

June 24, 1941.

W. T. REA

2,246,952

SIGNALING SYSTEM

Filed March 16, 1939

4 Sheets-Sheet 1

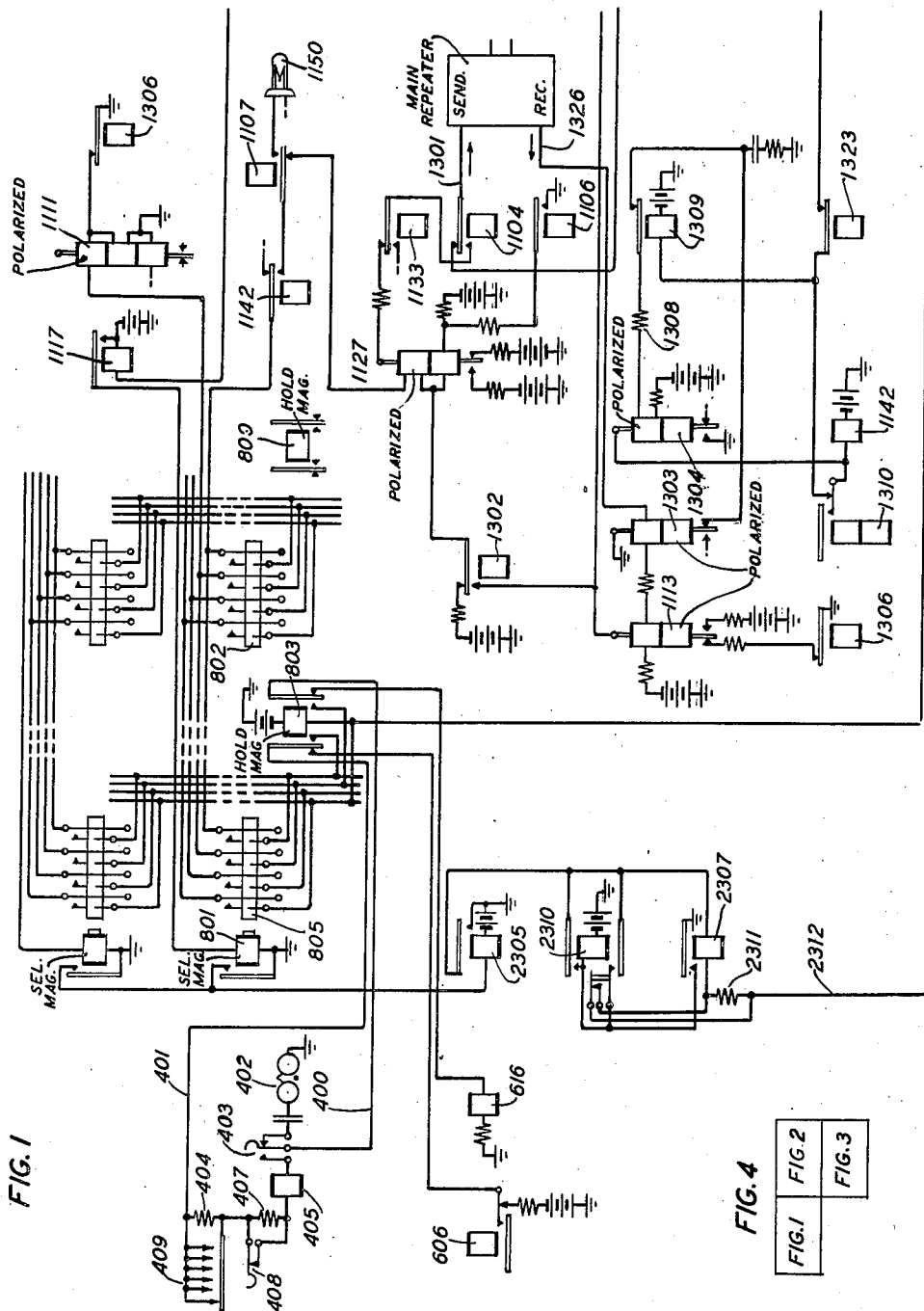


FIG. 4

FIG. 1	FIG. 2	FIG. 3
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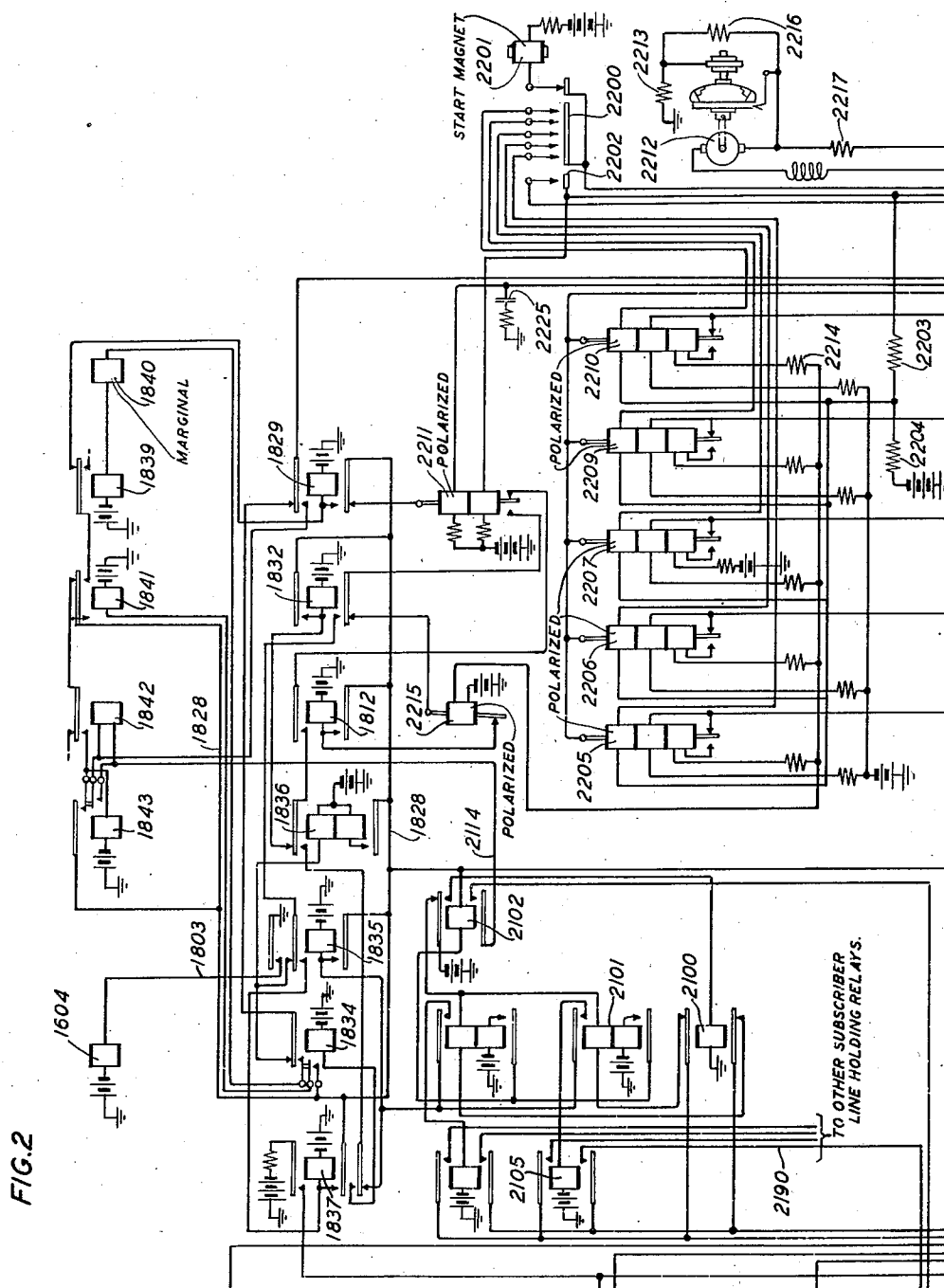
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4 Sheets-Sheet 2



