

Oct. 15, 1929.

R. F. STEHLIK

1,732,185

TELEPHONE SYSTEM

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Fig. 8

321	322	323	324	325
PU	X			
1		X		
2			X	
3				X
4				
5				
6				
7				
8				
9				
0				

SENDER COUNTING DEVICE

Fig. 7

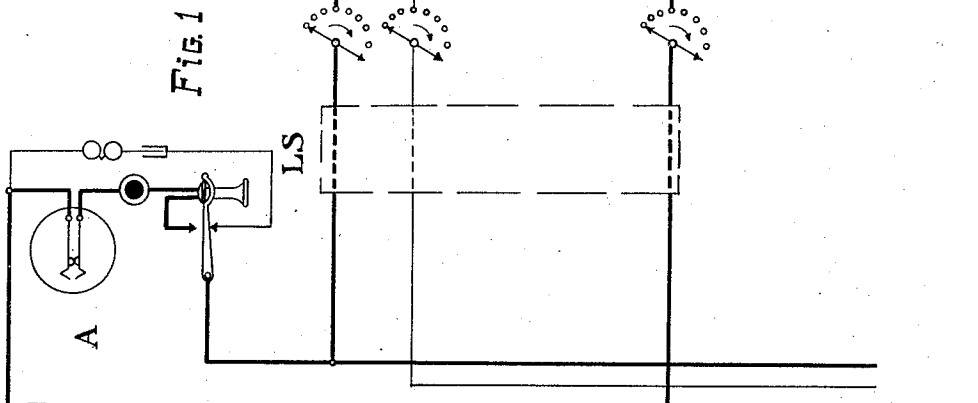
A	B	C	D
1	X		
2	X		
3	X		
4	X		
5		X	
6		X	
7		X	
8		X	
9		X	
0		X	

STORAGE SETS

Fig. 6

211	212	213	214	215
1	X			
2	X			
3	X			
4	X			
5		X		
6		X		
7		X		
8		X		
9		X		
0		X		

REGISTER



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Oct. 15, 1929.

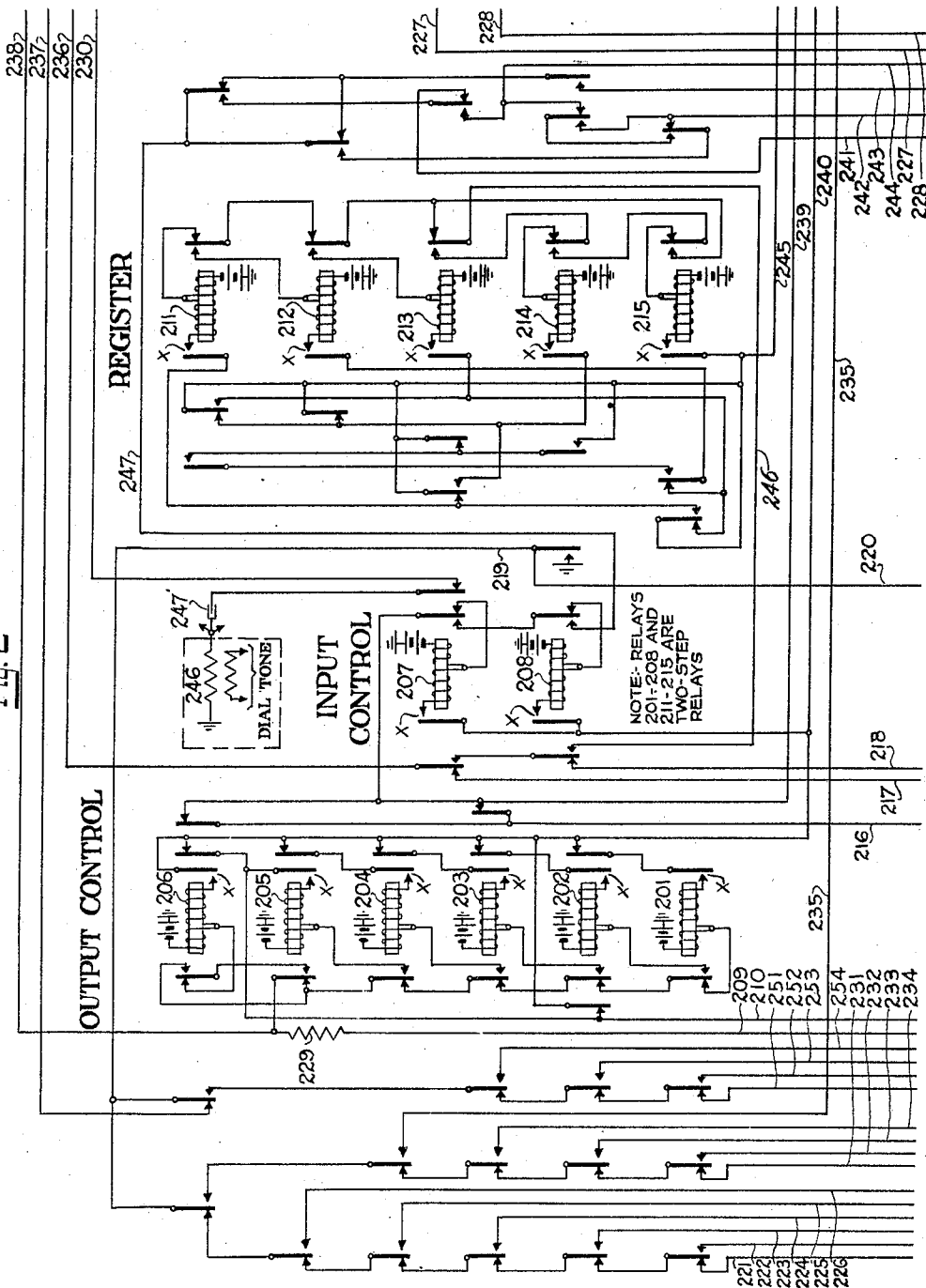
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TELEPHONE SYSTEM

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Fig. 2



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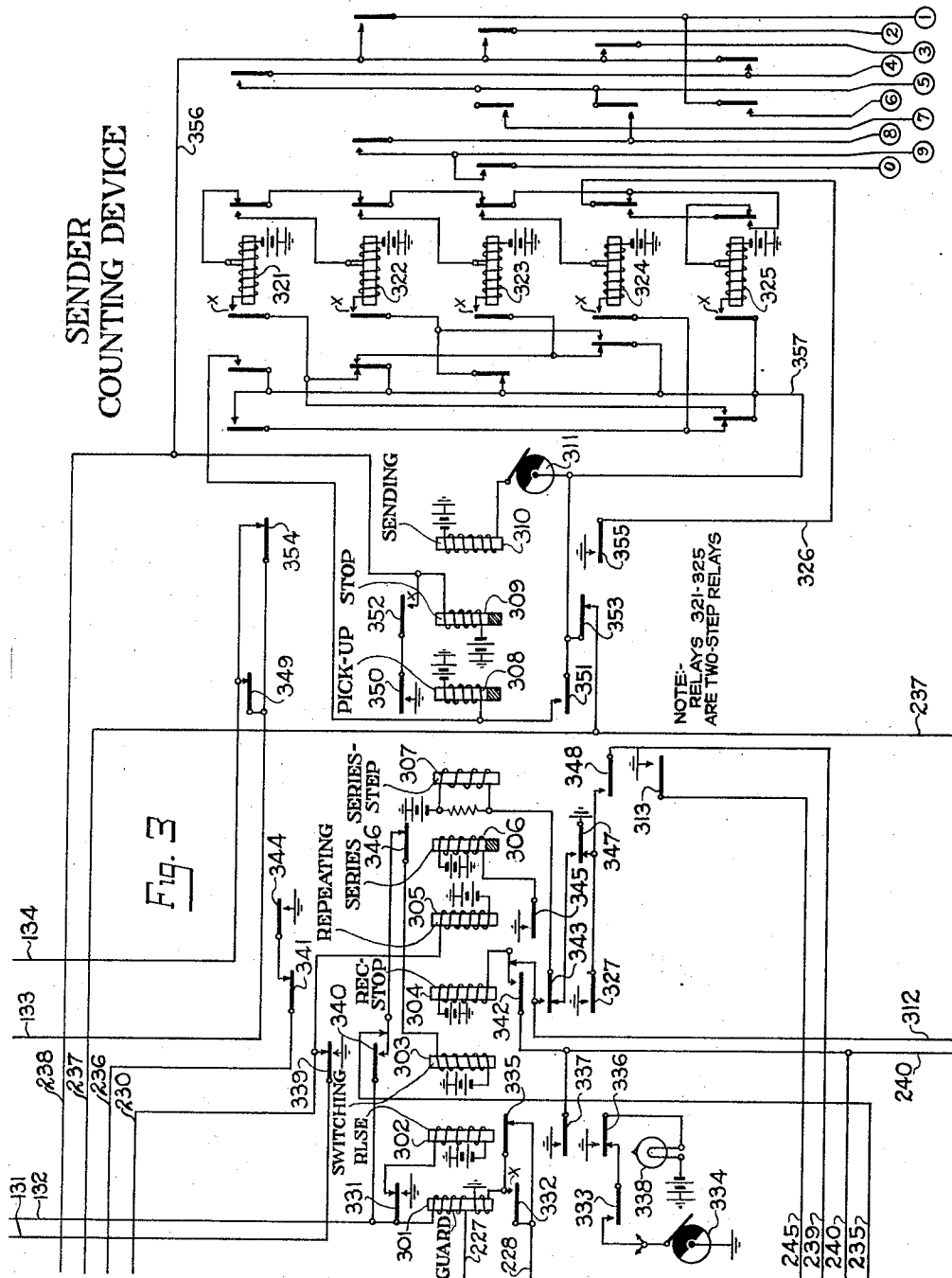
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TELEPHONE SYSTEM

