

April 13, 1937.

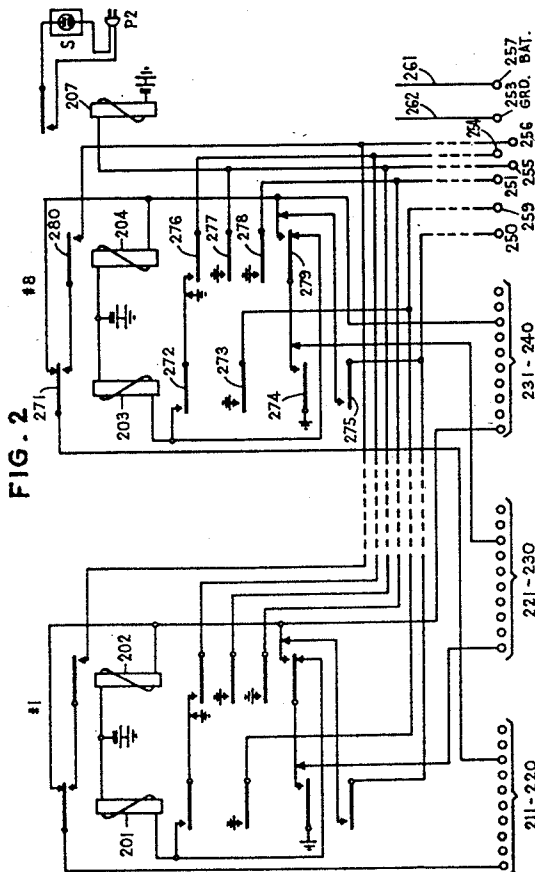
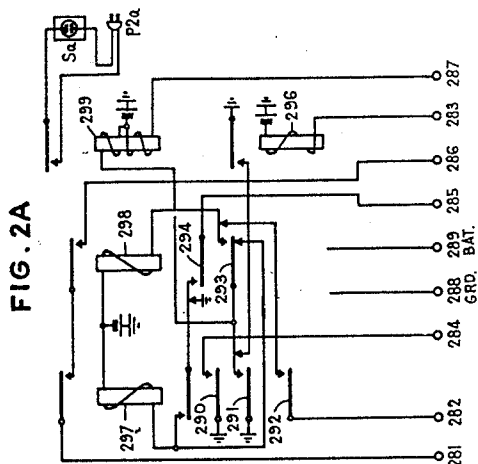
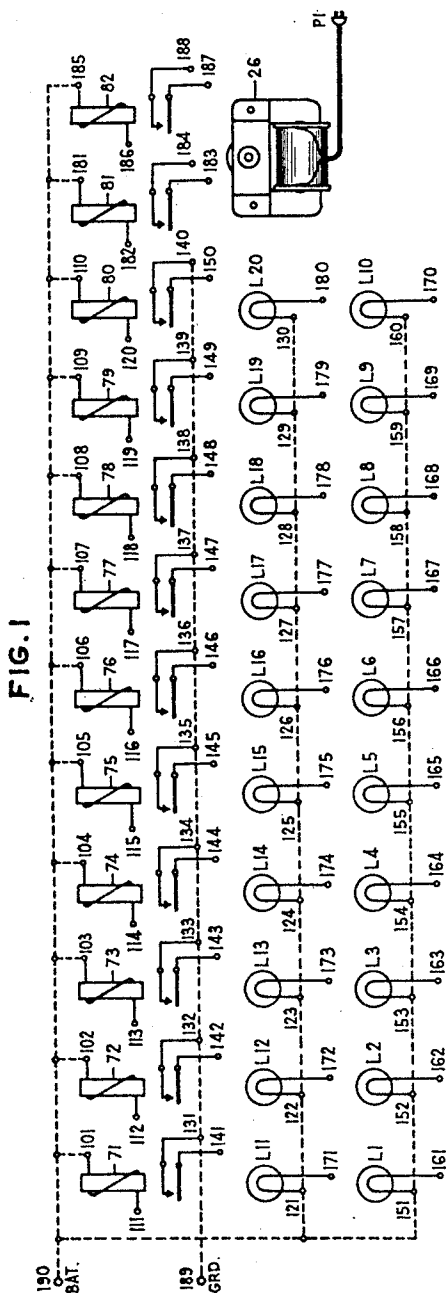
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2,076,676

