

Nov. 18, 1941.

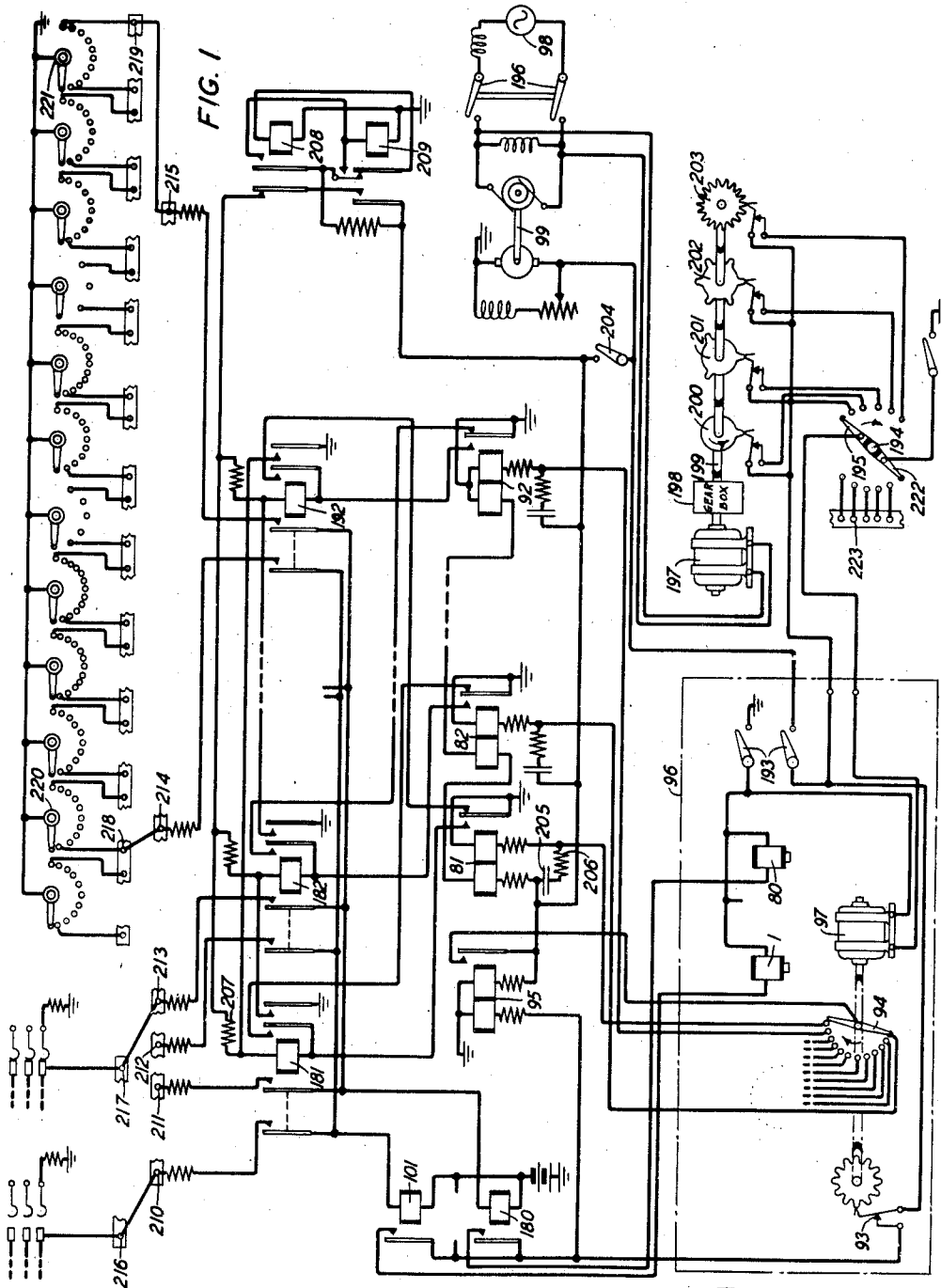
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2,263,291