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4 Sheets-Sheet 3

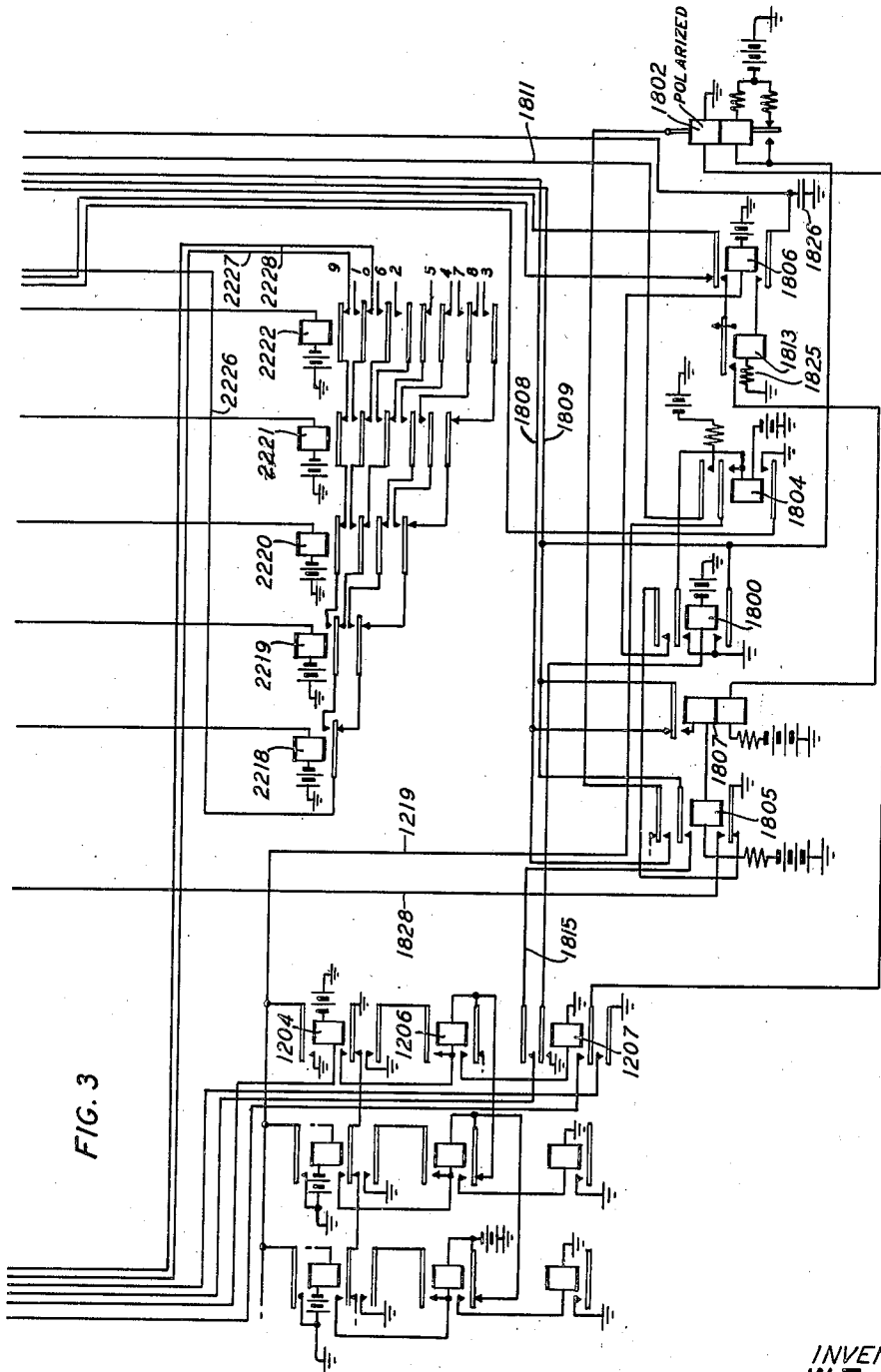


FIG. 3

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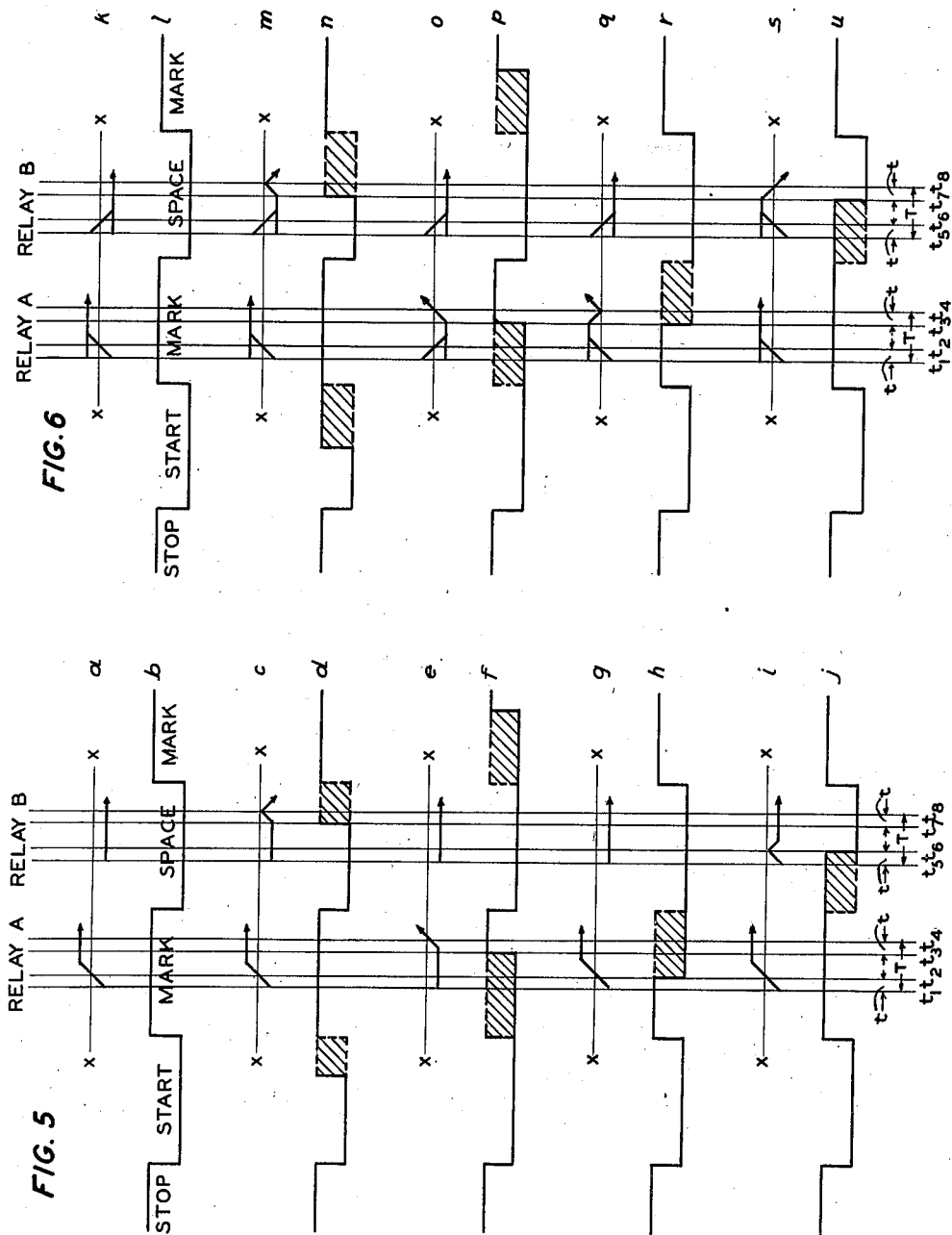
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SIGNALING SYSTEM

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4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

2,246,952

SIGNALING SYSTEM

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Application March 16, 1939, Serial No. 262,152

5 Claims. (Cl. 173--2)

This invention relates to switching systems and particularly to telegraph exchange systems where trunks are selectively extended to a plurality of individual subscriber lines.

The object of the invention generally is to improve on existing facilities by increasing the speed and reliability of their operation. Where a standard five-unit permutation code is used for telegraph signaling and the start-stop system is employed, present day practice calls for the transmission of about sixty words per minute or about six characters per second. Where machine switching devices are used for extending connections between subscribers it has been found convenient to direct the setting of the switches by the same type of impulses and by employing the existing transmitters rather than using an auxiliary device operable on the decimal basis as in many well-known types of telephone switching systems. Consequently the operation is essentially of a high speed nature and translating means must be used to change from permutation code to numerical code. Heretofore director circuits have been used and these circuits are temporarily assigned to trunks for setting switches after which they must be dismissed for service with other trunks. The holding time of the director circuit is important since such circuits are expensive and the fewer that can be made to give efficient service with a given number of trunks determines the greater the economy of the system. Heretofore each director circuit was equipped with a set of permutation code responsive relays and these relays had to respond to an incoming code, remain operated for a period long enough for the translating operation and then return to normal ready to receive the next code.

A feature of the present invention is a new arrangement whereby one step in the above operation is entirely eliminated thus enabling high speed operation to be more easily attained. In place of the so-called neutral relays heretofore employed, polar relays are now used, relays of the type sometimes referred to as the Potts relay. Such relays in a new circuit arrangement obviate the necessity for returning the relays to normal after each operation to be ready for the reception of the next code. Besides thus eliminating one complete operation these relays are readily designable to be inherently faster than any comparable neutral relay due to their more efficient magnetic circuit and thus speed in operation is gained.