RECORDING SYSTEM

Filed Aug. 24, 1934

7 Sheets-Sheet 1



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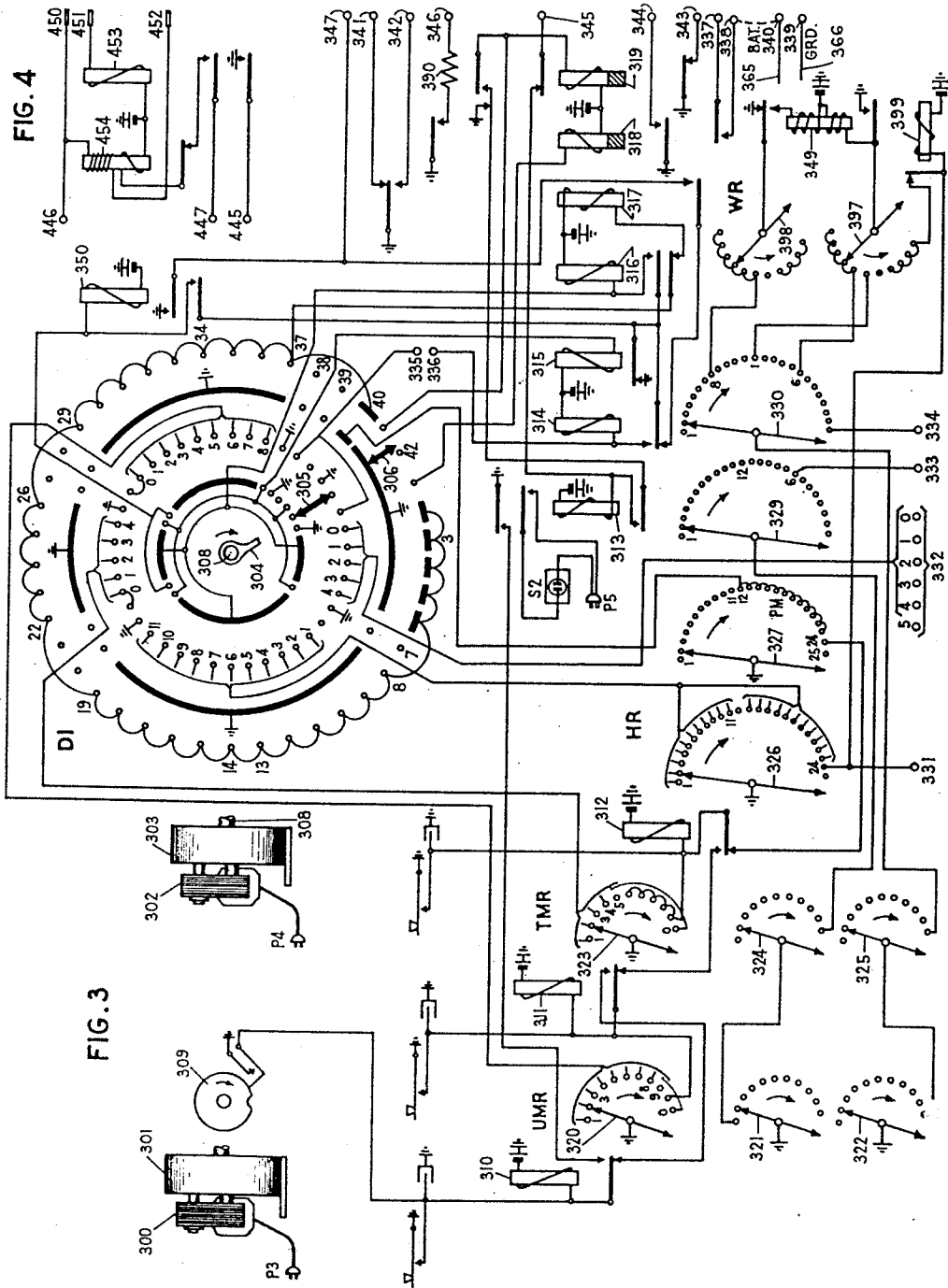
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RECORDING SYSTEM