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TELEPHONE SYSTEM

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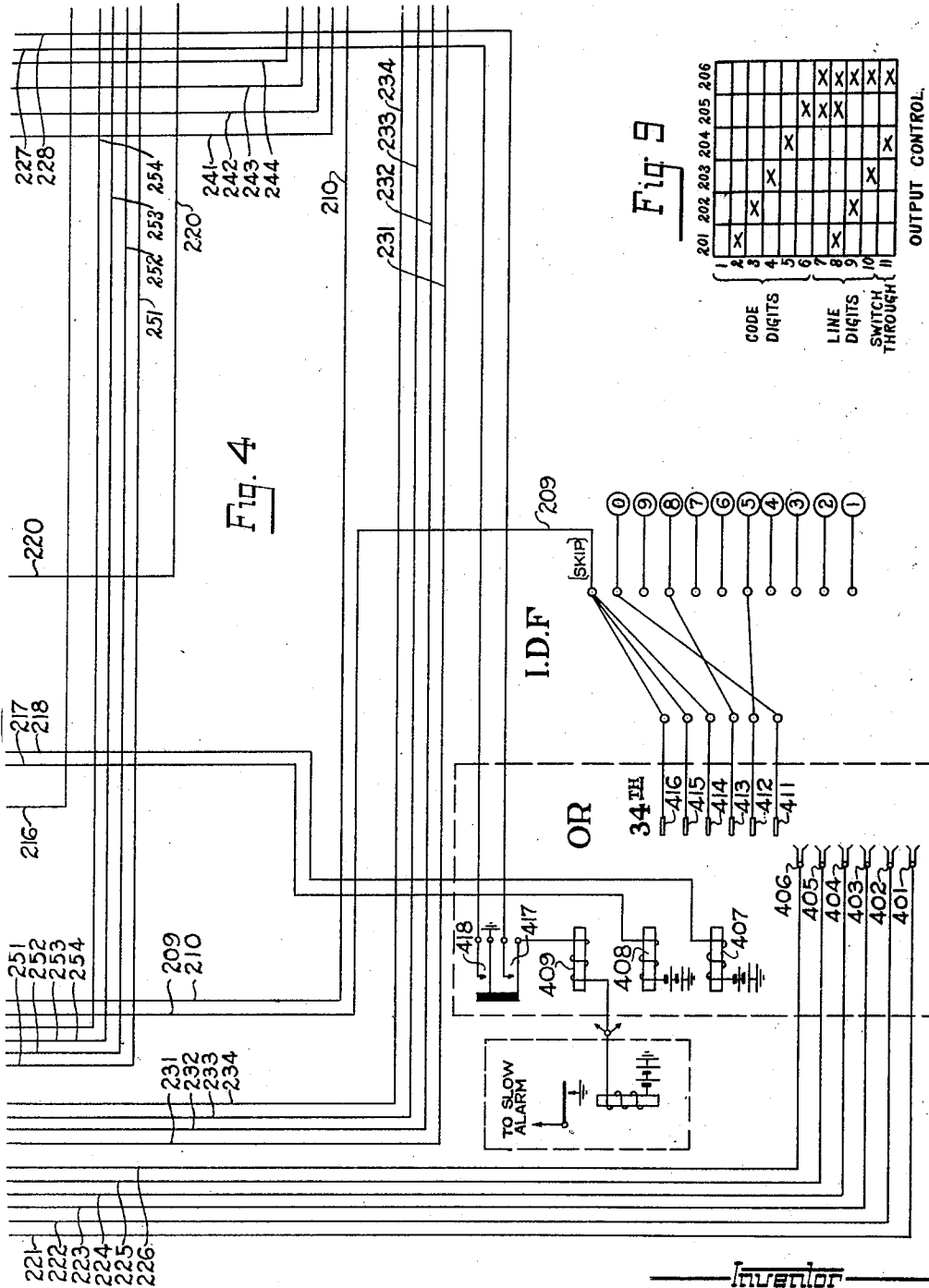


Fig. 9

	201	202	203	204	205	206
CODE DIGITS	1	2	3	4	5	6
LINE DIGITS	7	8	9	10	11	12
SWITCH THROUGH						

OUTPUT CONTROL

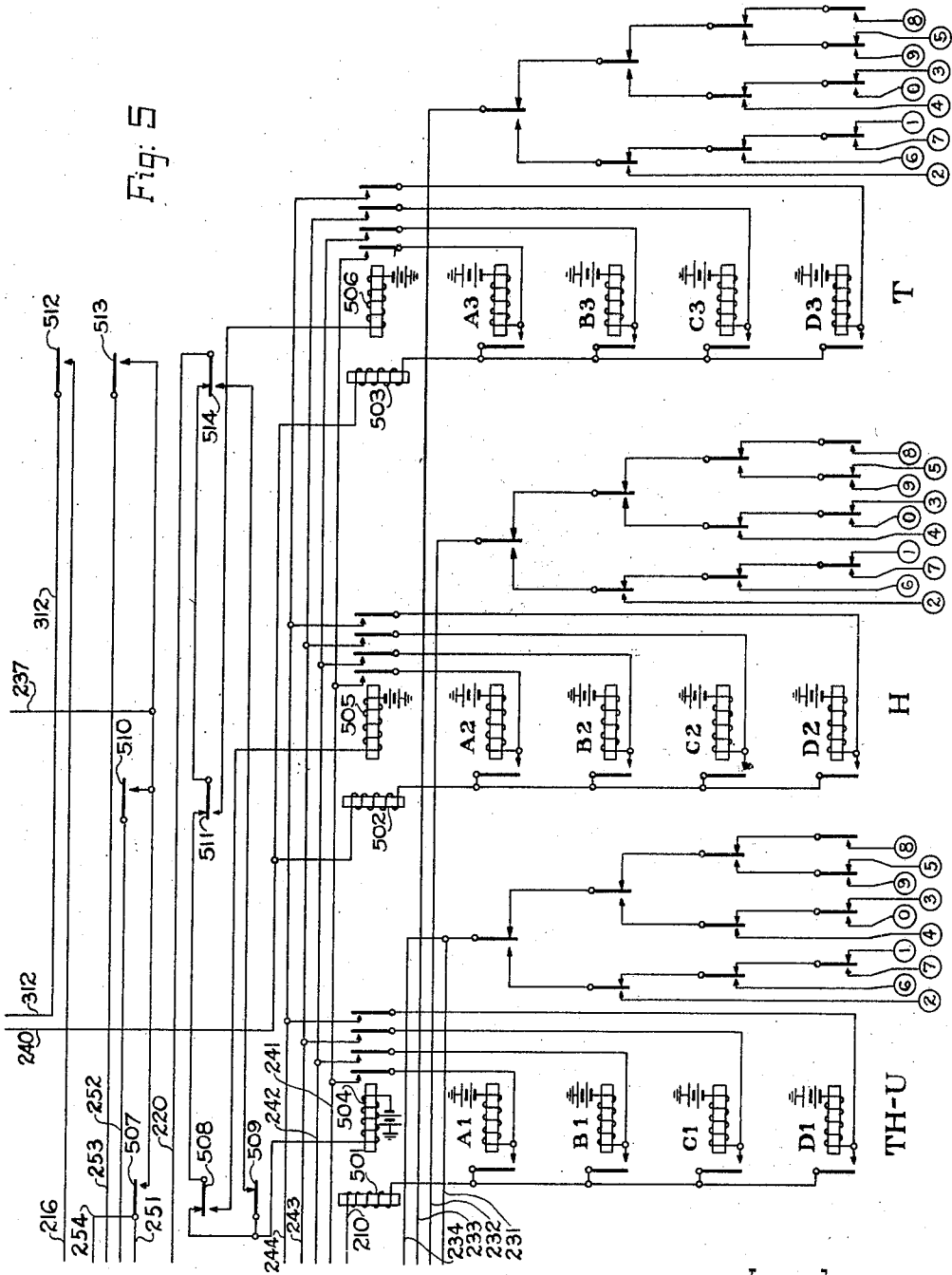
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TELEPHONE SYSTEM