Another feature of the present invention is an arrangement whereby wear and tear on the apparatus is minimized. Let us assume that in some combination of sequential operations of a particular one of such permutation code relays there is encountered a large number of like im-

pulses. Let us assume a sequence of ten marking impulses. Under previous conditions there would have been ten operations each followed by a return to normal of the neutral relay. Under the present invention there will be but a single operation and thus the polar relay now employed will have less severe service. In other words, there will be less wear and tear since the present circuit is so arranged that the relay is permitted to maintain its armature in the position last set until some succeeding character code drives the said armature of that particular relay to an alternate position.

Another advantage gained by the use of the present invention is the elimination of that part of the internal distortion of the director circuit heretofore caused by an improper ratio between the time required to operate one of the permutation code responsive relays and the time during which said relay is subject to the operative force. For reasons which will be explained later, internal bias occurs in the previous circuit when the ratio between said times is other than 1:2, while in the present invention the internal bias is independent of said ratio. The elimination of part of the internal distortion of a receiver is an improvement in that it correspondingly improves the tolerance of the device to distortions external to itself.

The drawings consist of three sheets of circuit diagrams and one sheet of diagrams explanatory of the operation of start-stop permutation code selective devices. The circuits shown thereon are, in most respects, a skeletonized version of the drawings in the application of C. W. Lucek filed on even date herewith now Patent 2,228,279, granted January 14, 1941. The relays and other pieces of apparatus are designated with the same numerals as those used in the Lucek application so that a much more detailed description of certain parts of the present circuit may be had by reference to such other application. Since it is only necessary herein to show the action of the polar relays in the director circuit, it is only the director circuit that is shown in any amount of detail.