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7 Sheets-Sheet 2



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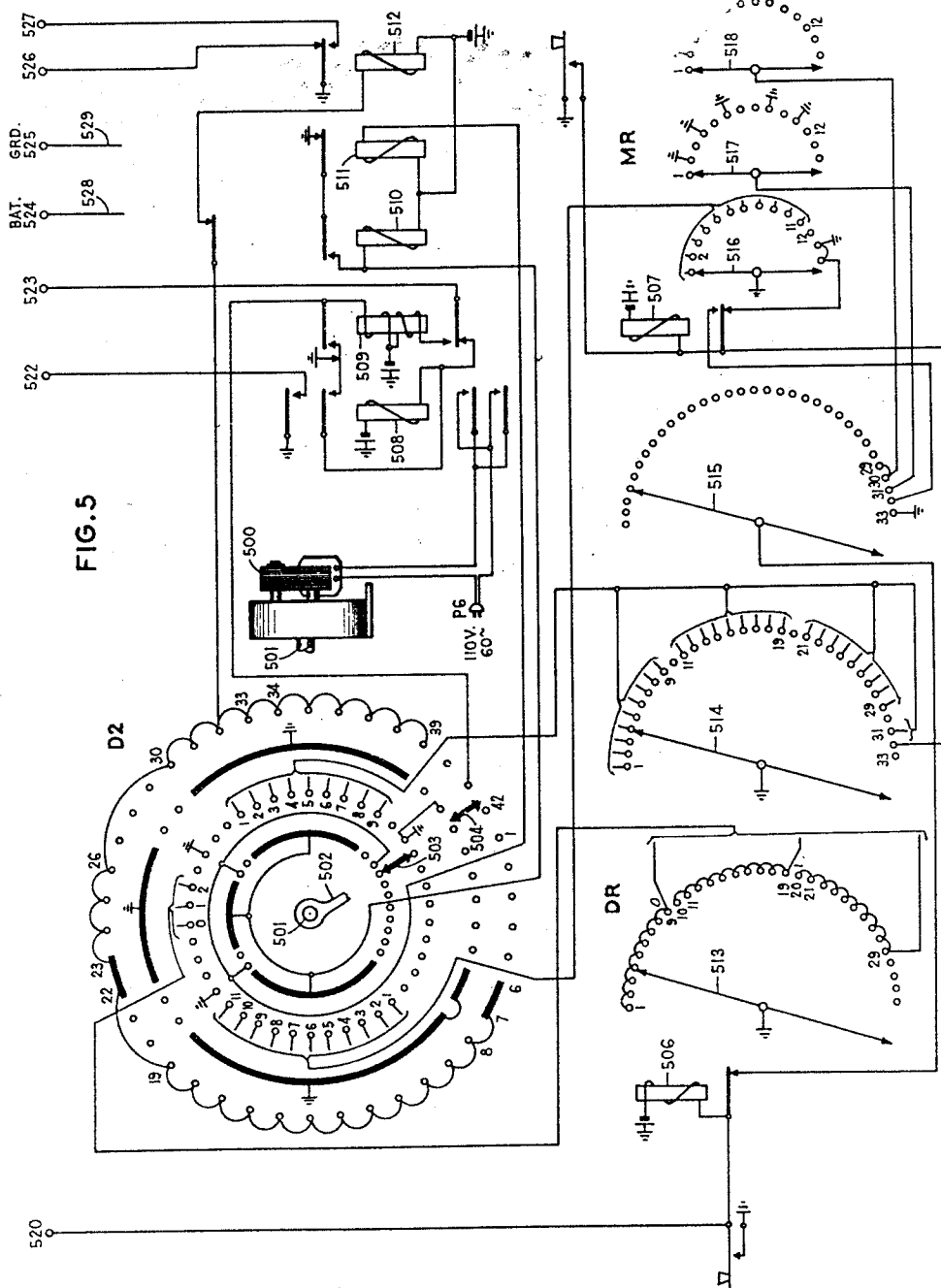
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RECORDING SYSTEM

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Sheets-Sheet 3



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RECORDING SYSTEM

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7 Sheets-Sheet 4

FIG. 7

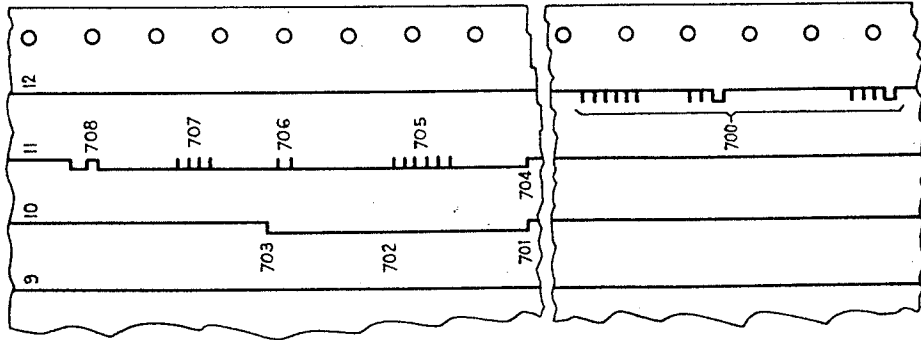
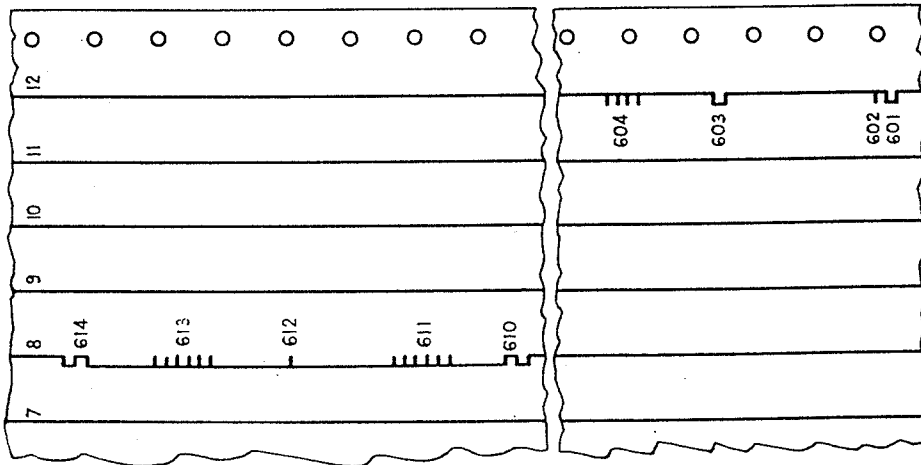