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UNITED STATES PATENT OFFICE

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TELEPHONE SYSTEM

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The present invention relates to telephone systems, but is concerned more particularly with telephone systems in which register senders are employed, and the principal object may be stated briefly to be the production of a new and improved register sender in which the functions previously performed by switching mechanisms of the progressively movable type are performed by groups of relays in order that the useful life of the device as a whole may be considerably prolonged, it being well known of course that a relay device will last practically an indefinite length of time, whereas a progressively movable switch may wear out in a comparatively short time in case it is subjected to frequent use, as is the case when it is employed in a register sender.

The type of register sender with which this invention is concerned is that type which has come to be known as the "director." A director is used primarily to promote trunk efficiency by accomplishing a translation so that the digit combination retransmitted to effect the trunking of a call to a desired office may consist of any desired number of digits of any desired value without regard to the particular combination of office digits registered. Specifically, the director registers the office digits of a telephone number and retransmits in response thereto the code digits necessary to trunk the call to the desired office, and it registers and retransmits unchanged the line designating digits of the number.

A further object of the invention may be stated to be the production of a new and improved arrangement of counting relays whereby the number of relays necessary to replace the step-by-step switches is reduced to a minimum. In general, this is accomplished by using what will be termed hereinafter a reflex arrangement. According to the reflex arrangement, the circuits of the counting relays are arranged so that one or more of the relays are used two or more times to record the maximum series of impulses, thereby reducing the number of relays considerably below the requirements of a non-reflexed arrangement.

Another object is the reduction in the number of storage devices used to store the line designating digits, these devices being reduced from four to three. In order to accomplish this object, the first three line designating digits that are received are stored on the three storage devices provided and the fourth line designating digit is retained in the register until the first line designating digit has been retransmitted, and the first register has been cleared out again.

At this point the digit retained on the register is transferred to the first line-designating storage device and is retransmitted after the digit stored on the third storage device has been sent out.

A further object of the invention is the provision of a novel arrangement for causing the relays of the output control device to operate one after another in quick succession so as to advance the device through unneeded code-digit positions.

A special feature of the present arrangement is that no special provisions need be made in case it is desired to cancel all the code digits positions, thus automatically wiping out the effect of the setting of the office register.

There are other objects and features of the invention having to do for the most part with the necessary provision of practical arrangements for carrying out the foregoing objects. All the objects and features will become apparent upon a further perusal of the specification.

Referring now to the accompanying drawings comprising Figs. 1-9, they show by means of the usual circuit diagrams a sufficient amount of apparatus employed in a telephone system embodying the features of the invention to enable the invention to be understood. Fig. 1 shows certain equipment used to set up a telephone connection; Figs. 2-5 show one of the directors that may be taken into use by the director selector DS, Fig. 1, to control the setting up of a connection; and Figs. 6-9 are tables showing, among other things, the operating order of the relays comprising certain devices of the director.

Specifically, Fig. 1 shows the line of sub-station A terminating at the telephone exchange in the lineswitch LS. The lineswitch LS has access to a number of selectors. One of these selectors is the selector S. The trunk circuit TC is inserted in the trunk line between the bank of the lineswitch LS and the selector S to permit a director to be taken into use upon the seizure of the trunk line. The selection of an idle director is accomplished by the director selector DS.

Referring now to Figs. 2-5, the portion of the director shown in Fig. 2 includes the output-control device comprising relays 201-206. By the operation of these relays during the retransmitting process, the device is caused to assume different positions so as to control the successive digits. This device also brings about the switch-through operation so as to cause the director to be freed and the trunk circuit TC, Fig. 1, to be switched through when the director has completed the retransmission. Fig. 2 shows also the input-control device comprising relays 207 and 208. These relays are operated automatically between received series of impulses so as to direct the first two series of impulses to the operating magnets of the office register OR, Fig. 4, and to direct the remaining series of impulses to the register comprising relays 211-215. The input-control device also performs certain other functions as will hereinafter appear.

The register comprising relays 211-215 records the four line-designating digits in the number, the digits being transferred one at a time to the storage devices shown in Fig. 5.

Regarding the equipment shown in Fig. 3, it will be noted that this drawing shows the control relays 301-310 and the sender counting device comprising relays 321-325. This counting device operates each time a digit is transmitted and counts the transmitted impulses so that the sending operation may be terminated at a predetermined point.

Relay 301, it will be noted, is labeled Guard. This relay operates to guard the director against seizure during the releasing operation of the office register OR, Fig. 4, by grounding the release trunk conductor 132 in a manner to be hereinafter explained. Relay 302, labeled Rlse is the release relay and it is operated over conductor 132 when the director is seized. This relay might also be termed a holding relay if so desired. Relay 303, labeled Switching, is the switching relay in that it is operated at the completion of the operation of the director to bring about the freeing of the director and the switching through of the connection by operating switching relay 106 of the trunk circuit TC, Fig. 1. Relay 304, labeled Rec-Stop is termed the receiving-stop relay because it is operated when all digits have been received by

the director to open the impulse conductor 236 at armature 341 so as to prevent any further operation of the registering device shown in Fig. 2. This relay also performs another function as will be hereinafter explained. Relay 305, labeled Repeating, is the repeating relay. This relay repeats the impulses received over the impulse conductor 131 to the registering portion of the director over conductor 236. Relay 306, labeled Series, is the series relay in that it responds at the beginning of a series of impulses and remains operated until the series of impulses has been terminated. Relay 307, labeled Series-Step, is the series-step relay in that it operates in conjunction with series relay 306 to produce the stepping action of the input control device, Fig. 2. It will be noted that relay 307 is shunted with a resistance. This resistance is shunted around the relay so as to make it slightly slow to fall back after its circuit is opened. By choosing the proper value of the resistance to place in shunt of relay 307, and by properly adjusting the relay, the time required for the relay to fall back after its circuit is opened can be adjusted very definitely so that sufficient time is allowed for the stepping operation of the input control device to take place without any danger of the relay holding up so long as to be still operated when the next series of impulses is received. The remaining relays 308-310 are associated with the sender counting device, the whole forming the sender proper. Relay 308 is the pick-up relay and it operates at the end of the first effective step of the sender counting device to remove the shunt at armature 349 from around the sending contacts 354 so as to synchronize the counting operations; and sending relay 309 is the stop relay and it is operated by the sender counting device in accordance with the position of the instant active register or storage device to stop the sending operation by opening the circuit of sending relay 310 at armature 353; and relay 310 is the sending relay as its name applies, the sending operation being performed at armature 354. It will be noted that each time sending relay 310 operates to open the outgoing control circuit at armature 354 it sends an impulse over conductor 326 to advance the sender counting device another step. It will be noted that conductor 328 extending to the output control device, Fig. 2, is connected to the preterminal of stop relay 309 with the result that an impulse is sent over conductor 238 to control the output control device each time the circuit of stop relay 309 is closed, the impulse being terminated when the circuit of relay 309 is again opened.

Referring now to Fig. 4, this drawing shows the office register OR, which registers the two office digits in the number. Mechanically, this switch is of the usual vertical and rotary

type, raising its wipers opposite the desired level of bank contacts upon the first digit and rotating them into engagement with the desired set of bank contacts on the second digit.