In Fig. 1 there is a subscriber station connected to the conductors 400 and 401 leading to the switching arrangement in a concentration office where such lines are extended by cross-bar switches to trunks leading to central offices. The contact sets 802, 805, etc., represent such a cross-bar switch and the circuit to the right thereof represents certain essential parts of the central office trunk. Below the contact set 805 of the cross-bar switch is shown a set of relays 2305, 2307 and 2310, all belonging to the miscellaneous alarm circuit. To the left of this set of relays there are two relays designated 606 and 616 which belong in the subscriber's line circuit and which

are used when the subscriber wishes to make an outgoing call. Since this operation is not essential to an understanding of the present invention, these relays are merely indicated.

In Fig. 2 the director circuit is shown in some detail with the polar relays 2205 to 2210 forming the essential feature of the present invention.

Fig. 3 shows more details of the director circuit and a group of relays in the left-hand portion comprising part of the trunk sequence circuit.

Fig. 4 is an indication of how Figs. 1, 2 and 3 should be arranged in order to properly follow the description of the circuit diagram contained therein.

Fig. 5 is an explanatory diagram used to illustrate the action of a start-stop receiver with distorted signals when neutral operated selectors are used as in the prior art, such for instance as in the application of Fitch, Large and Lucek, Serial No. 173,958, filed November 11, 1937.

Fig. 6 is a like explanatory diagram used to illustrate the action of a start-stop receiver with distorted signals when polar operated selectors are used as in the present application.

In order to give a precise understanding of the action of these relays the following description will first be with reference to Figs. 5 and 6 and will be in the form of a discussion of the theory of operation of the relays under different conditions of distortion of the signals intended to operate them. Thereafter a description of the circuit diagrams of Figs. 1, 2 and 3 will be given to illustrate the circuits in which the relays may be used.

The following discussion will explain how the ratio between the operating time of a permutation code responsive relay and the time during which said relay is subject to the operative force affects a receiver of the previous type and a receiver of the present type.

In Fig. 5 the lines *b*, *d*, *f*, *h* and *j* are simple signal diagrams and the lines *a*, *c*, *e*, *g* and *i* are diagrams illustrating in a conventional manner the action of the relays. Similarly in Fig. 6 the lines *l*, *n*, *p*, *r* and *u* are signal diagrams and the lines *k*, *m*, *o*, *q* and *s* are conventional illustrations of the operations of relays. These two figures should be considered to be on a coordinate basis as the signal current plotted against time in the case of the signal diagrams and relay armature movement plotted against time in the case of the diagrams explaining the action of the relays.

Fig. 5 shows in lines *a* and *b* the operation of two of the permutation code responsive relays in a receiver of the previous type, in which said relays, being initially unoperated are, in turn, connected for a certain period of time *T* to a circuit which tends to operate them when the incoming signal is marking and does not tend to operate them when the incoming signal is spacing. The selective periods *T* are spaced a unit pulse length apart and their times of occurrence may be adjusted with respect to the start transition by an "orientation" device.

When a relay becomes operated it locks in the operated condition and remains locked until the end of the particular signal combination being received. Line *b* shows a stop pulse, a start pulse, a marking and a spacing selective pulse of a permutation code signal train. Line *a* shows a simple explanatory diagram of the action of the relays in response to the signals of line *b*.

The relay A is subjected to the operating cur-

rent during the period, of duration *T*, from *t*₁ to *t*₄ and the relay B is subject to the operating current during a period, which here is shown as of equal duration *T*, from *t*₅ to *t*₈. The line *X—X* represents the division between the marking and spacing conditions of the relays and the arrows show schematically the action of the relays. When the arrow is above line *X—X* the relay is considered operated; when below, it is released. The time required for the relay to become operated after it is subjected to the operative force is denoted *t*. It will be seen that relay A is subjected to an operative force at time *t*₁, becomes operated at time *t*₂ and, of course, is locked when operated, thus correctly indicating a marking selection. Relay B is not subjected to an operating force during the period *t*₅ to *t*₈ because the signal is spacing during this period. It, therefore, remains unoperated, thus correctly indicating a spacing selection.

In line *d* the received signals are shown distorted by what is known in the art as "marking bias," the amount of this distortion being indicated by the shaded areas. Relay A operates in the same manner as in line *a*. Relay B is subjected to no operating force until the signal becomes marking at the time, *t*₇, when the signal becomes marking. It begins to operate but before operation can become complete the force is withdrawn at time *t*₈ and the relay fails to operate, thus correctly indicating a spacing selection. If the initiation of the marking signal had occurred any sooner the relay would have become operated and locked and thus would have incorrectly indicated a marking selection. Hence the amount of marking bias indicated by the shaded areas (about 30 per cent in this case) is the maximum that will be tolerated by this receiver.

Line *f* shows the signals affected by spacing bias indicated by the shaded areas. Relay B acts as in line *a*. Relay A, however, remains unoperated until the time, *t*₃, at which the signal becomes marking. The relay then begins to operate and barely becomes operated at the time, *t*₄, when the operative force is withdrawn. It then locks and correctly indicates a marking selection. Had the initiation of the marking signal been delayed an infinitesimal time, relay A would not have become operated before the operative force was withdrawn and would have incorrectly indicated a spacing selection. Hence the amount of spacing bias indicated by the shaded areas (about 70 per cent in this case) is the maximum that will be tolerated by this receiver.

Line *h* shows the signals affected by distortion which advances a mark-to-space transition relative to the start transition. Characteristic or fortuitous distortion of the signals, which may affect a start transition differently from a selective transition, will cause an effect of this type which is sometimes known in the art as a "spacing end-displacement." In this case relay B acts as in line *a*. Relay A begins to operate at time *t*₁ and barely becomes operated at the time, *t*₂, when the signal becomes spacing. It locks, correctly indicating a marking selection. Had the mark-to-space transition occurred earlier relay A would have failed to attain the operated condition and would have incorrectly indicated a spacing selection. Hence the amount of spacing end-displacement indicated by the shaded area (about 50 per cent in this case) is the maximum that will be tolerated by this receiver.

Line *j* shows the signals affected by a delay of a mark-to-space transition relative to the start transition. This effect, sometimes known in the art as "marking end-displacement," is also caused by characteristic or fortuitous distortion of the signals. Relay A acts as in line *a*. Relay B begins to operate at time t_5 and just fails to become operated at the time, t_6 , when the signal becomes spacing. It thus correctly indicates a spacing selection. Had the mark-to-space transition been delayed any later, relay B would have become operated and locked, incorrectly indicating a marking selection. Hence the amount of marking end-displacement indicated by the shaded area (about 50 per cent in this case) is the maximum that will be tolerated by this receiver.