FIG. 6



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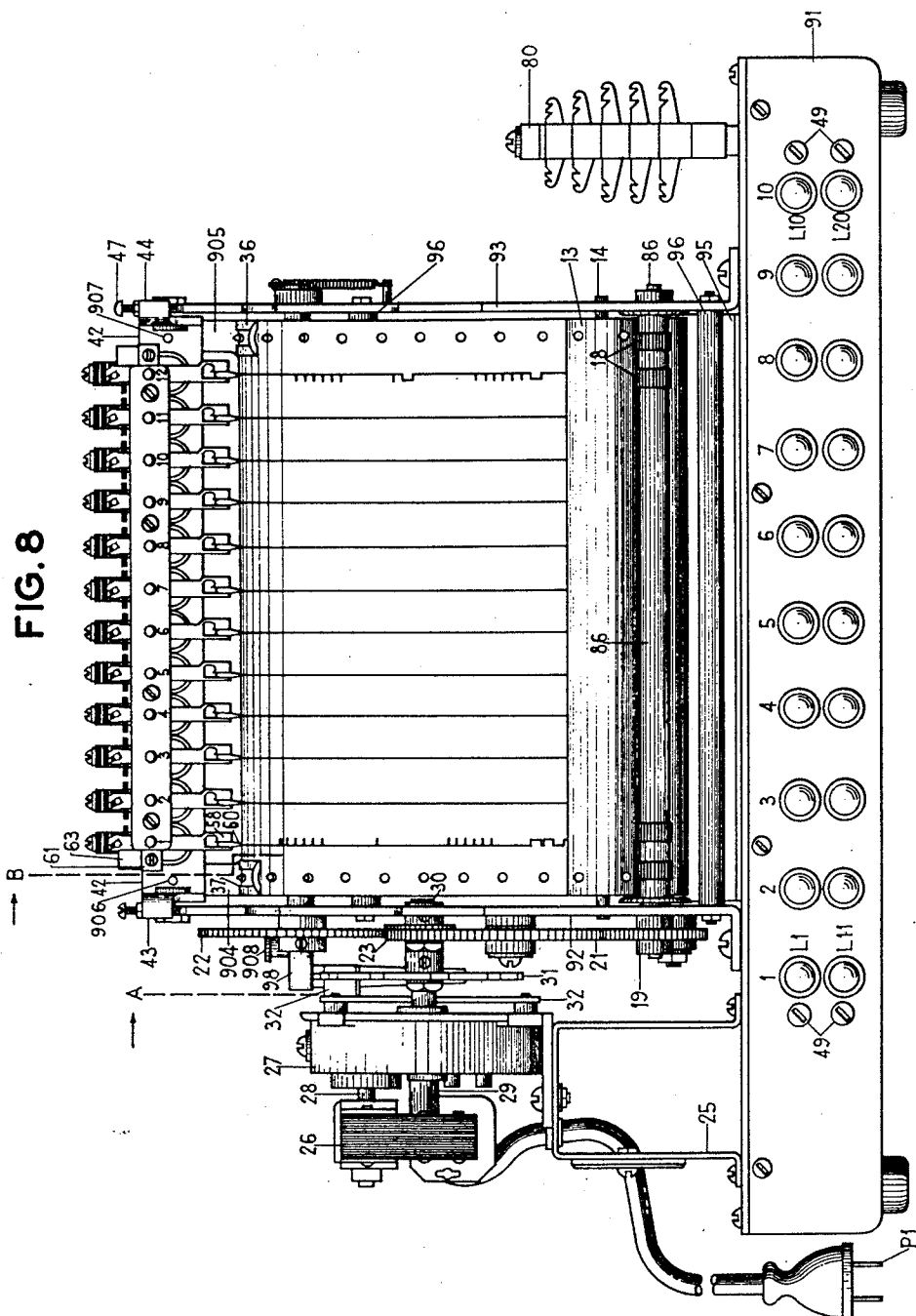
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7 Sheets-Sheet 5