TESTING AND RECORDING SYSTEM

Filed April 18, 1940

3 Sheets-Sheet 1



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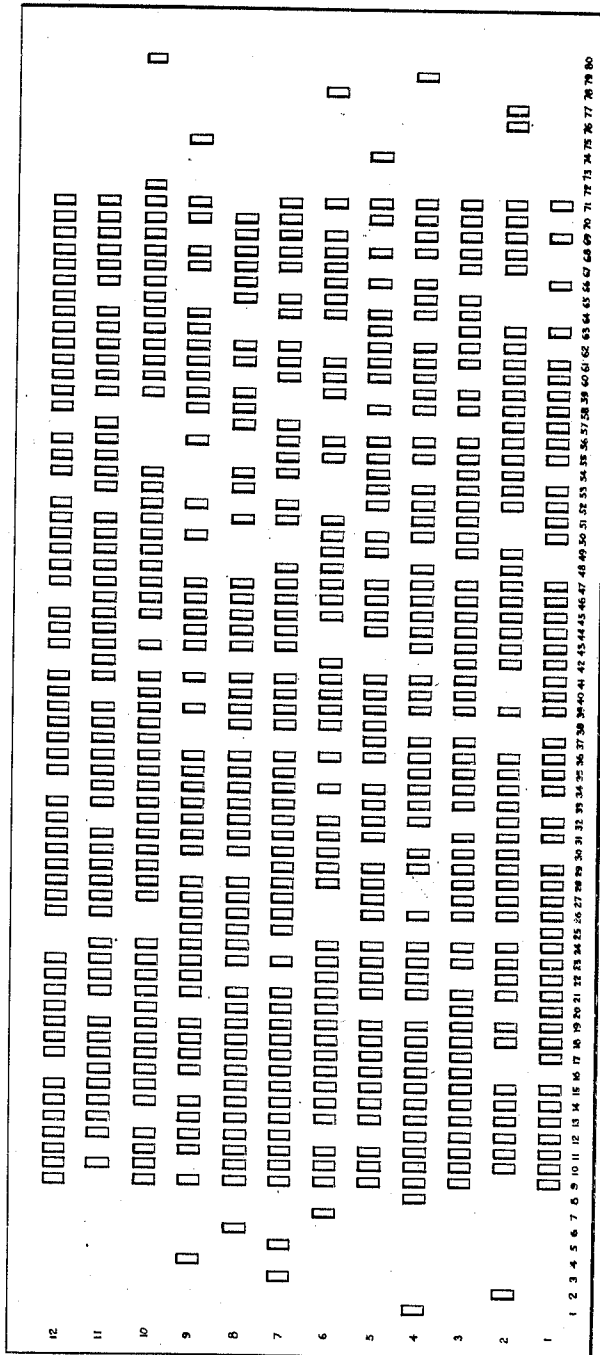
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TESTING AND RECORDING SYSTEM

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3 Sheets-Sheet 2

FIG. 2



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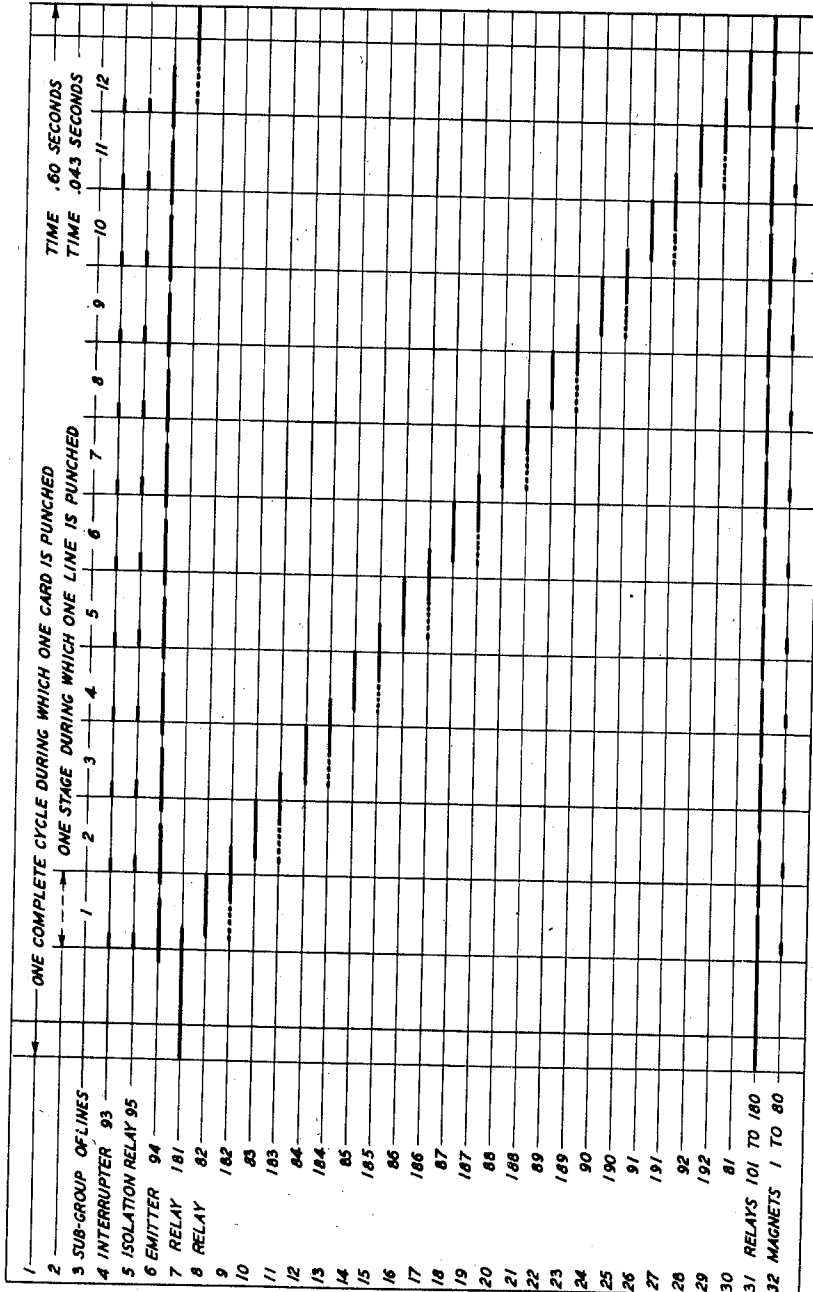
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TESTING AND RECORDING SYSTEM