Thus it is seen that the receiver will tolerate equal amounts of marking and spacing end-displacement but will tolerate 40 per cent more spacing bias than marking bias. This means that the receiver has 20 per cent internal marking bias; for, if some device producing 20 per cent spacing bias were introduced into the receiver, the tolerances to marking and spacing bias would become equal.

It should be noted that the limiting amounts of bias occur at times t_3 and t_7 while the limiting amounts of end-displacement occur at times t_2 and t_6 . The former times are known in the art as the "instant of decision for bias" and the latter as the "instant of decision for end-displacement."

It will be obvious that were t made greater, t_2 would approach t_3 . Specifically, if t becomes equal to $\frac{1}{2}T$, t_2 and t_3 become identical as do t_6 and t_7 . Then 40 per cent of marking bias or spacing end-displacement might be tolerated and 60 per cent spacing bias or marking end-displacement might be tolerated. If then the "orientation," which determines the time of occurrence of the selective intervals relative to the start transition, were advanced in time by 10 per cent of a unit pulse length, 50 per cent of each of the biases and end-displacements could be tolerated and the receiver would be considered to be adjusted for best tolerance to all types of distortion.

It should also be noted, in passing, that were t greater than $\frac{1}{2}T$ and the orientation so adjusted that equal amounts of end-displacement could be tolerated, the tolerance to marking bias would exceed that to spacing bias. In other words the receiver would then be affected with spacing internal bias. Thus it will be seen that the internal bias is equal to the period of time between the instant of decision for bias and the instant of decision for end-displacement. The difference between the instants of decision is equal to $T - 2t$.

Now refer to Fig. 6 which shows the operation of two of the permutation code responsive relays in the present device in which said relays are polar and, being initially operated or released, depending upon a previous selection, are in turn connected for a certain period of time to a circuit which tends to operate them when the incoming signal is marking and release them when the incoming signal is spacing. When the operating or releasing force is withdrawn the relay remains locked in the condition then attained and so remains until a subsequent signal train is received and selected.

The diagrams of lines *k* to *u*, inclusive, are similar in form to those of lines *a* to *j*, inclusive, except that at the beginning of any selective

period two possible courses are shown for a relay, depending upon whether it began the selective period in the marking or spacing condition.

Line *k* shows the selective action when the received signal is undistorted as shown in line *l*. Lines *m* and *n* show the case of received marking bias, lines *o* and *p* of received spacing bias, lines *q* and *r* of received spacing end-displacement and lines *s* and *u* of received marking end-displacement. The tolerance to each of these is 50 per cent, even though the ratio of t to T is not 1:2. This is due to the fact that the instants of decision for bias and end-displacement both occur at a time t before the end of the selective period T and are thus identical and not dependent upon the relation between t and T provided that t is not greater than about $\frac{2}{3}T$.

If t is greater than about $\frac{2}{3}T$ the instant of decision is dependent upon the condition of the relay at the beginning of the selective period and this constitutes in itself internal fortuitous distortion, reducing the tolerance to all four types of displacement. In practice there is very seldom any reason for this to occur since in most cases T can be made as long as necessary.

On the other hand, in the case of the previous receiver illustrated in Fig. 5, the instant of decision for bias occurs at time t before the end of the selective period while the instant of decision for end-displacement occurs at time t after the beginning of the selective period. Great difficulty may be experienced in making the time required to operate the relay exactly one-half the time during which the distributor subjects the relay to the operating force, particularly where the latter time, as is often the case, may be different for the various selective pulses. Thus the polar relay device of the present invention is much more stable and easily adjusted.

Since the polar relay of usual design in properly balanced circuits operates with equal speed in both directions the device of the present invention will be without internal bias, and will consequently be an improvement in the art.

The manner in which the present invention operates in a teletypewriter system will now be described with particular reference to Figs. 1, 2 and 3.

Let it be assumed that a call is being extended from the central office to the subscriber's line shown in the upper left-hand portion of Fig. 1. The trunk circuit from the central office will act through the main repeater and establish a transmission circuit over conductor 1326 and the upper windings of polarized relays 1303 and 1113. Relay 1113 responds to impulses coming in from the central office and relays them over the front contact and inner lower armature of relay 1207 of the trunk sequence circuit and thence through the upper winding of polarized relay 1302 in the director circuit. Relay 1302, in turn, relays these impulses through the upper outer armature and front contact of relay 1305 to the distributor contacts 2200 from whence they affect the polarized relays 2205 to 2210. These polarized relays, in turn, operate the fanning-out relays 2218 to 2222 and cause the operation of such relays as 2100, 2101 and 2105 which cooperate to energize the holding magnet 803 of the cross-bar switch. Since the relay 1207 of the trunk sequence circuit has caused the operation of relay 1117 in the trunk circuit, the selecting magnet 801 of the cross-bar switch will have been operated before this operation of the holding magnet 803. Therefore, upon the operation of the holding magnet

803 the set of contacts 805 will operate to extend the trunk to the subscriber's line. Thereafter, as is more fully explained in the copending Lucek application, the selecting magnet 801 will be released and the holding magnet 803 will be held by means in the trunk circuit. Through the operation of relay 1302, the sending relay 1127 is effectively connected to the transmission conductor 1326 and transmission over this conductor is repeated by the relay 1113 and thence over the circuit including the upper winding of polarized relay 1127, contacts of relays 1107 and 1142, through the left-hand contacts of the holding magnet 803 to conductor 401 of the subscriber's line, the return path for closing this transmission circuit being traced through the conductor 400, the right-hand contacts of holding magnet 803, the upper winding of the polarized relay 1111 to ground at the contact of relay 1306. Relay 1127 responds to impulses coming in from the subscriber's station but does not respond to impulses coming in over transmission conductor 1326. Transmission from the subscriber's station is, therefore, relayed by relay 1127 to the transmission conductor 1301 leading in to the central office.