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RECORDING SYSTEM

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FIG. 10

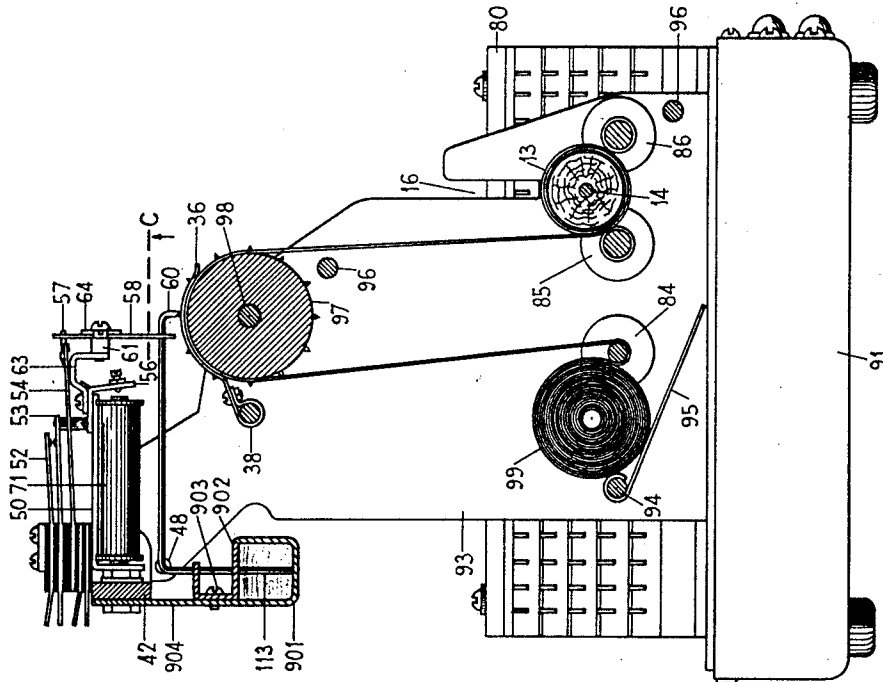
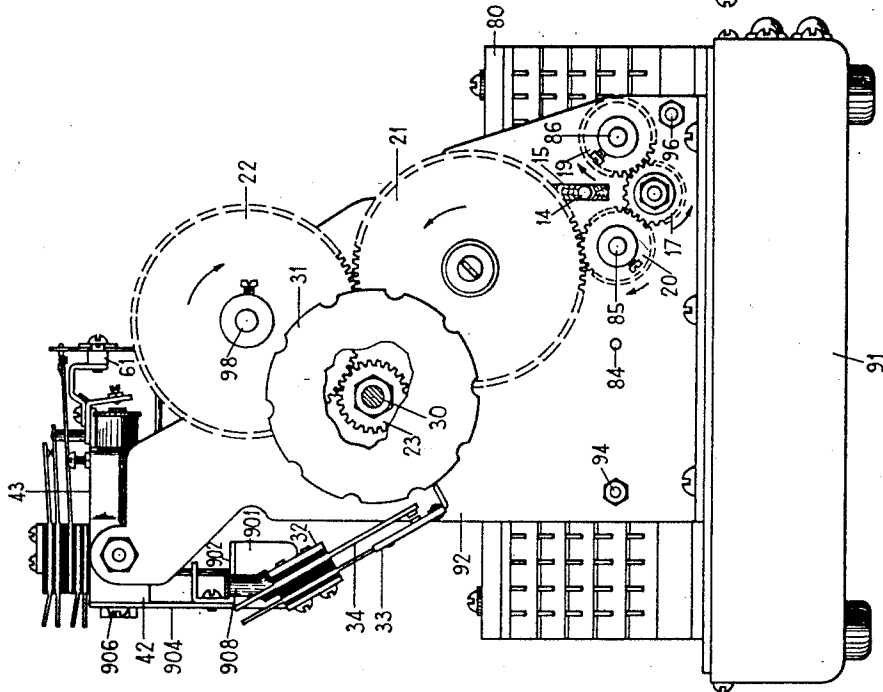