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3 Sheets-Sheet 3

FIG. 3



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2,263,291

TESTING AND RECORDING SYSTEM

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Application April 18, 1940, Serial No. 330,288

17 Claims. (Cl. 179—175.2)

This invention relates to means for testing and recording the condition of large groups of similar electrical circuits and particularly to means for recording information in such form that it may later be mechanically analyzed.

The object of the present invention is to record traffic conditions in large groups of similar circuits, such as trunks in a telephone system, in such form that a permanent record is produced which may immediately or later be analyzed either by inspection or by mechanical means. Another object is to make such a record at a high speed so that, if a series of such records are made successively and at very frequent intervals, the rate of change in conditions within the group of circuits may be accurately determined. When such records are made at the speed possible of attainment by the apparatus herein disclosed, any single record will practically show the condition at any particular instant while a series of rapidly taken records will reveal the holding time of each circuit. While it is possible for one call to disconnect and another to be set up between successive tests and therefore the holding times of two calls be registered as that of one longer call, the probability of this occurring is so remote that it may be discounted.

A feature of the invention is a controlling circuit for a card punching machine by means of which different groups of circuits may be successively connected to the punches of the machine as the card is progressively advanced in relation to the punches, whereby a large group of circuits may be explored by subgroups and a record made by punching holes in a card. By way of example, the punching machine may be provided with a group of eighty punches and an appropriate size card may accommodate twelve rows of eighty places so that the card may accommodate the record for nine hundred sixty tests. The circuits are then divided into twelve subgroups of eighty circuits each and relay means are provided to associate each of the twelve subgroups of eighty circuits with the eighty punches successively. As the record of one subgroup is made the card is advanced so that the record of the next subgroup will be made on another line.

Another feature of the invention is a means for controlling the card punching mechanism to operate at regular intervals of differing lengths. For instance, the record may be taken and the result punched completely on one card every seven-tenths of a second, or every two seconds, six seconds, twelve seconds or thirty-six seconds. Or this may be expressed as rates varying from approximately ninety to one and two-thirds records per minute.

Another feature of the invention is means for recording certain incidental information on each

card along with the result of the test of the large group of lines. For instance, the rate at which records are made as described in the foregoing paragraph may be recorded, a serial number for each card may be recorded, and the date and time at which the card is punched may be recorded, and so forth.

Still another feature is the arrangement of the record which is made. For instance, the incidental information which requires very few punch marks is practically equally divided and placed at the two ends of the card so that the card bearing the complete record will have greater mechanical strength than if the main mass of information were punched out at these points.

According to another feature of the invention, certain incidental information such as the serial number of the cards may be punched into the cards before they are placed in the punching machine. This will eliminate the necessity of adding an obvious but unnecessarily expensive and somewhat complicated counting mechanism to progressively put a busy condition on certain lines to cause the punching machine to automatically record the said serial numbers.

Another feature is a circuit arrangement for causing the high speed operation of a plurality of comparatively heavy duty multicontact relays. The punching machine is equipped with a commutator means for signaling the periods for the connection of each subgroup of circuits to the said machine. A comparatively light duty sensitive relay for each subgroup is provided and is operated under control of said commutator means. Since the period of energization of each of these sensitive relays is comparatively short, each relay is provided with a condenser charging circuit for prolonging its period of operation beyond its period of energization. These light duty sensitive relays each control a comparatively heavy duty multicontact relay for effectively connecting the lines of a subgroup of circuits to the testing and recording means.

Another feature is the circuit arrangement by means of which the exploration of the successive groups of circuits under test is made to synchronize with the punching operation on the card, irrespective of changes or irregularities in the speed of the punching machine or the interval between its operating periods. When current has been applied to the winding of a multicontact relay through the operation of a sensitive relay, then as soon as the multicontact relay has closed its contacts it locks itself in through one or more of these contacts allotted for that purpose. This is necessary because the interval during which each multicontact relay must remain operated is greater than could be provided by the aforementioned delay circuit associated with

each sensitive relay, unless an excessively large condenser were employed. Particularly is this true of the interval between the last commutator impulse associated with the passage of one card and the first impulse for the next card; this may be as great as thirty-six seconds, as mentioned above. The principal function of the delay circuit is therefore to prolong the operation of the sensitive relay sufficiently to cover the interval required for the outgoing multicontact relay to open its contacts, as explained below, and for the incoming multicontact relay to lock itself in. Furthermore, this locking circuit is made to pass through the back contact of the next sensitive relay, so that operation of the latter will destroy the circuit for the outgoing multicontact relay, as well as establish a circuit for the incoming multicontact relay. These provisions are important because they insure that no matter what variations or irregularities may occur in the speed of the punch, or the intervals between commutator pulses, or the intervals between operating periods, the operation of the multicontact relays and their dependent testing circuits will be inherently synchronous with the commutator pulses that also operate the punch magnets and so record the result of each test.