Seizure of director and transmission of "director ready" signal

When an operator seizes the trunk to the line concentration unit at the distant manual board, the associated trunk at the line concentration unit functions to cause the sequence circuit to attempt connection to the director circuit in use. When the two-way trunk at the line concentration unit receives permission to route the call through the office, the sequence circuit connects this director circuit to the particular trunk. The inward transmission path from the two-way trunk circuit is in a marking condition and is connected to the lead to the upper winding of relay 1802. The sequence circuit also places a ground on the lead connected to the winding of relay 1800. The operation of relay 1800 (1) operates relay 1804, (2) extends the ground from the lower armature and back contact of relay 1805 to the winding of relay 1806 to cause the operation of this relay, (3) extends ground through its front contact and lower armature (a) through the armature and back contact of relay 1807 to conductor 1808, leading to the receiving contacts 2200 and causes the operation of start magnet 2201 which permits rapid acceleration of the motor by eliminating clutch drag, (b) extends ground to the lower winding of the receiving relay 1802 which biases this relay to spacing, (c) extends ground over conductor 1809 to the stop pulse contact of the distributor 2202, (d) extends ground to the potentiometer formed by resistances 2203 and 2204, which potentiometer is later used in operating the polar relays 2205 to 2210, inclusive, (e) extends ground over conductor 1809 through the lower winding of polarized relay 2211 which biases this relay to spacing (as shown), and (f) extends ground to the front contact of the upper outer armature of relay 1805 which is later used to start the "director ready" signal.

Relay 1804 places battery on conductor 1811 and starts the distributor motor 2212, the return circuit being through current limiting resistance 2213 and the governor contacts which are closed while the motor is coming up to speed. Relay 1804 locks to ground on conductor 1219, leading from relays, such as relay 1204, in the trunk sequence circuit. Therefore, the motor is kept

running under control of the sequence circuit as long as an incoming call is awaiting completion. Relay 1804 also supplies ground to the armatures of the polar relays 2205 to 2210 over its lower armature and front contact and this ground connection permits these relays to lock in either direction. If the relay 2205, for instance, is on its right-hand contact, as shown, then this ground connection is extended over its right-hand contact through its middle winding and a resistance to battery, this middle winding tending to hold the armature in the direction in which it is shown. If the armature, on the other hand, were resting on its left-hand contact, then the lower winding of this relay would be energized through the winding of relay 2215 and the armature thus held in its left-hand position.

While the motor is attaining speed, the distributor cams are successively operating, causing brief closures of each receiving contact in turn. The polar relays will, therefore, operate and lock in the spacing direction due to these closures to ground.

The spacing locking paths of polar relays 2205, 2206, 2209 and 2210 are through such resistances as 2214 and the winding of relay 2215. Polar relay 2207 has a spacing locking path independent of the winding of relay 2215 for a purpose which will be hereinafter described. Therefore, relay 2215 will operate as soon as any one of relays 2205, 2206, 2209 or 2210 operates to spacing. The operation of relay 2215 opens the operating path of relay 1812 to prevent its premature operation.

Meanwhile relay 1806 in operating has in effect placed a sensitive relay 1813 across the governor contacts and has prepared in advance a path for operating the fast-operating relay 1807. While the motor 2212 is being accelerated relays 1800, 1804 and 1806 are operated. When full speed is reached the governor contacts open momentarily removing the short circuit from resistance 2216 and allowing relay 1813 to operate through resistances 1825 and 2217. Relay 1813 is slow-releasing and with the help of condenser 1826 holds over during momentary governor contact closures operating relay 1807 as soon as the stop pulse contacts 2202 close.

Relay 1807 in operating removes ground from the receiving contacts and the start magnet 2201, latching the clutch and preventing further operation of the contacts. Relay 1807 locks through the winding of and operates relay 1805 which in operating applies ground to start the director ready signal out over lead 1815 to the loop repeater. The director ready signal consists of the connection from ground on the lower armature of relay 1800 through the inner upper armature and front contact of relay 1805, conductor 1815, outer upper armature and front contact of relay 1207, back contact and armature of relay 1104 to the transmission conductor 1301 leading to the main repeater and thence to the central office from which the connection was originated. This constitutes a marking signal and remains in this condition until the sequence circuit is dropped out after the connection to the subscriber is made.

Relay 1805 in operating also (1) connects the armature of relay 1802 to conductor 1803 leading to the start magnet 2201 and the contact 2200 preparatory to receiving pulses from the main repeater, (2) releases relay 1806 and (3) provides off-normal ground on conductor 1823 to a large part of the director circuit including ground on

the armature of relay 2211 through the back contact and lower armature of relay 1828. Relay 1806 in releasing disconnects relay 1813 from the governor contacts and transfers the stop pulse contacts 2202 from relay 1807 to the upper winding of relay 2211 preparatory to receiving pulses from the main repeater. The circuit is now prepared to receive pulses from the distant office.

Reception of figures character

Telegraph pulses over the inward path are repeated by relay 1802 which is normally held to its marking contact. The distributor motor is running but the receiving contacts of the distributor are not operating because the start magnet 2201 is released latching the clutch. As soon as a character is received the start pulse of the character sends relay 1802 to spacing which operates magnet 2201 allowing the cams to successively operate the receiving contacts. The motor speed and receiving contacts are adjusted so that at this time when the first selecting pulse of the character is received, the top winding of relay 2210 is momentarily connected to the armature of relay 1802. If the first pulse is marking, relay 2210 will operate and lock to its marking contact. Similarly the other polarized relays 2209, 2207, 2206 and 2205 will in turn be left either spacing or marking depending on the character of the following pulses. It should be noted that as hereinbefore mentioned, these relays are held to their marking or spacing contacts through their middle and lower windings, respectively, and the circuits are so adjusted by such resistances as 2214 that the force which holds the armature in either position is equal. The energization of the uppermost winding through the contacts for operating relay 2209 is enough to overcome the force of these biasing windings and the speed with which these relays move their armatures from one contact to another is equal in both directions.

The reception of the figures character then proceeds as follows:

Dot elements	Relay 1802	Register relays	Fan relays operated
1.....	Marking	2210 marking	2222
2.....	do.	2209 marking	2221
3.....	Spacing	2207 spacing	
4.....	Marking	2206 marking	2219
5.....	do.	2205 marking	2218

With the polarized register relays operated as above it will be noted that none of the locking paths of these relays pass through the winding of relay 2215. Since the figures character is the only one having this particular code it will, therefore, happen that relay 2215 will release only when a figures character is received since with any other one of these relays in its spacing condition or with relay 2207 in its marking position the relay 2215 will be energized. With relay 2215 released a momentary closure of ground by the stop pulse distributor contacts causes relay 2211 to operate to its marking contact overcoming the effect of its bias to its spacing contact. The timing condenser 2225 causes relay 2211 to remain on its marking contact for .030 second after the stop pulse distributor contacts open. This allows time for the operation of relay 1812 which thereupon locks to ground on conductor 1828 and prepares a path for operating relay 1832 when relay 2211 returns to its spacing contact. In this way relay 1832 operates and locks to ground on

conductor 1828 and transfers the marking contact of relay 2211 along to the succeeding counting relays in preparation for the registration of the next two digits. The reception of "figures" has, therefore, set up a combination of register relays locking direct to battery instead of through the winding of relay 2215 thereby unlocking relay 2215 and allowing the next two characters to be registered. Hits or short interruptions like the spacing signals on the line are harmless unless the operator has sent preliminary "figures." After the figures character has been received the following relays are operated: 1809, 1804, 1807, 1805, 2218, 2219, 2221, 2222, 1812, 1832, 1802 (to marking), 2210 (to marking), 2209 (to marking), 2207 (to spacing), 2206 (to marking), 2205 (to marking) and 2211 (to spacing). The operation of relays 2218, 2219, 2221 and 2222 performs no useful function at this time since the path from conductor 2226 is not closed to any one of the conductors leading out from these fanning relays.