FIG. 9



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FIG. 13

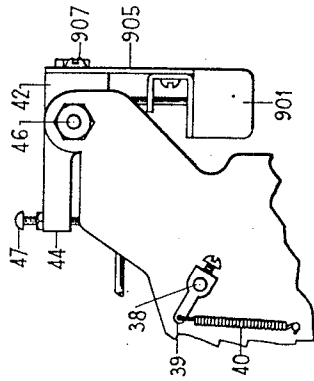


FIG. 12

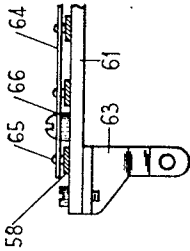


FIG. 11

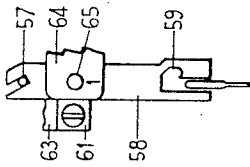


FIG. 15

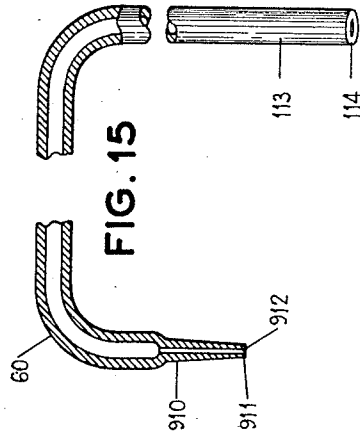
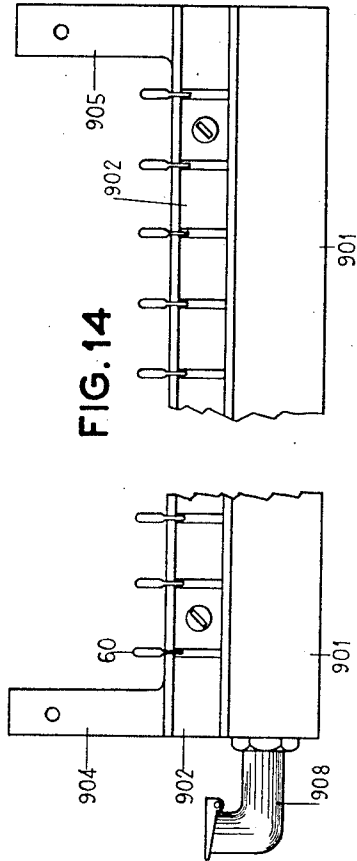


FIG. 14



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UNITED STATES PATENT OFFICE

2,076,676

RECORDING SYSTEM

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Application August 24, 1934, Serial No. 741,275

49 Claims. (Cl. 179—5)

The present invention relates in general to recording systems, and more in particular to novel circuits and equipment for controlling recording apparatus of the type shown in my prior application S. N. 704,851, filed January 2, 1934, or in my application Ser. No. 728,683, filed June 2, 1934. By this invention the necessary equipment items are provided by means of which recording systems suitable for many different industrial situations can be provided. These include a system of recording for a watchman's service installation, which will make a graphic record of the reports made by the watchman from the several stations which he is required to visit on his round, by marking the time when each visit is made; a system of recording circuit breaker operations in an electrical distribution system, or generating station, by marking the time the individual circuit breakers operate; and other situations in which graphic records are required of the occurrence of events and the time at which they occur.

Due to the nature of the problems involved, which are of exceedingly diverse character, it has been found advantageous to construct the apparatus in the form of separate equipment units, each of which is provided with terminals by means of which the several units can be connected up to make any recording system demanded by the particular situation being dealt with, provided it is within the limits for which the equipment is designed. These units are referred to hereinafter as a multiple pen recorder, a line relay set, a time clock, and a dater.

A complete system, and modifications thereof, will be described hereinafter, reference being made to the accompanying drawings, in which:

Fig. 1 is a circuit diagram of the multiple pen recorder;

Fig. 2 is a circuit drawing of a line relay set;

Fig. 2A is a circuit drawing of a modified line relay set;

Fig. 3 is a diagrammatic drawing of the apparatus and circuits of the time clock;

Fig. 4 shows a pair of relays which are provided in an automatic telephone system when the time clock is used for time signalling;

Fig. 5 is a diagrammatic drawing showing the apparatus and circuits of the dater;

Figs. 6 and 7 show several examples of the graphic records produced; and

Figs. 8 to 15, inclusive, show the mechanical construction of the multiple pen recorder and parts thereof. More specifically,

Fig. 8 is a front view of the multiple pen recorder;

Fig. 9 is a section on the line A, Fig. 8, except for the base;

Fig. 10 is a section on the line B, Fig. 8, also excepting the base;

Fig. 11 is a detailed view of one of the pen operating levers;

Fig. 12 is a detailed view, partly in section, on the line C, Fig. 10, of a portion of the pen operating lever assembly;

Fig. 13 is a view of a portion of the recorder shown in Fig. 8 as it appears from the right, a partial end view, in other words;

Fig. 14 shows the ink reservoir, approximately full size; and

Fig. 15 shows one of the pens enlarged about three times actual size.

Referring to Fig. 1, and to Figs. 8 to 15 inclusive, the multiple pen recorder comprises mechanism driven by a motor 26 which has the function of driving a paper tape past a group of recording pens. The paper is unwound from a supply roll and as it leaves the vicinity of the pens may be wound up on another roll. There are twelve pens, each provided with an individual controlling electromagnet. Fig. 1 shows these magnets, indicated by reference characters 71—82, and their circuits. When the paper is advanced each pen draws a line thereon, and with the pen magnets or relays deenergized the lines drawn will be straight parallel lines longitudinal of the paper. However, when any pen relay is energized, the associated pen is displaced to the left and draws a line which is offset from normal.