Still another feature is an interlocking circuit for the said multicontact relays for preventing the multiple connection of said circuits through overlap operation of the multicontact relays. Each light duty sensitive relay upon operation acts, as mentioned above, to deenergize the previously energized multicontact relay and to energize the next in order multicontact relay. However, such next in order multicontact relay is shunted through operated contacts of the previously energized multicontact relay and, therefore, cannot operate its contacts until such previously energized relay has opened its contacts.

The drawings consist of three sheets, the first of which, containing Fig. 1, is a circuit diagram by which the operation of the apparatus may be explained. The second sheet, containing Fig. 2 is an enlarged representation of a punched card containing the record of a test of a group of similar electrical circuits, and the third sheet, containing Fig. 3 is a timing chart by means of which the operation of the apparatus may be more easily understood.

In the lower left-hand corner of Fig. 1 there appears a broken line rectangle 96 which represents a commercially available punching machine. This machine may be supplied with a large stack of cards of an appropriate size and when set in operation will punch holes in these cards at the rate of approximately ninety cards per minute. The number of holes punched by one type of machine is nine hundred sixty arranged in twelve rows of eighty each. In this figure only so much of the apparatus included in the commercially available machine is indicated as is necessary to a clear understanding of the invention.

The machine consists essentially of eighty magnets, here represented by the two magnets numbered 1 and 80, it being assumed that the remainder of these magnets are indicated by the missing numbers between 1 and 80 and by the multiple connection shown. These magnets are for causing the proper operation of corresponding punches. The machine is powered by a motor 97 which is here shown only in connection

with the emitter or commutator device 94 and the circuit breaker or interrupter 93. It is understood, however, that the motor 97 will operate the mechanical parts of this machine.

Power is supplied from a source of power 98 operating a motor generator set 99, or it may be taken directly from a 110 volt direct current source if available. For convenience of illustration, one side of the generator of this set is shown grounded and the other side is extended into the punching machine 96. At this point a switch 193 is used to connect the source of power to the electrical circuits of the machine. The motor, however, will not be operated until a switch 194 is moved so that its right-hand brush contacts with one of the points to which a connection is made. If the right-hand brush 195 is moved so as to make connection with its first contact, then the motor 97 will be connected directly from ground, the upper blade of switch 193, the motor 97, the brush 195 and its first connected contact through the lower blade of switch 193 to the source of power 99. Under this condition the motor 97 will run continuously.

When the switch 196 is operated to connect a source of alternating current to the motor generator 99, it also closes a circuit for operating motor 197 which through an appropriate set of gears 198 will turn a shaft 199 carrying a number of cams 200, 201, 202, and 203. Each of these cams operates a set of contacts and the timing of the shaft 199 is so arranged that the contacts operated by the cam 203 will operate once every two seconds, the contacts operated by the cam 202 will operate once every six seconds, the contacts operated by the cam 201 will operate once every twelve seconds, and the contact operated by cam 200 will operate once every thirty-six seconds. These cams are also arranged to close their contacts for a period just sufficient to cause the motor 97 to operate the punching device through one complete cycle of operations. Closing of contacts by cams can be very brief, because the punch contains a device for automatically keeping power on the motor through one complete card cycle, once the operation has been initiated by a momentary closing of the circuit which the cam contacts control. Thus, when the brush 195 is moved to its second connected contact, the motor 97 will operate once every thirty-six seconds to cause the machine 96 to perform one complete operation.

During the operation of the machine 96, the circuit breaker or interrupter 93 will cause the isolation relay 95 to operate twelve times, each for a very short interval of time. This is illustrated in the timing chart, Fig. 3, by lines 4 and 5. Line 4 indicates the periods during which the circuit through the interrupter 93 is closed and line 5 indicates the periods during which the isolation relay 95 is operated. Assuming that the emitter or commutator device 94 has moved its brush to the point where relay 81, for instance, will be operated, then during this period, indicated in line 6 of the timing chart, Fig. 3, and while the isolation relay 95 is operated, a circuit may be traced from ground, the right-hand winding of relay 81 and its associated resistance, brush of commutator device 94, the front contact and armature of relay 95, through the switch 204 to the source of power. This will cause a current flow through the right-hand winding of relay 81 which will cause it to move its armature to its front contact. Relays 81 to 92, inclusive, one for each of the twelve subgroups, as

represented by the twelve lines on the card, Fig. 2, as well as the relay 95, are comparatively light duty sensitive relays. It will be noted by the timing chart, Fig. 3, that the period of energization of the relay 81 is extremely short. Hence, these relays are provided with a polarizing circuit through their left-hand windings in series and each is provided with a condenser, such as 205. The connection through the contact and armature of the isolation relay 95 and the commutator device 94 will short-circuit this condenser 205 and its associated resistance 206, but as soon as the relay 95 becomes deenergized, this condenser will again charge from the source of power 99 and through the right-hand winding of relay 81 and this charge current will tend to hold the relay 81 operated for a period beyond the period of its energization through the front contact and armature of relay 95.

