* are opened at No. 4, No. 3 and No. 1 normal contacts, respectively, of key 2. Sources *a* and *d* now alone supplying frequency to line T, relays A and D are maintained operated and relays B, C and E released. Relay G1 reoperates over a circuit extending from battery through the winding of said relay, conductor 55, No. 3 front contacts of relay A, No. 3 back contacts of relay B, No. 3 back contacts of relay C, No. 2 front contacts of relay D, and No. 2 back contacts of relay E to ground. By the release of relays B, C and E, the circuit, previously traced, of relay K is opened and said relay released, short-circuiting the winding of and releasing relay TRB in the manner previously described for relay TRA. Circuits are now completed from battery through the lower winding of relay H1, No. 6 front contacts of relay TR2, No. 6 back contacts of relay TR1, conductor 58, No. 1 front contacts of relay A, conductor 59, and No. 2 contacts of relay G1 to ground, and from battery through the lower winding of relay H4, No. 3 front contacts of relay TR2, No. 3 back contacts of relay TR1, conductor 61, No. 1 front contacts of relay D, conductor 59, and No. 2 contacts of relay G1 to ground, over which relays H1 and H4 operate, locking up over circuits extending from battery through their respective upper windings and No. 1 contacts, and No. 2 back contacts of relay TRB to ground. Relays H1 and H4 operated indicate the second digit received as "2" in accordance with the code previously given.

In a similar manner, release of key 2 and subsequent depression of key 3 causes the operation and locking up of relays T1 and T5 and the release of key 3 and subsequent depression of key 4 causes the operation and locking up of relays U2 and U3. The locked-up relays TH1, TH3, H1, H4, T1, T5, U2 and U3 indicate, in accordance with the code previously given, the number "1234," which is the number intended to be transmitted, and the ground on conductor 56 indicates that said number was transmitted by combinations of two frequencies. This indication, while not essential, is valuable as it may signify an additional character or item of intelligence.

Upon the release of key 4, all five frequencies are again applied to line T, as previously described, and relays A, D and E, which were not operated when key 4 was depressed, reoperate. Relay G1 releases and relay K reoperates as previously described, opening the locking circuit of and releasing relay CX, which, after the release of relays TR1—TR3, was locked up through its No. 1 contacts, No. 1 back contacts of relays TR3—TR1, conductor 57, and back contacts of relay K to ground. Relays TRA and TR1 then operate in series over the circuit previously traced, operating, in turn, relays TRB, TR2, TRC, TR3, TRN and CX. Operation of relays TRA, TRB, TRC, and TRN opens the locking circuits of and releases the locked-up register relays. When key KP is restored, the frequencies from the sources *a-e* are removed from line T, releasing relays A-E. The circuit, previously traced, of relay F is thereby restored and said relay operated, opening the circuits of and releasing relays G2, TRA, TR1, TRB, TR2, TRC, TR3, TRN and CX, restoring the circuits to normal.

When any one of the keys is depressed subsequent to the depression of the first key, as described above, should, through some fault, three

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frequencies from the sources *a-e* be applied to line T, for example, from sources *a*, *c*, and *d* (the depression of the first key having indicated that signals would be sent in combinations of two frequencies), relays A, C, and D remain operated, as described above. Relay HX then operates over a circuit extending from battery through the winding of said relay, conductor 64, No. 4 front contacts of relay A, No. 4 back contacts of relay B, No. 3 front contacts of relay C, No. 2 front contacts of relay D, and No. 2 back contacts of relay E to ground. Relay HY operates over a circuit extending from battery through the contacts of relay F, winding of relay HY, and No. 2 contacts of relay HX to ground and locks up through its No. 3 contacts to ground. Relay G1 does not now operate, its operating circuit being open at No. 2 back contacts of relay D. Relay G2 being operated, as previously described, the reorder circuit RE is energized by ground through No. 2 contacts of relay G2 and No. 1 contacts of relay HY, giving a reorder signal to the operator of the keyset. The No. 2 contacts of relay HY ground conductor 65 as an indication that the reorder circuit was actuated in response to the receipt of three frequencies in error. The operator may then restore key KP, reoperating relay F over the circuit previously traced, which opens the locking circuits of and releases relays G2 and HY. Relay HX is made slow to operate in order that a reorder signal will not be produced by a momentary false operation of relays A-E.