The apparatus is mounted on a hollow base 91 which is shown clearly in Figs. 1, 2, and 3. The base 91 may be made of sheet metal. Inside the base there is mounted a strip of ten pairs of lamps, which may be of any well known type. The lamps are in two rows, comprising lamps L1 to L10, and lamps L11 to L20, respectively. The lamp strip is supported inside the base by four screws 49, with the lamps behind translucent caps of standard type which are inserted in openings in the edge of the base which are provided for this purpose, all as is shown clearly in the drawings.

The main frame of the pen recorder includes two end plates 92 and 93, Figs. 8, 9, and 10. These end members are bent over at the bottom as shown in Fig. 8 so as to form two feet resting on the base 91, and secured thereto by heavy machine screws as shown in Figs. 8 and 9.

In order to stiffen the frame, two heavy cross rods 96 are provided. These cross rods each have a portion at each end which is reduced in size and which is threaded. These reduced end portions pass through holes in the end plates 92 and 93, which are firmly held against the shoulders on the rods 96 by means of nuts screwed on the threaded ends of the rods. There is also provided a similar rod 94, which is rigidly secured between the two end members in the same manner as rods 96. The rod 94 supports one edge of a flat metal strip or apron 95. This member 95 has one end wrapped around the rod 94 and the other edge rests on the base 91. It extends clear across from the member 92 to the member 93, as shown in Fig. 8, and provides a support for the roll of paper 99.

The mechanism for handling the record paper comprises an idler spool 84, a driven roller 97, two take-up spools 85 and 86, and a take-up roller 13, shown in Figs. 8 and 10. The driven roller 97 is supported on a shaft 98, which is mounted in bearings in the two end plates 92 and 93. The take-up roller 13 is supported on a shaft 14. The two ends of the shaft 14 lie in slots 15 and 16, which are cut in the end plates 92 and 93, respectively. The take-up spool 86, which can be seen clearly in Fig. 8, is supported on a shaft 86, forming part of the spool. Bearings for the shaft are provided in the end plates 92 and 93. The shank of the spool is provided with knurled portions such as 18. The spool 85 is constructed the same as spool 86. The spool 84 is also constructed similar to spool 86, except that the shank thereof may be somewhat smaller in diameter and is not provided with the knurled portions such as 18. The paper supply roll 99 rests on the plate 95, and against the spool 84, as shown clearly in Fig. 10. The paper is brought around under spool 84, from which point it is carried upward and around over the driven roller 97. As shown clearly in Fig. 8, the paper is preferably perforated along each edge, and these perforations are engaged by pins on the two ends of the roller in order to provide for a positive drive. From the roller 97 the paper is brought down to the take-up roller 13. The roller 13, with the accumulated paper thereon, rests on the two take-up spools 85 and 86. These take-up spools are positively driven by gears, as will be explained hereinafter, and the knurled portions thereon provide for rotating the take-up roller 13. As the paper accumulates on the take-up roller, the shaft 14 of the latter rises up in the slots 15 and 16.

As shown in Fig. 8, two curved clips 36 and 37 are provided, which hold the paper in position on the driven roller 97. These clips are desirable because the take-up roller 13 will have to be lifted from position from time to time to remove sections of the paper record, or is dispensed with altogether, and at these times the clips 36 and 37 keep the paper in position on the driven roll, with the pins at the ends thereof registering with the perforations in the paper. The clips 36 and 37 are mounted on a shaft 38, which is provided with bearings in the end plates 92 and 93. As shown in Fig. 13, the right-hand end of the shaft 38 is provided with a lever 39. Between the end of this lever 39 and a pin secured to the end plate 93 there is provided a coil spring 40 under tension, which tends to rotate the shaft 38 and hold the clips 36 and 37 in contact with the paper.

The power for driving the apparatus is fur-

nished by a motor 26, shown in Fig. 8. The drawings show a bracket or support 25, on which is mounted a gear case 27. The motor 26 is mounted against the face of the gear case by means of two studs, such as 29. The shaft 28 of the motor extends into the gear case 27, as shown. By means of suitable reduction gears which are enclosed in the gear case, the motor transmits power to the shaft 30 which projects from the right-hand side of the gear case. The motor 26 may be of any suitable design, except that it should be of the synchronous type so that it will run at a constant rate of speed. The gear case 27 is also of well known construction and need not, therefore, be described in detail.