The operation of relay 81 closes a circuit for a multicontact relay 181 from ground, the armature and front contact of relay 81, the winding of relay 181, through the resistance 207, the back contact and outer left-hand armature of relay 208, the front contact and outer left-hand armature of relay 209, through the switch 204 to the source of power 99. In the normal operation of the apparatus, however, relay 192 would have remained operated until this operation of relay 81, through a locking circuit involving front contact and inner right-hand armature of relay 192 and the back contact and armature of relay 81. Therefore, the winding of relay 181 will be short-circuited or shunted at this time through a connection from the upper terminal of the winding of relay 181 to the front contact and outer right-hand armature of relay 192. Therefore, upon the operation of relay 81 an energizing circuit for relay 181 is closed but does not become effective until the relay 192 has become completely deenergized and moved its armatures to their normal positions. Similarly once that relay 181 has closed its contacts, it locks itself in, and remains operated independently of relay 81, through a locking circuit running from its inner right-hand armature and front contact through the back contact and armature of relay 82, to ground. It will therefore remain operated until relay 82 has opened its back contact, and furthermore relay 181 will in its turn inhibit the operation of relay 182 until it has opened the shunt circuit running from the upper winding terminal of relay 182 through the front contact and outer right-hand armature of relay 181 to ground. The same sequence of operations is followed with all the other relays in this series, and in this way their operation is made inherently synchronous with that of the circuit breaker 93, and therefore with the speed of the punching machine.

Each of the multicontact relays 181 to 192, inclusive, carries a plurality of armatures whereby the windings of relays 101 to 180, inclusive, may be connected to terminal connections, such as 210, 211, 212, 213, 214 and 215. The terminal 210, by way of example, is shown connected to another terminal 216 which, in turn, is connected to a circuit which is here indicated as being idle. By way of example, this circuit is shown schematically as a trunk circuit in a telephone system wherein the sleeve circuit has not been connected to ground as yet. Also by way of example, the terminal 213 is shown connected to another terminal 218 which is connected to a busy circuit, this latter condition being indicated by the resting of a brush on a trunk terminal. Thus,

when relay 181 is operated, relay 101, being connected to a circuit which is in an idle condition, will not become operated. By the same token, when relay 182 is operated, relay 180, being connected to a busy circuit, will become operated. During the time that relay 181 is operated, the circuit breaker or interrupter 93 will momentarily close, whereupon each one of the magnets 1 to 80 which is connected to an operated relay 101 to 180 will become operated and cause a punched hole to appear in the record card at an appropriate place.

Other terminals leading through the contacts of these multicontact relays to the relays 101 to 180 may be connected to terminals such as 218 and 219. These terminals are connected to ground by manually operated switches, such as 220 and 221, and by means of these switches incidental information may be recorded on the card. Looking for a moment at Fig. 2, columns 1, 2, 3 and 4 may be reserved for an indication of the serial number of the card. Column 1 will contain a punched mark indicating thousands, column 2 will indicate hundreds, column 3 will indicate tens and column 4 will indicate units. In the example shown, the serial number indicated is 4279.

Columns 5, 6 and 7 may be used for indicating or recording the office code in a telephone system wherein this recording machine may be employed. The code here indicated is 7, 8, 6 or, if translated into the usual code shown on the dials of telephone instruments, this might be SU6 which would indicate an office known as Summit.

Column 8 may indicate the rate at which the records are taken. In the present case a hole is punched in the fourth line of column 8 which would indicate that this is one of a series of cards made at the rate of one every twelve seconds. In this case the switch 194 would be set onto its next to last effective contact and the brush 222 would be making connection to terminal 223 which would be cross-connected to an appropriate terminal leading through one of the multicontact relays.

The columns 9 to 71, inclusive, will be reserved for indicating the condition of the trunks. Columns 72 and 73, 74 and 75, may be used to indicate the exact time at which this record was made. Thus, the punch mark in column 72 will indicate 10 a. m., column 73 having no punch mark is used for the hours post-meridian, columns 74 and 75 will indicate minutes in tens and units. Thus the minutes here shown are 59 so that this record is indicated as having been taken at 10:59 a. m.

Columns 77 and 78 may indicate days in tens and units; thus 26 is indicated. The last two columns 79 and 80 may indicate years in tens and units so that the year 40 is indicated. The complete record of incidental information, therefore, is that the card shown in Fig. 2 is Serial No. 4,278, taken at the Summit office at the rate of one card every twelve seconds at 10:59 a. m. on February 26, 1940.