Reception and deciphering of the first digit

The first digit of the subscriber's number will be repeated by relay 1802, broken up pulse by pulse by the distributor contacts and recorded by the register relays in much the same way as the "figures" character was received. The polarized register relays will be operated in accordance with the position of relay 1802 during the reception of the corresponding pulses. In each case the operating winding of such polarized relays can quickly overcome the holding winding but otherwise the relays hold in whichever direction they are operated under control of the lower armature and front contact of relay 1804. The following table indicates the condition of the register relays resulting from the transmission of numerical characters. M indicates marking, S indicates spacing.

Character		Relay condition				
Lower case	Upper case	R2210	R2209	R2207	R2206	R2205
Figures	Figures	M	M	S	M	M
P	0	S	M	M	S	M
Q	1	M	M	M	S	M
W	2	M	M	S	S	M
E	3	M	S	S	S	S
R	4	S	M	S	M	S
T	5	S	S	S	S	M
Y	6	M	S	M	S	M
U	7	M	M	M	S	S
I	8	S	M	M	S	S
O	9	S	S	S	M	M

It will be noted that when relay 2205 is on its marking contact fanning relay 2222 is operated. Similarly the other fanning relays are operated when their associated register relays are on their marking contacts. Also relay 2215 will be operated during the reception of the first digit but performs no useful function after the "figures" character has been received. At the conclusion of the dot elements of the particular character sent, relay 2211 again operates to marking, and is again held for an additional period of .030 second.

Let it be assumed that the call is being extended to the subscriber's station, shown in the upper left-hand corner of Fig. 1, and that this station is designated as No. 90. The first digit, therefore, will be the digit 9 having three successive spacing signals followed by two successive marking signals. This will result in the

operation of relays 2210, 2209, 2207 to their spacing contacts and 2206, 2205 to their marking contacts. As a result relay 2218 is operated by relay 2205 and relay 2219 is operated by relay 2206. Therefore, a connection can be traced from conductor 2226 through the armature and front contact of relay 2218, the inner armature and front contact of relay 2219, the innermost armature and back contact of relay 2220, the innermost armature and back contact of relay 2221, the innermost armature and back contact of relay 2222 to conductor 2227. This latter conductor can be traced through the upper armature and back contact of relay 2100, the upper winding of relay 2101, the back contact and upper armature of relay 2102 to battery. In the other direction this battery connection will be extended over conductor 2226, the upper armature and back contact of relay 1829, the upper armature and back contact of relay 1834, the back contact and inner upper armature of relay 1835, the front contact and lower armature of relay 1832 to the marking contact of relay 2211. When the stop contact 2202 is closed with relay 2211 on its marking contact, ground from the front contact and lower armature of relay 1800 extending over conductor 1809, thence over conductor 1828 to the armature of relay 2211 and thus eventually over the lower armature of relay 1832, causes the operation of relay 1836 and in parallel therewith relay 2101. Relay 2101 which corresponds to the tens group of the particular called subscriber's line, in operating locks in series with relay 2102 to a ground which may be traced from the winding of relay 2102 to ground on conductor 1828. Relay 2102 in operating (1) removes battery from the operating windings of all other relays corresponding to relay 2101 preventing the operation of another such relay on this call, (2) causes the operation of relay 2100 which definitely removes any one of the relays such as 2101 from their associated 0 to 9 fanning-out leads and (3) closes a connection to conductor 2114 which later supplies ground to operate the hold magnet of the link circuit in case the line is idle. Relay 1836 in operating prepares a path for the operation of relay 1835. When the polarized relay 2211 returns to its spacing contact after .030 second, relay 1835 will operate and ground will be supplied to a contact on relay 2101, in a circuit from the ground supplied for the operation of relay 1835 over the upper armature and front contact of relay 2101 to the winding of relay 2105 associated with the particular tens group of the called subscriber's line. Relay 2105 in operating connects the fanning-out leads 0 to 9 (only two of which are shown) to the 0 to 9 leads of the particular tens group of subscribers' lines. The relay 1835 in operating (1) locks to ground on conductor 1828, (2) opens the operating paths of relays 1836 and 2101 and prepares a path for the operation of relay 1837, (3) connects ground to lead 1803 to the sequence circuit where it causes the operation of relay 1804 to fix the trunk advance chain and prevent the release of any link circuit in use on an established call. After the first digit has been received the following relays are operated: 1800, 1804, 1807, 1812, 1832, 1836, 1835, 2101, 2102, 2100 and 2105. Relay 1802 is marking, relay 2211 is spacing and in the particular case described relays 2210, 2209 and 2207 are spacing and relays 2206 and 2205 are marking and relays 2218 and 2219 are operated.

Reception and deciphering of the second digit

The second digit of the called subscriber's number is received, registered and made to operate the fanning-out relays in the same way as the first digit. In this particular case we are assuming that the second digit is 0; therefore, relay 2210 will be spacing, relays 2209 and 2207 will be marking. Relay 2206 will be spacing and relay 2205 will be marking. With the register relays so effected fanning-out relays 2218, 2220 and 2221 will be operated; therefore, a connection may be traced from conductor 2226 through the armature and front contact of relay 2218, the inner armature and back contact of relay 2219, the second inner armature and front contact of relay 2220, the second inner armature and front contact of relay 2221, the second armature and back contact of relay 2222 to conductor 2228. This conductor may be traced through the lower armature and front contact of relay 2105, whence it leads over conductor 2190 to the winding of holding magnet 803.