Only one contact set in the bank of the office register OR, the 34th, is shown. It may be pointed out that, while the other switch mechanisms formerly used in directors, have been replaced by relays, it has not been considered to replace the office register OR by relays on account of the fact that the life of switches of this type is great and also on account of the complex and expensive relay arrangement required to replace it. Fig. 4 of the drawing shows also the intermediate distributing frame I.D.F. This frame is interposed between the bank of the office register OR and the various impulse stop conductor and the skip conductor 209. At this point it may be well to mention that the circles connected with the contacts on the right-hand side of the I.D.F. indicates the terminals that are to be connected to terminals indicated by corresponding circles shown in Figs. 3 and 5 in association with the sender counting device and the line-designating-digit storage devices.

Fig. 5 shows the three line-designating-digit storage devices TH-U, H, and T. The first device, comprising relays A^1-D^1 , stores the thousands digit; the second device, comprising relays A^2-D^2 , stores the hundreds digits; the third device, comprising relays A^3-D^3 , stores the tens digits; and the first device TH-U is reoperated, after the thousands digit has been retransmitted, to store the units digits, thereby obviating a fourth storage device. Fig. 5 shows also the three connecting relays 504-506 which operate to connect the setting conductors 241-244 to the storage devices in order. These connecting relays are in turn controlled by the relays 501-503 in a manner to be subsequently explained.

Call to office 34, line 0534

In order that the invention may be understood best, a detailed description of the operation of the apparatus shown will now be given. For this purpose it will be assumed that the subscriber at substation A, Fig. 1, desires to call a subscriber whose line terminates in office 34, and whose line number is 0534. Consequently, the complete number may appear in the directory as 34-0534. As will be later explained the office designation, 34, is translated into the code 058, the complete retransmitted number being 058-0534.

Selection of idle director

When the subscriber at substation A removes his receiver, the lineswitch LS operates in the well known manner to select an idle trunk line. Assuming that the trunk line comprising conductors 101-103 and ex-

tending to the selector S through the trunk circuit TC is the one selected, line relay 104 operates over the calling line and at armature 107 closes a circuit for relays 105 and 106 in series. Relay 105 operates in series with relay 106, but the latter relay is not operated owing to the fact that it is stiffly adjusted. It will be noted that a direct circuit is closed momentarily for relay 106 during the extremely short time that all three springs of relay 104 are in contact. This, however, does not result in the operation of relay 106 owing to the fact that the stroke of the armature proper of relay 104 is completed before relay 106 can start to operate. At armature 108, relay 105 places ground on release trunk conductor 102 so as to maintain the lineswitch LS operated and to maintain the trunk line busy to the other switches having access to it. At armature 110 relay 105 closes a circuit through relay 121 and stepping magnet 122 in series, and at armature 109 it connects the junction of relay 121 and magnet 122 through armature 124, normal, to test wiper 128. In case the contact set on which the wipers are standing is idle, this latter operation is of no effect and relay 121 operates immediately, seizing the contact set. Assuming that the director connected with the contact set is in use, a ground potential is encountered by test wiper 128, short circuiting relay 121 and affording a direct circuit for magnet 122. Accordingly, the wipers 127-130 are advanced in the usual buzzer-like manner by magnet 122 until an idle contact set is reached. When an idle contact set is reached, for example, the contact set to which the conductors 131-134 are connected, the buzzer-like action of magnet 122 ceases, and relay 121, being no longer short circuited, operates in series with magnet 122. Magnet 122 it may be stated, will not operate in series with relay 121 owing to the relatively high resistance of the relay. At armature 124, relay 121 opens a point in the test circuit and places ground on test wiper 128 so as to make the seized contact set busy immediately, and at armatures 123, 125, and 126 it connects up the remaining wipers of the switch. As a result of the connecting up of wipers 129 and 130, the line relay (not shown) of the selector S operates over conductors 133 and 134 of the director to which the said conductors extend. As the result of the operation of its line relay, the selector S is prepared for the reception of impulses.

In the director, the release relay 302 is operated through armature 331, normal, of relay 301 responsive to the grounding of conductor 132 through the test wiper 128 of the director selector DS. At armature 336, relay 302 closes a circuit for lamp 338 so that the busy condition of the director may be apparent to an attendant; it grounds the locking conductor 240 at armature 337; and at armature

335 it opens a point in the circuit of release magnet 409 of the office register OR before. It will be noted that, with wiper 127 of the director selector DS connected up at armature 123 of relay 121, repeating relay 305 is connected through armature 339, normal, and conductor 131 to the winding of release relay 105, Fig. 1, in multiple with switching relay 106. Repeating relay 305 is not operated at this time in series with relay 105 owing to the fact that its winding has fewer turns than that of relay 105. It will be noted that a connection exists between the free terminal of the secondary winding of the common dial tone transformer 246, Fig. 2, and the impulse conductor 131. This connection includes the condenser 247, outer-right-hand armature of relay 207, and armature 339, normal, of relay 303. Accordingly, the dial tone current passes up the impulse conductor 131 to the trunk circuit TC and thence through the condenser in the trunk circuit TC to the lower talking conductor 103 by way of armature 113, normal. The calling subscriber, upon hearing this dial tone, is informed that he may now proceed to dial the digits in the desired number.

Registration of called number

When the calling subscriber dials the first digit 3, line relay 104 is caused to fall back three times momentarily. Each time it falls back, it shunts relay 105, thereby closing a direct circuit for repeating relay 305 over conductor 131, and it disconnects the switching relay 106 so as to prevent the operation of this relay at this time. Repeating relay 305 operates each time relay 105 is shunted and it restores each time the shunt is removed from around the winding of relay 105. The result is three momentary operations of the relay 305. It may be mentioned at this time that relay 105 remains operated during the operation of line relay 104 owing to the fact that the magnetic flux persists due to the self-induced current in the shunted winding.

Each time relay 305 operates in the foregoing manner, it closes at armature 344 a circuit through armature 341 and over conductor 236 for the vertical magnet 408 of the office register OR. This circuit includes the outer left-hand armature, normal, of relay 207 and branch conductor 217. In response to the three impulses of current, the vertical magnet 408 of the office register OR raises the wipers 401—406 step-by-step until they arrive opposite the third level of bank contacts.

As a further result of each energization of repeating relay 305, it closes at armature 345 a circuit for the slow acting series relay 306. Relay 306 operates when its circuit is first closed and maintains its energization throughout the series of impulses. At armature 347, relay 306 closes a circuit through armature 343, normal, for relay 307. Relay 307 operates and at armature 348 prepares a

circuit for advancing the input control device.

When the repeating relay 305 comes to rest, relay 306 falls back and at armature 347 places ground on conductor 239 through armature 348. An instant later relay 307, which is only slightly slow-acting due to the resistance shunted around its winding, falls back and again removes ground from conductor 239 at armature 348. When ground is applied to conductor 239 a circuit is closed through the inner right-hand armature, normal, of relay 207 for the left-hand winding of the said relay. When energized through the left-hand winding alone, relay 207 operates through its first step only, closing only the contacts marked "X". It may be pointed out at this time that throughout the drawings the letter X has been used to indicate contacts that operate first. Upon the closure of the first step contacts of relay 207 a locking circuit for both windings in series is closed including the locking conductor 240. The left-hand winding of relay 207 does not receive current at this time owing to the fact that it is furnished with ground potential at both of its terminals. When the impulse to the right-hand winding of relay 207 is terminated by the falling back of relay 307, the shunt is removed from around the left-hand winding of the relay, whereupon the energization of the relay is increased sufficiently by the left-hand winding to cause the relay to operate through its second step. At its outer left-hand armature, relay 207 extends the impulse conductor through the outer left-hand armature, normal, of relay 208 to conductor 218; at its inner right-hand armature it extends the series stepping conductor 239 to relay 208; and at its outer right-hand armature it disconnects the dial tone conductor 230 from the secondary winding of the dial tone transformer 246.

When the second digit 4 is dialed, four impulses of current are delivered over conductor 218 to rotary magnet 407 of the office register OR with the result that the wipers 401—406 are set on the 34th set of bank contacts comprising contacts 411—416. By the joint action of relays 306 and 307 an impulse of current is delivered over conductor 239 and through the inner-armatures of relays 207 and 208 to the right-hand winding of relay 208. Relay 208, being similar to relay 207, operates through its first step upon the receipt of the impulse of current and it operates through its second step upon the termination of the impulse. At its outer left-hand armature, relay 208 extends the impulse conductor 236 to the branch 246 leading to the register comprising relays 211—215. At its inner right-hand armature it shifts the series stepping conductor 239 into connection with the set-up conductor 247; and at its outer right-hand armature it places ground on start conductor

219 and conductor 220. As a result of the placing of ground potential on conductor 219, the sender shown in Fig. 3 is started to retransmit the code digits necessary to trunk the call to the desired office, in a manner to be subsequently explained. As a result of the placing of ground potential on conductor 220, a circuit is closed through armatures 515, 511, and 508, normal, for connecting relay 504. Relay 504 responds and connects the set up conductors 241—244 to the relays A¹—D¹ of the thousands-units storage device, preparatory to the storing of the thousands digits on the storage device.