It will be understood, of course, that the entire eighty columns may be used for recording the condition of an equivalent number of circuits and that such incidental information as is here described may be placed on the card in some other manner. In accordance with Fig. 2 where seven hundred fifty-six circuits may be tested, six hundred nine are shown as busy and one hundred forty-seven are shown as idle. This will show

that about 80.5 per cent of the trunks were busy at this particular time.

There are commercially available a number of well-known analyzing machines which will accommodate cards of this nature so that if a large number of such punched cards are placed in the machine they will be mechanically analyzed and certain statistics obtained therefrom.

Since these cards may be taken at the rate of about ninety per minute or one approximately every seven-tenths of a second, the holding time of any one or more trunks may be determined. For instance, the trunk represented by the punch mark in the lower or first row and the ninth column is shown in this card as busy. Searching back over other cards taken and according to their serial numbers the exact time at which this trunk became busy can be determined, and searching further over cards taken subsequent to this card the exact time at which the trunk was released may be determined and from these the holding time will be established.

The information recorded hereon may be analyzed in a number of ways, as will be readily apparent.

The timing chart shown in Fig. 3 is here given by way of example. It represents the closure intervals of the previously mentioned circuits and relay contacts during one complete cycle of operation of the punching machine 96. During this cycle one card, as is shown in Fig. 2, may be punched and the time taken for this operation is about six-tenths of one second. The card is actually divided into fourteen stages during twelve of which the twelve subgroups represented by the twelve rows in Fig. 2 are tested and the record of busy circuits therein made. These twelve stages are indicated in line 3 of this timing chart. Line 4 indicates the periods during which the interrupter 93 closes the circuit from the source of power to the armatures of relays 101 to 180 and to the left-hand winding of relay 95. The line 5 represents the time during which the isolation relay 95 has its armature closed. It will be noted that there is a slight displacement between the time during which interrupter 93 closes its contacts and the time during which the isolation relay 95 is operated. This is accounted for by the delay in movement of the armature of relay 95 even though this is a highly sensitive light duty relay. Line 6 indicates the period during which the twelve different circuits through the armature of commutator device 94 are closed. Line 7 indicates the time during which relay 181 is operated. While this relay is operated and the machine 96 is started again, the first relay thereafter to be operated will be the relay 82. Relay 82 closes the circuit for relay 182 and opens the circuit for relay 181. Relay 181, however, does not immediately break its contacts and, therefore, relay 182, as indicated in line 9, does not operate for a short period after its winding circuit has been closed. This circumstance is indicated by a series of dots on line 9 before the solid line indicating the full operation of relay 182.

The chart indicates the operation of relays 81 to 92, inclusive, and relays 181 to 192, inclusive, even though these relays are not completely shown on Fig. 1. Line 31 shows the operation of such of the relays 101 to 180 as may be connected to busy lines at these particular periods and line 32 shows the operation of such of the magnets 1 to 80, inclusive, as may be controlled by the corresponding operated relays 101 to 180. Each operation of the magnets 1 to 80, inclusive,

by means of a pulse, for example pulse 1, from the interrupter 93, therefore occurs through a circuit which was established by the previous pulse, which was 12, from the interrupter 93, and, in fact, this pre-established circuit is in process of being broken by the opening of the back contact of relay 82 by pulse 1. The actual card punching operation therefore occurs during an interval which becomes available because of the operating time of relay 95, plus the operating time of relay 82, plus the release time of relay 181.

The function of relays 208 and 209 is to prevent an unduly heavy load on the source of power when the system is started in operation and when switch 204 is closed. Since at that time no one of the relays 81 to 92, inclusive, or multicontact relays 181 to 192, inclusive, is operated and no one of the condensers, such as 205, is charged, the closure of the switch 204 might cause the momentary simultaneous operation of all these relays. Upon the closure of switch 204 each of the condensers, such as 205, becomes charged and the charging current is enough to cause the operation of the associated relay so that relays 81 to 92, inclusive, will all simultaneously move their armatures to close energizing circuits for relays 181 to 192, inclusive, respectively. However, at this instant, due to the deenergized condition of relays 208 and 209, these energizing circuits are ineffective.

Upon the closure of switch 204 the source of power 99 is connected through the normal contacts of the inner left-hand armature of relay 209, and thence through the winding of relay 208 to ground. Relay 208 operates, whereupon the source of power is connected through the inner left-hand armature and front contact of relay 208 and thence through the winding of relay 209 to ground. Relay 209 operates, and now the source of power 99 is connected through the alternate contacts of the inner left-hand armature of relay 209 directly to the winding of relay 209 to hold this relay energized. Due to the energization of relay 209, relay 208 will become deenergized. Thus, after switch 204 is closed, relays 208 and 209 will go through this cycle of operations and will thereafter remain in the condition with relay 209 steadily operated. Therefore, the source of power 99 will be connected to the resistances, such as 201, and thence to the windings of relays 181 to 192. However, this cycle of operation of relays 208 and 209 prevents the connection of the source of power to these points until after the condensers, such as 205, have become fully charged and relays 81 to 92 have returned to normal.