When it is desired to send and receive a number, for example, "1234," by combinations of three frequencies, key KP is thrown to the left closing its right-hand contacts. All five frequencies are thereupon transmitted over line T with the effects already described. When key 1 is now depressed, the circuits of frequency sources *b*, *d* and *e* are maintained closed through No. 4, No. 2, and No. 1 front contacts, respectively, of said key and No. 6 contacts of key KP to ground, while the circuits of frequency sources *a* and *c* are opened at No. 5 and No. 3 normal contacts of key 1, respectively. The frequencies of sources *a* and *c* are therefore removed from line T and relays A and C are released. Relay HX then operates over a circuit extending from battery through the winding of said relay, conductor 64, No. 5 back contacts of relay A, No. 4 front contacts of relay B, No. 4 back contacts of relay C, No. 3 front contacts of relay D, and No. 2 front contacts of relay E to ground. Relay HY operates over a circuit extending from battery through the contacts of relay F, winding of relay HY, and No. 2 contacts of relay HX to ground and locks up through its own No. 3 contacts to ground, its No. 2 contacts connecting ground to conductor 65. The reorder circuit not being actuated, ground on conductor 65 now indicates that signals are being sent in combinations of three frequencies. Like the previous indication on conductor 56, this indication is not essential but may be useful. Relay K is released, short-circuiting the winding of and releasing relay TRA, as previously described.

Circuits are now completed from battery through the lower winding of relay TH1, No. 6 front contacts of relay TR1, conductor 58, No. 1 back contacts of relay A, conductor 67, and No. 1 contacts of relay HX to ground, and from battery through the lower winding of relay TH3, No. 4 front contacts of relay TR1, conductor 60, No. 1 back contacts of relay C, conductor 67, and No. 1

contacts of relay HX to ground, over which relays TH1 and TH3 operate, locking up over circuits extending from battery through their respective upper windings and No. 1 contacts, and No. 2 contacts of relay TRA to ground, thus registering the first digit as "1" in accordance with the previously given code.

The operations consequent upon the release of key 1 and subsequent operation and release of keys 2, 3 and 4 are similar to those already described, relays H1, H4, T1, T3, U2 and U3 being operated and locked up over circuits similar to those traced above for relays TH1 and TH3. The number "1234" is thereby registered, but ground on conductor 55 applied by the operation of relay HY indicates that said number was transmitted by combinations of three frequencies. Upon the restoration of key KP, the circuits are restored to normal, as previously described.

If, upon the depression of any key subsequent to the depression of the first key in the example above, only two frequencies, for example, the frequencies of sources *a* and *d* upon the depression of key 2, are, through some fault, impressed upon line T (the depression of the first key having indicated that signals would be sent in combinations of three frequencies), only relays A and D of the relays A-E remain operated. Relay G1 then operates over a circuit extending from battery through the winding of said relay, conductor 55, No. 3 front contacts of relay A, No. 3 back contacts of relay B, No. 3 back contacts of relay C, No. 2 front contacts of relay D, and No. 2 back contacts of relay E to ground, operating relay G2 which locks up, as previously described. Ground is then supplied through No. 2 contacts of relay G2 and No. 1 contacts of relay HY to the reorder circuit RE, causing said reorder circuit to send a reorder signal to the operator at the transmitting end of the system. The No. 1 contacts of relay G2 apply ground to conductor 56 as an indication that two frequencies were received in error.

In either of the examples given above, if upon the depression of key 1, 2, 3 or 4, only one frequency is through some fault, impressed upon line T, for example, the frequency of source *a*, relay A alone of the relays A-E remains operated. Relay L then operates over a circuit extending from battery through the winding of said relay, conductor 70, No. 2 front contacts of relay A and No. 2 back contacts of relays B-E in series to ground. Ground is then supplied through the No. 2 contacts of relay L to the reorder circuit RE to cause a reorder signal. Relay L is made slow to operate in order that a reorder signal will not be caused by a momentary failure of frequency or of the apparatus responsive thereto. The No. 1 contacts of relay L ground conductor 72 as an indication that one frequency was received in error.