When the thousands digit 0 is dialed, ten impulses of current are transmitted by the repeating relay 305 over conductor 236, outer left-hand armatures, operated, of relays 207 and 208, and conductor 246 to the registering device comprising relays 211—215. It will be noted that the impulse conductor is carried through the inner right-hand armatures of relays 211—213 to the right-hand winding of relay 211. All of the relays of the register are two-step relays, operating through the first step upon the receipt of an impulse and operating through the second step when the impulse terminates. The first impulse results in the operation of relay 211, whereupon the impulse conductor is transferred to relay 212 at the inner right-hand contact of relay 211. In a similar manner the remaining relays are operated and the impulse conductor is shifted along until relay 215 operates in response to the fifth impulse. It will be noted that the locking conductor 245, grounded at armature 313 of relay 307 during the receipt of an impulse series, is connected through the left-hand armatures of relays 211—215 in such a manner that each of the relays with the exception of relay 215 is subsequently unlocked as the registering operation proceeds, relay 215 being arranged to lock directly to conductor 245. While the relays 211—215 operate one after another in regular order, as above pointed out, to register the first five impulses. The relays 211—214 operate in a somewhat different manner to register the remaining five impulses, the complete relay operating order being 211, 212, 213, 214, 215, 211, 212, 213, 214, and 212. It will be noted that relay 215 is operated only once; relays 211, 213, 214 are operated twice; and relay 212 is operated three times. The table, Fig. 6, shows the condition of the relays at the end of each of the ten impulses.

It may be noted for example that only relay 211 is energized at the end of the first impulse; that relays 211 and 212 are energized at the end of the second impulse; that relays 212 and 213 are energized at the end of the third impulse; and that all of the relays are energized at the end of the tenth impulse.

Referring now to Fig. 7, this table shows the permutations in which relays of any

storage set are energized to store any digit from 1 to 0. It will be noted that relay A of any set is energized alone to store the digit 1, and that relays A and B are energized together to store the digit 2 etc. As the particular digit registered on the relays 211—215 at the present time is the digit 0, a reference to Fig. 7 shows that relays B¹ and D¹ of that set, B¹ and D¹, should be operated to store the digit. Accordingly, with all of the relays in the register operated, conductors 242 and 244 should be connected to the set-up conductor 247, and conductors 241 and 243 should be disconnected from the said set-up conductor. A reference to Fig. 2 will show that such is now the case, as conductor 247 is extended through the middle right-hand armature of relay 212, operated; outer right-hand armature of relay 215, operated; and the middle right-hand armature, operated, of relay 214 to conductor 242; and conductor 247 is connected through the outer right-hand armatures, operated, of relays 211 and 213 to conductor 244, conductor 241 being disconnected at the normal contact of the outer armature of relay 213, and conductor 243, which is extended through the outer armature, operated, of relay 214, is disconnected at the outer armatures, operated, of relays 211 and 212. Since the circuits for relays D¹ and B¹ are now prepared over conductors 242 and 244, these circuits are completed at armature 247 of series relay 306 when this relay puts ground on conductor 239 in the hereinbefore explained manner through armature 348, conductor 339 now being extended, as hereinbefore explained, through the inner right-hand armatures of relay 207 and 208 to conductor 247. Upon operating, relays B¹ and D¹ both close locking circuits for themselves at their left-hand armatures, the locking circuits of both relays including relay 501, conductor 210, two armatures in multiple on relays 202 and 206, and the locking conductor 240. No current flows over this locking circuit immediately on account of the fact that the initial circuit for relays B¹ and D¹ is still established.

When relay 307 removes ground from conductor 247 at armature 348, upon falling back, it opens the initial circuit for relays B¹ and D¹ whereupon current through these two relays in multiple is drawn through relays 501, thereby maintaining the storage relays operated and operating relay 501. At the same time, the locking circuit of the register relays is opened by the removal of ground from the locking conductor 245 at armature 315. Relays 211—215 now fall back. Relay 501, upon operating, disconnects conductor 220 from relay 504 and extends it to relay 505, whereupon relay 504 falls back and relay 505 operates to connect up the relays A²—B² to the set-up conductors 241—244.

When the calling subscriber dials the hundreds digit 5, the impulses of current are

transmitted over conductor 246, in the manner hereinbefore explained, to relays 211—215. As the second digit is represented by five impulses, the fifth relay 215 responds to the fifth and last impulse, and, as may be seen from Fig. 6, the fourth and fifth relays 214 and 215 are energized at this time, relays 211—213 being normal. Upon reference to Fig. 7, it will be noted that the digit 5 is stored with the C relay operated and with relays A, B, and D normal. Accordingly, upon the grounding of the set-up conductor 247 a circuit is closed through the outer right-hand armatures of relays 211 and 212, normal, the outer right-hand armature of relay 214, over conductor 243 for relay C². Relay C² locks itself energized, through its left-hand contacts and through relay 502. When relay 307 falls back, the locked up relays of the register restore and relay 502 operates upon the opening of the initial circuit of relay C². At armature 511 relay 502 opens the circuit of relay 505 and closes a circuit through relay 506. Relay 506 now operates and connects up the relays A²—B² preparatory to storing the tens digit.

When the calling subscriber dials the tens digit 3, the three impulses received over conductor 247 are counted by relays 211—213, and relays 212 and 213 remain operated at the end of the series of impulses as may be seen from Fig. 6. With relays 212 and 213 operated, a circuit is closed over conductor 247, upon the deenergization of relay 306, for relay B³. This circuit includes the outer right-hand armature, operated, of relay 212 and the outer right-hand armature, normal, of relay 215, and conductor 242. Relay 503 operates when the initial circuit of relay B³ is opened upon the falling back of relay 307. At armature 514, relay 503 opens the circuit of relay 506 and prepares a circuit for re-operating relay 504. Relay 504 is not re-operated at this time owing to the fact that its new circuit is open at armature 509 of relay 501, unless relay 501 has been deenergized in a manner to be pointed out hereinafter. For the purpose of explanation, however, it will be assumed that relay 501 is still operated. At armature 512, relay 503 prepares a circuit for operating the receiving stop relay 304 at the end of the registration of the next and last digit.

When the calling subscriber dials the last digit 4 in the desired number the four impulses received by the register over the impulse conductor 246 are counted by the relays 211—214, and the relays 212—214 are operated at the end of the registration, which may be seen from Fig. 6. The register is now in readiness to transfer the registration of the digit 4 to the thousands-units register TH-U, but this registration cannot be transferred until the thousands digit has been retransmitted. Upon the deenergization of

relay 306, ground is again placed on conductor 239, closing at this time a circuit through the outer armatures, normal, of relays 201 and 206, conductor 216, armature 512, and normally closed contacts controlled by armature 342 for the receiving-stop relay 304. Relay 304 operates over this circuit and closes a locking circuit for itself at armature 342, at the same time opening its initial circuit. At armature 341 it opens the impulse conductor 236 so that in case the calling subscriber again turns the calling device no further impulses will be delivered to the register. At armature 243, relay 304 opens the initial circuit of the still-operated relay 307 and closes a new circuit for the said relay over the path just traced for relay 304. At armature 327, relay 304 shunts armature 347 and its resting contact so as to prevent the removal of ground from conductor 239 at armature 347 in case the calling subscriber again manipulates his calling device.

In order to enable the description to be understood clearly, it should be remembered at this point that the actual sending operation, although not as yet described, was started at the end of the setting of the office register OR by the grounding of conductor 219 at the outer right-hand armature of relay 208. The description of the registration and storing of the four line-designating digits has been given under the assumption that the sending operation, although proceeding, remains sufficiently behind the registering operation so that the registering operation and the storing process proceed just as though the sending operation were not taking place. The sequence of operations taking place in case the calling subscriber dials slowly enough to permit the sending operation to progress further is slightly different than that covered by the foregoing description, as will be explained more in detail hereinafter. As matters now stand, the thousands, hundreds and tens digits have been registered and stored in the manner hereinbefore described, on the storage devices shown in Fig. 5, and the units digit has been registered, but has not yet been stored, as the thousands-units register is still retaining the thousands digit.