What is claimed is:

1. In a system comprising a group of similar electrical circuits each of which may be individually marked as either busy or idle, an automatic punching device for recording the condition of said circuits on a card, a particular point on said card being allocated to each said circuit, said circuits being divided into subgroups each of a number corresponding to the number of punches in said device, means for simultaneously testing the busy or idle condition of the circuits of a subgroup, means responsive thereto for operating corresponding punches of said device and means for successively bringing the subgroups of said circuits under control of said testing means whereby each circuit may be identified as busy or idle by the presence of absence of a punch mark at its said allotted point on the said card.

2. In a telephone system, a group of trunk

lines divided into a plurality of subgroups, means for making said trunk lines busy, means common to all subgroups for simultaneously testing the busy or idle condition of all trunks in a subgroup and for periodically and in a definite order bringing each subgroup under test, and an automatic punching device common to all said subgroups for recording the identity of each busy trunk in each subgroup.

3. In a system comprising a group of similar electrical circuits each of which may be individually marked as either busy or idle, an automatic punching device for recording the condition of said circuits on a card, a particular point on said card being allotted to each said circuit, said circuits being divided into subgroups, means for simultaneously testing the busy or idle condition of the circuits of a subgroup, means responsive thereto for operating said punching device to record the condition of each circuit of the said subgroup at its said allotted point on the said card, means for successively bringing the subgroups of said circuits under control of said testing means and means for simultaneously recording incidental information on the said card.

4. In a system comprising a group of similar electrical circuits each of which may be individually marked as either busy or idle, an automatic punching device for recording the condition of said circuits on a card, a particular point on said card being allotted to each said circuit, said circuits being divided into subgroups, means for simultaneously testing the busy or idle condition of the circuits of a subgroup, means responsive thereto for operating said punching device to record the condition of each circuit of the said subgroup at its said allotted point on the said card, means for successively bringing the subgroups of said circuits under control of said testing means, certain lines of said group being connected to means for indicating incidental information.

5. In a system comprising a group of similar electrical circuits each of which may be individually marked as either busy or idle, an automatic punching device for recording the condition of said circuits on a card, a particular point on said card being allotted to each said circuit, said circuits being divided into subgroups, means for simultaneously testing the busy or idle condition of the circuits of a subgroup, means responsive thereto for operating said punching device to record the condition of each circuit of the said subgroup at its said allotted point on the said card, means for successively bringing the subgroups of said circuits under control of said testing means, certain lines of said group being connected to means for indicating incidental information, and manually controlled means for adjusting said last means.

6. An automatic card punching machine constructed and arranged to punch a plurality of rows each of a plurality of holes, the holes of a row being punched simultaneously and the rows being punched successively, a plurality of terminals corresponding in number to the number of rows times the number of punches per row, a plurality of testing relays corresponding in number to the number of punches per row, each said testing relay being in operative relation to a punch, a plurality of relay means corresponding in number to the said number of rows, each said relay means operating to connect one of said terminals to one of said test-

ing relays, means for successively operating said relay means, and means for placing different electrical conditions on said terminals denoting intelligence.

7. In a system comprising a group of similar electrical circuits each of which may be individually marked as either busy or idle, means for connecting said circuits in subgroups to means for testing and recording the busy or idle condition of said circuits comprising relay means individual to each subgroup each operating a number of contacts equal to the number of circuits in a subgroup, and interlocking means between the individual said relay means for preventing the effective operation of a second of said relay means before a first of said relay means has become fully released whereby interconnection of said electrical circuits through the contacts of said relay means is prevented.

8. In a system comprising a group of similar electrical circuits each of which may be individually marked as either busy or idle, means for connecting said circuits in subgroups to means for testing and recording the busy or idle condition of said circuits comprising a multicontact relay for each subgroup and a directing relay for each subgroup, said directing relays operating to cause the energization of a corresponding multicontact relay, commutator means for successively operating said directing relays, condenser timing circuits for prolonging the operation of said directing relays beyond the intervals afforded by said commutator means and means for shunting each of said multicontact relays when energized by its corresponding directing relays through operated contacts of a previously operated multicontact relay whereby multiple connection of said circuits through the contacts of said multicontact relays is prevented.

9. In a system comprising a group of similar electrical circuits each of which may be individually marked as either busy or idle, means for successively connecting subgroups of said circuits to testing and recording means at high speed, comprising sensitive high speed relays each successively energized for a short period, each said relay being provided with a condenser charging circuit for prolonging the operation of the said relay beyond its period of energization, a multicontact subgroup relay responsive to each said sensitive high speed relay for connecting a subgroup of said circuits to said testing and recording means and an interlocking circuit arrangement for said multicontact relays for preventing the effective operation of more than one said relay at a time.

10. In a system comprising a group of similar electrical circuits each of which may be individually marked as either busy or idle, means for successively connecting subgroups of said circuits to testing and recording means, comprising commutator means for signaling the period for the connection of each subgroup of circuits to said testing and recording means, a relay for each subgroup of circuits responsive to said commutator means, and a multicontact relay responsive to each said subgroup relay for connecting the circuits of the corresponding subgroup to said testing and recording means.