Relay 2211 operates to its marking contact while the stop segment is grounded and thereby causes the operation of relay 1837. Relay 1837 in operating (1) establishes a connection from ground, the upper winding of relay 1802 through the inner lower armature and front contact of relay 1207, the front contact and upper armature of relay 1837 to battery to prevent any additional incoming impulses from being registered, (2) locks to ground on conductor 1828, and (3) opens the original operating paths of relays 1835 and 2105 and prepares a path for the operation of relay 1834.

When the polarized relay 2211 after .030 second returns to its spacing contact it causes the operation of relay 1834. This relay in operating (1) connects battery through the windings of relays 1839 and 1840 in series, thence through the front contact and upper armature of relay 1834, the back contact and upper armature of relay 1829, conductor 2226 and thence over the circuit traced to the holding magnet 803 of the particular called subscriber's line, and (2) causes the operation of slow-acting relay 1841. It will be noted as usual that the polarized registration relays remain locked in the direction in which they were last operated.

Testing subscriber's line

The connection of battery through the relays 1839 and 1840 to the particular called subscriber's line enables these two relays to determine if the individual lead 2190 to the subscriber's line is terminated in a direct ground which causes the operation of both relays 1839 and 1840 and denotes a busy condition or a high resistance ground which results in the operation of relay 1839 only and denotes an out-of-order condition. In case no ground is available neither relay 1839 nor 1840 operates. This test takes place during the slow-operating time of relay 1841 which begins to operate as soon as relay 1834 moves its armatures. As soon as relay 1841 operates off normal ground on conductor 1828 is connected to the armature of relay 1839.

Assuming the subscriber's line idle, in which case ground is not connected to the lead passing through relays 1839 and 1840, neither of these relays will be operated and ground connected to the armature of relay 1841 will cause the operation of relay 1829. Relay 1829 in operating (1) removes relays 1839 and 1840 from connection to the subscriber's line lead 2190 and replaces

this connection by a connection through the winding of relay 1842, (2) causes the release of relay 1834 by removing ground from the armature of polarized relay 2211, and (3) locks to ground on conductor 1838. The release of relay 1834 allows relay 1841 to release but since this latter relay is slow in releasing there will be a short interval during which relay 1834 is released and relay 1841 is operated, giving relay 1842 an opportunity to cause the energization of relay 1843. During this time ground is connected through the winding of relay 2307 in the miscellaneous alarm circuit through conductor 2312, the front contact and lower armature of relay 2102, winding of relay 1842, the front contact and upper armature of relay 1829, and thence over the path through conductor 2226 to the subscriber's holding magnet 803. Under the assumed condition of the subscriber's line being idle, battery on the winding of relay 803 on the cross-bar switch permits relay 1842 to operate but due to the high resistance of the circuit relay 803 remains unoperated at this time. Relay 1842 in operating closes a path to operate relay 1843. When relay 1841 releases, ground supplied over the conductor 1828 is connected to the armature of relay 1842 through the back contact of relay 1841 so that now the circuit for the operation of relay 1843 is completed and this relay operates. Relay 1843 in operating (1) locks to ground on conductor 1828, and (2) short-circuits the winding of relay 1842. With the winding of relay 1842 short-circuited ground supplied by the miscellaneous alarm circuit connected through the fanning-out relays of the director circuit and thence over conductor 2190 will cause the operation of magnet 803. The subscriber will, therefore, be connected to the trunk circuit which will thereupon function to release the sequence circuit. The sequence circuit in turn will function to remove the ground on the conductor leading to relay 1800. Relay 1800, therefore, releases (1) removing off-normal ground from various parts of the circuit including relays 1805 and 1807, and (2) releases relay 1804 unless conductor 1219 leading to the inner upper armature of relay 1804 is held grounded indicating that another inward call is awaiting completion. Relay 1805 releasing removes off-normal locking ground from conductor 1828 leading to a considerable part of the circuit. If relay 1804 releases, motor 2212 will be stopped and all remaining parts of the circuit will be deenergized.

Further details of the operation of this circuit may be found in the aforesaid copending Lucek application.

What is claimed is:

1. In a communication system, a plurality of lines, a plurality of trunks, a switch for inter-connecting said lines and said trunks, a director circuit for setting said switch, means for temporarily assigning said director circuit to an individual one of said trunks and a set of relays in said director circuit each having an equal time of movement in each direction, said relays being responsive to permutation code impulses received over said individual one of said trunks for translating said permutation codes into switch setting circuit conditions.

2. In a communication system, a plurality of lines, a plurality of trunks, a switch for inter-

connecting said lines and said trunks, a director circuit for setting said switch, means for temporarily assigning said director circuit to an individual one of said trunks, a set of relays in said director circuit responsive to permutation code impulses received over said individual one of said trunks for translating said permutation codes into switch setting circuit conditions, each of said relays having a single high speed armature which may be driven with equal speed from one position to the other and each of said relays being included in a circuit wherein the said armature will be maintained in the last position to which it has been driven by some previous permutation code impulse until some succeeding permutation code impulse drives it to the other position, and means for dismissing said director circuit when its switch setting functions have been completed.

3. In a communication system, wherein a receiving device responds to incoming permutation code impulses, a distributor to distribute the impulses to said receiving device, means to render the internal bias of said receiving device independent of the ratio of the operating time of any one of its selectors to the time during which said any one of said selectors is subject to an operating impulse comprising a selector for each impulse unit of the permutation code, each said selector including a polar relay with a high speed armature, and a circuit arrangement wherein each said armature will be maintained in the last position to which it has been driven by some previous permutation code impulse until some succeeding permutation code impulse drives it to the other position.

4. In a communication system, a plurality of lines, a plurality of trunks, a switch for inter-connecting said lines and said trunks, a director circuit for setting said switch, and means for temporarily assigning said director circuit to an individual one of said trunks, said director circuit including a receiving device responsive to permutation code impulses, comprising selectors each having a definite operating time and a start-stop distributing means for distributing the impulses of an incoming code for a definite time each to a corresponding selector, and a circuit arrangement for operating said selectors from the position to which each was last set whereby the tolerance of said receiver to external distortions of signals is extended and the internal bias of said receiver is rendered independent of the ratio of said operating time of said selectors to the exposure time of said selectors to the signaling impulses.

5. In a line selecting system, a source of impulses, a distributor assigning said impulses in code combinations of which a predetermined consecutive number are assigned to make a selection, a plurality of polar relays equal in number to said number, means for applying said impulses in sequence to said relays, circuit means controlled at least in part by said relays for holding said relays in either position when moved by their respective impulses to said position, and means controlled by a new sequence of impulses to reset any one or more of said relays, and line identifying instrumentalities controlled by said polar relays.

WILTON T. REA.