Retransmission

Returning now to the point at which conductor 219 is grounded upon the operation of relay 208 at the end of the rotary movement of the office register OR, the sender is started to transmit the first code digit 0. A start circuit is closed, upon the grounding of conductor 219. This circuit includes the middle left-hand armature, normal, of relay 206, start conductor 237, armature 353 of stop relay 309, the interrupter 311, and the sending relay 310. Sending relay 310 accordingly commences to operate and restore under the control of the interrupter 311. Each time

it operates, it opens a point in the outgoing control circuit including conductors 133 and 134 at its upper armature 354. The first operation of armature 354 is shunted at armature 349 of pick-up relay 308. Each time relay 310 operates it sends an impulse of current at armature 355 over conductor 326 to the sender counting device comprising relays 321—325. This counting device controls the operation of the pick-up and stop relays 308 and 309 and it controls the connection between the stop conductor 356 and the ten impulse stop conductors 1—0. These stop conductors, it may be pointed out, are connected in multiple to the contacts of the storage devices shown in Fig. 5 and to the corresponding terminals on the right-hand side of the intermediate distributing frame, I.D.F., Fig. 4.

The first impulse of current transmitted over conductor 326 is delivered through the inner right-hand armatures of relays 321—324 to the first-step winding of relay 321, with the result that relay 321 operates through its first step when the impulse is delivered and it operates through its second step when the impulse is terminated, the relay being locked at its inner left-hand armature to the grounded conductor 357 through the outer left-hand armature, normal, of relay 322. Since ten impulses must be counted when the digit 0 is to be transmitted and since the sender counting device must go through a preliminary pick-up step before starting to count impulses, there are eleven different positions that must be assumed by the relays of the sender counting device when the digit 0 is to be transmitted. The condition of the relays at the end of any one of the impulses is shown by the table given in Fig. 8. The relay operating order it may be pointed out is 321, 322, 323, 324, 325, 321, 322, 323, 324, 322, 323, as may be seen from the table given in Fig. 8.

When relay 321 operates through its second step at the end of the first impulse transmitted over conductor 326, it closes at its middle left-hand armature a circuit for pick-up relay 350 including conductor 357. Pick-up relay 308 thereupon operates and locks itself to conductor 357 at armature 351. At armature 350, relay 308 prepares a locking circuit for stop relay 309, and at armature 349 it removes the shunt from around the sending contacts 354. As a result, each subsequent energization of sending relay 310 results in the interruption of the outgoing control circuit at armature 354. Upon referring to the I.D.F., Fig. 4, it will be noted that the first office-register wiper 401, which wiper is grounded normally through the outer right-hand armatures of the output control relays, is extending ground through bank contact 411, on which it is now standing, and the associated I.D.F. jumper to the tenth impulse stop conductor 0. This stop conductor is not connected with the stop-relay conductor 356

until the sender counting device has counted ten transmitted impulses, at which time the relays are all energized as may be seen from Fig. 8. A circuit is then completed for stop relay 309 from the grounded conductor 0 through the corresponding armature of relay 323, middle right-hand armature of relay 322, middle right-hand armature of relay 324, outer right-hand armature of relay 321, outer right-hand armature of relay 325, and the stop-relay conductor 356. Relay 309 operates over this circuit and at its lightly adjusted armature spring 352 closes a locking circuit for itself before it removes ground from conductor 326 at armature 353. When the circuit of the stop relay 309 is closed, a parallel circuit exists through conductor 238 and the inner right-hand armatures, normal, of relays 201—205 for the first-step winding of relay 201. Relay 201 operates through its first step, closing its locking contact.

When stop relay 353 removes the ground potential from conductor 357, at armature 353, the sending relay 310 stops operating, terminating the digit. In addition, the locked up counting relays 321—325 all fall back. As a further result of the removal of the ground potential from conductor 357, the circuit of pick-up relay 308 is opened and this relay falls back after a short interval of time and opens the circuit of stop relay 309 at armature 350, at the same time opening a further point in its own previously-established locking circuit and again shunting contacts 354. When the circuit of stop relay 309 is opened, the branch circuit including conductor 238 and extending to the first-step winding of relay 201 is also opened, with the result that relay 201 operates through its second step. At its outer left-hand armature, relay 201 removes ground from the first wiper 401 of the office register OR and connects it to the second wiper 402.

After a slight interval following the opening of its circuit at armature 350 of pick-up relay 308, stop relay 309 falls back and starts the sender to transmit the next code digit, by replacing ground from start conductor 237 on conductor 357 at armature 353. When sending relay 310 starts to operate again due to the grounding of conductor 357, the sender counting device goes through its pick-up position in the hereinbefore described manner, operating pick-up relay 308. Following this, the relays 322, 323, 324, and 325 operate in regular order and relay 321 reoperates. When relay 321 has reoperated, five impulses have been retransmitted by the sending relay 310. Stop relay 309 is now operated over the fifth impulse stop conductor. Relays 322—324 have been released, and only relays 321 and 325 remain operated, as may be confirmed upon reference to Fig. 8. The circuit over which relay 309 is operated at this time includes the fifth impulse stop conductor 5;

outer right-hand armature, operated, of relay 321, outer right-hand armature operated of relay 325, and conductor 356. By the operation of stop relay 309, the second code digit 5 is terminated in the manner hereinbefore explained, and another impulse of current is delivered over conductor 238 to the output control device, operating the second relay 202 to shift the ground potential from the second wiper 402 of the office register OR to the third wiper 403. The third wiper 403 is standing on the bank contact 413 which is connected with the eighth impulse stop conductor 8. Accordingly, the third code digit 8 is retransmitted when the sender again starts and it is terminated upon the operation of stop relay 309 upon the termination of the eighth transmitted impulse. At this time the relays 321, 324, and 325 are operated as may be confirmed upon looking at the chart in Fig. 8. The circuit of stop relay 309 at this time includes the eighth impulse stop conductor 8, middle right-hand armature of relay 324, outer right-hand armature of relay 321, and the outer right-hand armature of relay 325.

The output control device receives another impulse of current over conductor 338 during the time that the stop relay circuit is closed, and the third relay 203 is operated to shift the ground potential from the third to the fourth wiper of the office register OR when the stop relay circuit is opened by the falling back of pick-up relay 350. The bank contacts 414, 415, and 416, it will be noted, are cross-connected on the I.D.F. to skip conductor 209. The result is that when bank contact 414 is grounded through wiper 404, upon the operation of relay 203, a circuit is closed over conductor 209 and the resistance 229 for the first-step winding of the fourth output control relay 204, through the inner left-hand armatures of relays 205, 204, and 203. A branch circuit exists over conductor 238 for maintaining stop relay 309 operated. Due to the fact that resistance 229 is included in its circuit, the right-hand winding of relay 204 is not short circuited when the locking contact, the inner right-hand contact, closes, and the relay operates through its second step right away, transferring the skip circuit relay 205 and transferring ground from wiper 404 to wiper 405. For the same reason, relay 205 operates through the fifth wiper 405 of the office register OR and the skip conductor 209, and it transfers the skip conductor to the sixth relay 206 and transfers ground to the sixth wiper 406 of the office register OR. A circuit is now closed for relay 206, and this relay operates in the same manner as relays 204 and 205 operated. When relay 206 operates, it transfers ground from the sixth wiper 406 of the office register OR to the thousands digit stop conductor 231 through the second left-hand armatures, nor-

mal, of relays 201—204, relays 201—204 having been restored (see Fig. 9). Relay 206 at its middle left-hand armature disconnects the grounded conductor 219 from the start conductor 237 and connects it instead through the corresponding armatures, normal, of relays 201—203 to branch conductor 241. This is done so that the further operation of the sending apparatus is dependent upon whether or not the first line designating digit has been registered and stored on the thousands digit storage device. According to the previous assumption, this has been done, and branch conductor 251, now grounded, is connected to start conductor 237 at armature 507 of relay 501. The result is that conductor 237 is still provided with a ground potential to enable the sending apparatus to start again when stop relay 309 falls back. At this point it is well to remember that, during the skipping operation above described, stop relay 309 is maintained operated over conductor 238, thereby preventing any possibility of the restarting of the sender before the output control device has arrived in a position to control the thousands digit.