11. In a system comprising a group of similar electrical circuits each of which may be individually marked as either busy or idle, means for successively connecting subgroups of said cir-

cuits to testing and recording means, comprising commutator means for signaling the period for the connection of each subgroup of circuits to said testing and recording means, a relay for each subgroup of circuits responsive to said commutator means, a multicontact relay responsive to each said subgroup relay for connecting the circuits of the corresponding subgroup to said testing and recording means, and timing means for periodically rendering said testing and recording means operative.

12. In a system comprising a group of similar electrical circuits each of which may be individually marked as either busy or idle, means for successively connecting subgroups of said circuits to testing and recording means, comprising commutator means for signaling the period for the connection of each subgroup of circuits to said testing and recording means, a relay for each subgroup of circuits responsive to said commutator means, a multicontact relay responsive to each said subgroup relay for connecting the circuits of the corresponding subgroup to said testing and recording means, and adjustable timing means for periodically rendering said testing and recording means operative at a plurality of different rates.

13. In a system comprising a group of similar electrical circuits each of which may be individually marked as either busy or idle, means for successively connecting subgroups of said circuits to testing and recording means, comprising commutator means for signaling the period for the connection of each subgroup of circuits to said testing and recording means, a comparatively light duty sensitive relay for each subgroup of circuits responsive to said commutator means, each said relay having a condenser charging circuit for prolonging its operation beyond its period of energization by said commutator means, and a comparatively heavy duty multicontact relay responsive to each said subgroup relay for connecting the circuits of the corresponding subgroup to said testing and recording means.

14. In a system comprising a group of nine hundred and sixty similar electrical circuits each of which may be individually marked as either busy or idle, means for successively connecting twelve subgroups of eighty of said circuits to testing and recording means within a period of six-tenths of a second, each said subgroup being allotted a period of forty-three milli-seconds, said connecting means comprising commutator means for signaling the period for the connection of each subgroup of circuits to said testing and recording means, a comparatively light duty relay for each subgroup of circuits responsive to said commutator means, each said relay having a condenser charging circuit for prolonging its operation beyond its period of energization by said commutator means, and a comparatively heavy duty multicontact relay responsive to each said subgroup relay for connecting the circuits of the corresponding subgroup to said testing and recording means.

15. In a system comprising a group of nine hundred and sixty similar electrical circuits each of which may be individually marked as either busy or idle, means for successively connecting twelve subgroups of eighty of said circuits to testing and recording means within a period of six-tenths of a second, each said subgroup being allotted a period of forty-three milli-seconds, said connecting means comprising commutator

means for signaling the period for the connection of each subgroup of circuits to said testing and recording means, a comparatively light duty relay for each subgroup of circuits responsive to said commutator means, each said relay having a condenser charging circuit for prolonging its operation beyond its period of energization by said commutator means, a comparatively heavy duty multicontact relay responsive to each said subgroup relay for connecting the circuits of the corresponding subgroup to said testing and recording means, and control means for said testing and recording means for causing said group of circuits to be tested and a record of the conditions of the separate circuits thereof to be taken at the rate of approximately ninety per minute.

16. In a system comprising a group of nine hundred and sixty similar electrical circuits each of which may be individually marked as either busy or idle, means for successively connecting twelve subgroups of eighty of said circuits to testing and recording means within a period of six-tenths of a second, each said subgroup being allotted a period of forty-three milliseconds, said connecting means comprising commutator means for signaling the period for the connection of each subgroup of circuits to said testing and recording means, a comparatively light duty relay for each subgroup of circuits responsive to said commutator means, each said relay having a condenser charging circuit for prolonging its operation beyond its period of energization by said commutator means, and a comparatively heavy duty multicontact relay responsive to each said subgroup relay for connecting the circuits of the corresponding subgroup to said testing and recording means, and adjustable control means for said testing and recording means comprising a plurality of different rate interrupters for causing said group of circuits to be tested and a record of the condition of the separate circuits thereof to be taken at different rates between approximately ninety and one and two-thirds per minute.

17. In a system comprising a group of similar electrical circuits, each of which may be individually marked as either busy or idle, means for connecting said circuits in subgroups to means for testing and recording the busy or idle condition of said circuits comprising a multicontact relay for each subgroup, a commutator, an interrupter, and means for synchronizing the operation of said multicontact relays with said interrupter comprising an isolation relay directly responsive to said interrupter, a light duty sensitive relay for each subgroup responsive to said isolation relay in a circuit completed through said commutator, means for prolonging the operation of said light duty relays beyond their period of energization by said isolation relay, and a sequence circuit for operating the corresponding multicontact relays including a front contact on the light duty relay corresponding to a given multicontact relay, a locking circuit for each multicontact relay including a back contact on the next in order light duty relay and a shunting contact for each multicontact relay on each prior order multicontact relay, whereby no more than one of said multicontact relays may be operated at one time.

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