If upon the depression of key 1, 2, 3 or 4, in the above examples, four frequencies are, through some fault, transmitted over line T operating four of the relays A-E, for example, relays B-E, relay J operates over a circuit extending from battery through the winding of said relay, conductor 68, No. 6 back contacts of relay A, No. 5 front contacts of relay B, No. 4 front contacts of relay C, No. 3 front contacts of relay D, and No. 2 front contacts of relay E to ground, its no 2 contacts supplying ground to the reorder circuit RE, to send a reorder signal. The No. 1 contacts of relay J ground conductor 71 as an indication that four frequencies were received in error. Relay J

is made slow to operate in order that a reorder signal will not be produced by a momentary false operation of four of the relays A-E. In each case, restoration of key KP releases relays A-E, opening the circuit of and releasing relay L or relay J.

The above examples show how the number "1234" may be transmitted and received in two ways, the grounding of conductor 56 or conductor 55 indicating, at the receiving end, the way in which said number was transmitted. Said conductors may be connected to suitable indicating or other devices to utilize said indication, for example, to distinguish between the numbers of coin and of non-coin telephone lines. Having received in indication in connection with the first digit of the manner in which the number is being transmitted, a reorder signal is given if any subsequent digit is, through some fault, represented by a wrong number of frequencies in combination. It is obvious, from the above examples, that any other number of four digits may be similarly transmitted and received and, by extension or contraction of the circuits shown, numbers of more or less than four digits may be similarly transmitted and received.

What is claimed is:

1. In a signaling system, in combination, sources of different electrical frequencies, means for sending a signal composed of a number of said frequencies, means for sending a signal composed of a different number of said frequencies, and a receiver responsive to all of the frequencies in each of said signals to register the same indication for each of said signals.
2. In a signaling system, in combination, sources of different electrical frequencies, means for sending signals composed of combinations of said frequencies in a plurality of different codes, and a receiver comprising means for receiving said signals, means responsive to all of the frequencies in each of said signals to register the same indication for two of said signals sent in different codes, and means for indicating the code in which each of said signals is sent.
3. In a signaling system, in combination with sources of different electrical frequencies, means for sending a signal composed of two of said frequencies, means for sending a signal composed of three of said frequencies, and a receiver responsive to all of the frequencies in each of said signals to register the same indication for each of said signals.
4. In a signaling system, in combination with sources of different electrical frequencies, means for sending a signal composed of two of said frequencies, means for sending a signal composed of three of said frequencies, and a receiver comprising means for receiving said signals, means responsive to all the frequencies in each of said signals to register the same indication for each of said signals, and means for indicating the number of frequencies included in each of said signals.
5. In a signaling system, in combination with sources of different electrical frequencies, means for sending a first signal composed of either one number or another number of said frequencies, means for sending subsequent signals each composed of a number of said frequencies, means for receiving said signals, and means for indicating any of said subsequent signals composed of a number of frequencies different from the number of frequencies composing said first signal.
6. In a signaling system, in combination with

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sources of different electrical frequencies, means for sending a first signal composed of either two or three of said frequencies, means for sending subsequent signals each composed of a number of said frequencies, means for receiving said signals, and means for indicating any of said subsequent signals composed of other than the number of said frequencies in said first signal.

7. In a signaling system, in combination with sources of different electrical frequencies, means for sending a signal composed of a number of said frequencies, means for sending a signal composed of a different number of said frequencies, and a receiver responsive to all of the frequencies in each of said signals to register the same indication for each of said signals and to indicate the number of frequencies composing each of said signals.

8. In a signaling system, in combination with sources of different electrical frequencies, means for sending a signal composed of two of said frequencies, means for sending a signal composed of three of said frequencies, and a receiver responsive of all of the frequencies in each of said signals to register the same indication for each of said signals and to indicate the number of frequencies composing each of said signals.

9. In a signaling system, in combination with sources of five different electrical frequencies, means for sending a signal composed of two of

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said frequencies, means for sending a signal composed of the other three of said frequencies, and a receiver responsive to all of the frequencies in each of said signals to register the same indication for each of said signals.

10. In a signaling system, in combination with sources of five different electrical frequencies, means for sending a signal composed of two of said frequencies, means for sending a signal composed of the other three of said frequencies, and a receiver responsive to all of the frequencies in each of said signals to register the same indication for each of said signals and to indicate the number of frequencies composing each of said signals.

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