When the sender is again started, the digit 0, registered on the thousands-units register, Fig. 5, is retransmitted. When the last impulse is terminated, stop relay 309, Fig. 3, is connected to the tenth impulse stop conductor, and is operated through the grounded thousands digit stop conductor 231, conductor 231 being connected to the tenth impulse stop conductor 0 through the right-hand armature, normal, of relay A¹, right-hand armature operated of relay B¹, middle right-hand armature, normal, of relay C¹, and the second right-hand armature, operated, of relay D¹. The digit is terminated in the usual manner upon the energization of the stop relay, and another impulse of current is transmitted to the output control device, over conductor 238, reoperating relay 201 to shift ground potential from stop conductor 231 to stop conductor 232 and to shift starting ground potential from conductor 251 to conductor 252, from whence it passes to start conductor 237 through armature 510.

The digit 5, stored on the hundreds storage device H, is the next digit retransmitted. The grounded conductor 232 is connected with the fifth impulse stop conductor 5 through the right-hand armature, normal, of relay A², the right-hand armature, normal, of relay B², the right-hand armature operated of relay C², and the corresponding armature, normal, of relay D².

When the second digit 5 is terminated the resulting impulse of current transmitted over conductor 238 causes the reoperation of relay 202 to shift ground potential from conductors 232 and 252 to conductors 233 and 253. From conductor 253 ground potential extends to start conductor 237 via armature 513.

It will be noted that one point in the connection between the grounded locking conductor 240 and conductor 210 was broken at the middle right-hand armature of relay 206 upon the energization of the said relay. Now when relay 202 operates at the end of the retransmission of the second line designating digit, it breaks the remaining connection between these two conductors, permitting relay 501, Fig. 5, to fall back. When this occurs, a reoperating circuit for relay 504 is closed at armature 509 including armature 514, operated, and the grounded conductor 220. Relay 504 operates over this circuit and connects the conductors 241—244 to the storage relays A¹—B¹. Since the units digit 4 has been registered, and is being held on the relays 211—215, conductors 242 and 243 are grounded by the three operated relays 242—244 (see Fig. 6). When the grounded conductors 242 and 243 are connected up, the relays B¹ and C¹ operate to store the digit. These relays close points in their locking circuit including relay 501, but this locking circuit is open at this time owing to the fact that conductor 210 has just been ungrounded as above described. However, the initial circuit of the storage relays remains closed for the time being.

The digit 3, stored on the tens storage device T is now retransmitted and is terminated responsive to the operation of stop relay 309 over conductor 233, right-hand armature, normal, of relay A³ right-hand armature, operated, of relay B³, middle right-hand armature, normal, of relay C³, and the corresponding armature, normal, of relay D³.

When the output control relay 203 operates at the end of the retransmission of the tens digit 3, it opens, at its middle right-hand armature, the circuit previously closed over conductor 216 and through armatures 512 and 343 operated for the series stepping relay 307. At the same time, relay 203 opens the locking circuit of relay 202, whereupon relay 202 falls back and replaces ground on conductor 210 so as to complete the locking circuit of relays B¹ and C¹ through relay 501. A moment later relay 307 falls back and opens the initial circuit of relays B¹ and C¹ at armature 348, and at armature 313 removes ground from conductor 245, whereupon the locked up relays of the register fall back. When the initial circuit of relays B¹ and C¹ is opened, relay 501 reoperates and opens the circuit of relay 504 at armature 509, permitting relay 504 to fall back, and at armature 507 it closes a point in the starting circuit including branch conductor 244 so as to permit the sender to operate to send out the fourth and last line designating digit 4.

At the end of the usual interval following the retransmission of the tens digit 3, the sender starts operating again and retransmits the digit 4 now stored on the thousands-

units register. The digit is terminated upon the energization of stop relay 309 over the fourth impulse stop conductor 4, which is now grounded through the grounded conductor 234, the right-hand armature, normal, of relay A¹, right-hand armature, operated, of relay B¹, and the middle right-hand armature, operated, of relay C¹.

Switching through

When the usual impulse of current is transmitted over conductor 238 to the output control switch at the end of the retransmission of the fourth and last line designating digit, relay 204 is reoperated through its first step and operates through its second step when the impulse is terminated. At this time ground potential is shifted at the middle left-hand armature of relay 204 from conductor 230 to the switching conductor 235, thereby closing a circuit through the normally closed contacts controlled by armature 340, and armature 346, normal, for switching relay 303. Relay 303 operates and closes a locking circuit for itself at armature 340, at the same time opening its initial circuit. At armature 339, relay 303 disconnects the combined impulse and switching conductor 131 from the repeating relay 305 and connects it to ground, thereby short circuiting release relay 105 of the trunk circuit TC and closing a circuit through armature 107 for relay 106. Relay 106 operates and locks itself to the release trunk conductor 108 at armature 117, and at armatures 111 and 112 switches the connection through, at the same time cutting off line relay 104 and the control loop extending to the director. This leaves the established connection under the direct control of the calling subscriber. Line relay 107 falls back when it is disconnected and release relay 105, being short circuited, falls back a moment later.

Release of director

At armature 108, release relay 105 breaks a connection between ground and release trunk conductor 102, but the release trunk conductor 102 has previously been grounded at another point in the usual manner to hold up the connection. At armatures 109 and 110 relay 105 releases the director selector DS, whereupon relay 121 falls back and disconnects the wipers. When the wipers of the director selector are disconnected, the original ground connection to release trunk conductor 132 extending to the director is broken. When this occurs, guard relay 301 energizes in the following circuit: from ground by way of the off-normal contacts 418 of the office register OR, conductor 227, upper winding of relay 301, armature 331, normal, and release relay 302 to battery. The resistance of the upper winding of the guard relay is sufficiently low to provide sufficient current to cause a hunt-

ing director selector to pass over the contact set in case it lands thereon immediately upon the removal of the original ground potential from the release trunk conductor. Upon operating in this circuit, guard relay 301 closes a locking circuit for itself and a release circuit for the office register at armature 332. Upon the complete operation of relay 301, conductor 132 is disconnected from relay 302 and is connected directly to ground at armature 331, and a flashing circuit is prepared for lamp 338 at armature 333. When relay 302 is disconnected, it falls back and shunts the locking contacts of the guard relay at armature 335; it completes the flashing circuit for lamp 338 at armature 336; and at armature 337 it removes ground potential from the locking conductor 240. When this occurs, all the locked up relays of the director with the exception of relay 301 fall back.

It will be noted that the locking circuit of the lower winding of guard relay 201 includes conductor 228, off-normal contacts 407 of the office register OR, release magnet 409, and a common supervisory relay. As a result, release magnet 409 operates in this circuit and restores the office register OR to normal, whereupon the circuit of release magnet 409 is opened at off-normal contacts 417, and off-normal contacts 418 disconnect the lower terminal of the upper winding of relay 301 from ground. When its locking circuit is opened at contacts 417, relay 301 falls back and reconnects the release trunk conductor 132 to release relay 302 and opens the flashing circuit of lamp 338. The director is now in readiness to handle another call.

Considering now the case where the office register OR is mechanically defective so that it does not restore to normal, guard relay 301 remains operated and the flashing circuit for lamp 338 remains closed. In addition, the supervisory relay common to the release magnets of a number of directors remains operated and the associated slow alarm device (not shown) operates to sound an alarm. The attendant can readily locate the director in trouble by looking at the lamps, such as 338, and noting that the lamp 338 is flashing.

Regarding the effect of the retransmitted digits, it may be pointed out that the selector S, Fig. 1, responds to the first code digit 0 and selects an idle trunk in the usual manner, and that other automatic switches respond to the remaining retransmitted digits to complete the extension of the connection to the desired office and to the desired line.

When the calling subscriber replaces his receiver at the termination of the ensuing conversation, ground potential is removed from the release trunk conductor of the established connection, whereupon the switches are released and relay 106 of the trunk circuit TC falls back.

Assuming now that a contact set in the bank

of the office register OR is so connected on the I.D.F. that all contacts in the set are cross connected to the skip conductor 209, no office code digits are retransmitted and relays 201—206 are operated one after another in quick succession to advance the output control device through its code digit positions. The advance of the output control device commences responsive to the grounding of conductor 219 at the end of the operation of the office register, as conductor 219 is normally connected with the first wiper 401 of the office register OR. It will be remembered also that the conductor 219 is normally connected with start conductor 238, with the result that the sender starts to operate responsive to the grounding of conductor 219. This does not result in any harm at this time on account of the fact that stop relay 309 is operated over conductor 238 to prevent the said sender from operating as long as the skipping operation is taking place. When the stop relay 309 falls back at the end of the skipping operation to permit the sender to start, the starting of the sender is held up, in a manner hereinbefore explained, until relay 210 operates at the end of the storing of the thousands digit and effects a connection between the grounded branch conductor 241 and start conductor 247.

What is claimed is:

1. In a register sender for registering and retransmitting a plurality of digits, a device comprising a plurality of counting relays for registering the digits, an output control device comprising a plurality of counting relays, and a sending device comprising a plurality of counting relays, said sending device being arranged to be controlled by said output control device so that it retransmits the registered digits one after the other in the proper order.

2. In a telephone system, a register sender for registering and retransmitting a plurality of digits, a sender comprising a plurality of counting relays for retransmitting the registered digits, and an output control device comprising a plurality of counting relays for controlling the sender so that it retransmits the registered digits one after the other in the proper order.

3. In a telephone system, a trunk line, a release relay in said trunk line, a number registering device for registering a plurality of digits, an impulse conductor extending from said trunk line to said registering device, means for transmitting impulses representing the digits to be registered over said impulse conductor by shunting said release relay, registers of different characteristics in said registering device each being arranged to receive a different digit of the number to be registered, and means for maintaining the circuit of the release relay in the trunk circuit constant regardless of the differing characteristics of said register, said means including a repeat-

ing relay arranged to respond to the impulses delivered over said impulse conductor and to repeat said impulses to the registers.

4. In a register sender for registering and retransmitting a plurality of digits, a registering device, a storage device, and a sending device, means for transferring a digit registered on the registering device to said storage device, means for holding a subsequent digit in said registering device, means for operating said sender to retransmit the digit stored on said storage device, and means for subsequently reoperating said storage device to store the digit held on said registering device and for again operating the sender under the control of the storage device to retransmit the second digit stored thereon.

5. In a register sender for registering and retransmitting a plurality of digits, a registering device, three storage devices, a sending device, means for operating and releasing the register four times to register four digits in a telephone number, means for transferring the first three digits to said storage devices, respectively, and for retaining the fourth digit on said registering device, means for operating said sender to retransmit the three digits stored under the control of the three registers, respectively, means for releasing the first storing device responsive to the operation of the sender, the storing means being again effective to store in the first storage device the digit held on the register, and said sender operating means being effective to operate said sender again under the control of the first storage device to retransmit the fourth digit stored thereon.

6. In combination, a plurality of counting relays, means for operating said relays to count impulses, for releasing and reoperating certain ones of said relays to count further impulses, and for maintaining one of said relays operated while said certain ones are being reoperated.

7. In combination, an impulse conductor, and a plurality of counting relays arranged to operate successively over said conductor, and circuit paths controlled by contacts on said relays for causing the relays to arrange themselves in any one of twice as many possible combinations as there are relays.

8. In combination, five counting relays, means for operating said relays successively to register any number of impulses from one to five, for releasing and suitably reoperating four of the five relays to register from one to five additional impulses, and for maintaining the fifth relay operated while the other four are being reoperated.

9. The combination including a switching device, means for operating and for releasing the same, and a signal arranged to operate in one manner while the device is operated and to operate in another manner while the device is being released.

10. In a telephone system, a switching device having a normal position and a plurality of off-normal positions, means for extending a connection to said switching device, means for operating said device to one of the off-normal positions after a connection has been extended to it, means for restoring said device to its normal position and for breaking said connection, a signalling device, and means for operating said device in one manner while the connection is established and for operating said device in another manner in the interval of time elapsing between the breaking down of the connection and the return of said device to its normal position.

11. In a telephone system, a trunk line, a registering device, means for effecting a connection between said trunk line and said registering device, a relay in said trunk line for severing said connection, means for transmitting digits from said trunk line to said registering device, a circuit for said relay, means for closing said circuit at said registering device, and means for preventing the closure of said circuit at any time while a digit is being received.

12. A register sender for use in multi-office telephone systems including: a mechanical step-by-step office register, relay-type registering devices for registering line designating digits, a relay-type input-control device, a relay-type sender counting device, and a relay-type output-control device.

13. A register sender for use in multi-office telephone systems comprising: a relay-type input control device, a relay-type output control device, a relay-type sending device, a mechanical step-by-step office register, a relay-type digit register for registering line-designating digits consecutively, and digit storing devices for storing the line designating digits after they are registered and until they are retransmitted.

14. In a register controller for receiving office designating digits, for retransmitting in accordance therewith the digits necessary to trunk the call to the desired office, for receiving line designating digits and for retransmitting them untranslated to trunk the call to the desired line, a mechanical step-by-step office register in said register sender, and means consisting solely of relays for performing the remaining stated functions.

15. In an output-control device of the relay type for controlling the transmission of successive digits from a register sender, two groups of digit-control conductors extending from said output control device, means for operating the relays of the device successively, each relay of a plurality of said relays being arranged to connect up a pair of said conductors, one in each group, certain of said relays being arranged to reoperate in a second counting operation after all the relays have been operated once, circuit connec-

tions for maintaining the last relay operated continuously after it has operated in response to the first wave of relay operations, and contacts on the last-named relay for suitably shifting the associated circuit connections so that only conductors of the first group are effective upon being connected before such relay is operated and only conductors of the second group are effective upon being connected up after it has operated.

16. In a register sender for use in a telephone system, a single-digit set of counting relays arranged to respond successively to a plurality of digits in a desired telephone number, a plurality of digit-storage devices arranged to store the several digits respectively registered on the counting relay set, and means including a further set of counting relays for associating the storage devices successively with the counting-relay set.

17. In a register sender for use in a telephone system, a sending device for retransmitting a plurality of digits, an output-control device comprising a plurality of counting relays for controlling the sender so that it retransmits the digits one after the other in the proper order, and means effective in case certain digits are to remain unsent for operating the respective relays corresponding to such digits one after the other in rapid succession.

18. In a sending device for use in a telephone system to transmit a variable plurality of digits successively, a sending device for transmitting the several digits of a group, an output-control device comprising a plurality of successively operable relays for controlling the sender so that it retransmits the digits one after the other in the proper order, and means effective in case less than the maximum number of digits is to be transmitted for operating the relays of the output control device in quick succession until such device has passed through the desired number of positions.

19. In combination, an impulse conductor, and a plurality of counting relays arranged to operate successively over said conductor, and circuit paths controlled by contacts on said relays for causing the relays to arrange themselves in any one of more than twice as many possible combinations as there are relays.

20. In a telephone system, a release relay for controlling the release of an established connection, an impulse repeating relay for repeating impulses to cause the establishment of a desired connection, and means for short circuiting said release relay in order to send impulses to said repeating relay.

21. In a telephone system, a release relay for controlling the release of an established connection, an impulse repeating relay for repeating impulses to cause the establishment of a desired connection, and a line relay con-

trolled over a calling line for short circuiting said release relay in order to send impulses to said repeating relay.

22. In a telephone system, a release relay for controlling the release of an established connection, an impulse repeating relay for repeating impulses to cause the establishment of a desired connection, means for short circuiting said release relay in order to send impulses to said repeating relay, and an automatic switch included in the connection between the two relays.

23. In a telephone system, a release relay for controlling the release of an established connection, a plurality of impulse repeating relays for repeating impulses to cause the establishment of desired connections, means for associating said release relay with any one of said repeating relays, and means for short circuiting said release relay in order to send impulses to the associated repeating relay.

24. In a telephone system, a release relay for controlling the release of an established connection, a plurality of magnets arranged to be operated to cause the establishment of desired connections, means for connecting any magnet to said release relay, and means for short circuiting the release relay in order to send impulses to any connected magnet.

25. In a telephone system wherein a register is set by series of impulses transmitted over a telephone line, a repeating relay in said line for repeating the impulses to the register over an impulse conductor, extending from the line to the register, a repeating relay in the register connected to said conductor and arranged to respond to the impulses received thereover, a tone generating device, a connection to said conductor from said device independent of said repeating relay in the register, and means responsive to the operation of the last named repeating relay for opening the connection between said tone generator and said conductor.

In witness whereof, I hereunto subscribe my name this 16th day of October, A. D., 1926.

RUDOLPH F. STEHLIK.