On the shaft 30 there is mounted a pinion 23, which may be held on the shaft by means of a set screw. The pinion is in mesh with the gear wheel 22, see Fig. 9, which is mounted on the shaft 98. Thus, the pinion 23 and gear wheel 22 provide for driving the roller 97. There is provided an idler gear 21 which is mounted on a stud secured to the end plate 92. Gear 21 is in mesh with gear 22 and is driven thereby. The spool 85 is provided with the pinion 20, secured thereto as shown in Fig. 9, which is in mesh with the gear 21. A small idler gear 17, mounted on a stud which is secured to the end member 92, serves to enable the pinion or gear 20 to drive the pinion 19 which is attached to the take-up spool 86. It will be seen that the spools 85 and 86 are driven in the proper direction so that they both tend to rotate the roller 13 in the proper direction to wind up the paper as it comes off the roller 97. These spools are driven at a speed which is somewhat higher than that which is required to rotate the roller 13 fast enough to keep the paper taut.

The shaft 30 which transmits power from the gear box 27 also has mounted thereon a circular cam 31, shown in Figs. 8 and 9. This cam may be mounted on a hub which is provided with a set screw so that it can be secured to the shaft 30 like the pinion 23. On the gear box there is mounted a bracket 32, to which are secured by the usual screws and washers a pair of contact springs 33 and 34. As shown in Fig. 9, the outer contact spring 33 has a bent-over end portion which engages the periphery of the cam 31. As the cam rotates the end of spring 33 will enter the successive notches which are cut in the edge of the cam, and spring 33 thus closes contact with spring 34. The gear ratio may be such that the shaft 30 makes one revolution per minute. Since there are ten notches cut in the periphery of the cam, the spring 33 will make contact with spring 34 ten times per minute. A source of potential may be connected to spring 33 and an impulse lead may be connected to the other spring. With this arrangement impulses will be delivered to the impulse lead at the rate of ten impulses per minute.

It will be seen that the motor and gear box together with the cam and pinion carried by the shaft 30, form a detachable unit which is supported by the bracket 25 in the proper position so that the pinion 23 will engage the gear 22. However, this unit may be removed if desired, by merely taking out the screws by which the gear case is attached to the bracket 25. This permits the motor and gear unit to be used separately if desired in case a source of timed impulses is wanted for some purpose which does not require the use of the pen recorder, assuming, of course, that the latter is not in use at the

time. The motor is preferably provided with a flexible cord, as shown in Fig. 8, which terminates in a plug so that the motor can be connected up to a source of power.

5 As shown in Fig. 8 there are twelve pen relays. These twelve pen relays control twelve recording pens, which are numbered from left to right as pens 1 to 12, inclusive. The pen relays are mounted in a row on a drilled cross member 10 42, Fig. 10. This cross member has two arms 43 and 44 which are formed integrally with it and which extend forward at right angles to it. The construction can be seen clearly from Figs. 8, 9, and 13. The arm 43 is pivoted in the end plate 15 92 of the frame at 45, which the other arm 44 is pivoted in end plate 93 of the frame at 46. A stop 48, Fig. 10, limits the rotation on the pivots in one direction. The arm 44, Fig. 13, has an adjustable stop screw 47 which limits the rotation in the other direction. There is a similar 20 stop screw carried by arm 43. It may be stated that this limited movement of the cross member 42 is provided so that the recording pens can be lifted from the paper. The stop screws 47 are, 25 of course, adjusted so that the pens will rest properly on the paper.

The pen relays are constructed along conventional lines. Each relay comprises a heel piece 50 and a coil 71, as shown in connection with the 30 relay which can be seen in Fig. 10. Each relay core has a threaded extension which passes through the associated heel piece, and through the drilled cross bar 42, to which it is secured by a nut on each side of the cross bar. In this 35 manner the pen relays are securely supported on the cross bar. Each pen relay has three springs such as 52, 53, and 54, which are attached to the heel piece by means of machine screws as shown in Fig. 10. The springs are suitably insulated 40 from each other. The two upper springs are contact springs and are normally separated from each other. The lower spring 54, which is operated by the armature 56 of the relay, provides for operating the associated recording pen, and 45 also by means of a bushing operates the spring 53. The recording pens such as 60 are each provided with an operating lever 58. These operating levers are supported on a cross bar 61, which can be seen in Figs. 8 to 12, the latter being a part 50 sectional view which shows the left-hand end of the bar 61. The bar 61 is supported on two brackets such as 63. The left bracket 63 is secured to the heel piece of the first pen relay 71 as shown in Fig. 10. There is a similar bracket 55 at the other end of the bar 61 which is similarly attached to the heel piece of the last pen relay 82. The manner in which the operating levers are supported on the cross bar 61 is shown clearly in Figs. 11 and 12. The cross bar 61 is provided 60 with twelve short studs or pivot pins, 65, which fit loosely in holes drilled in the operating levers 58 of the respective recording pens. There is also a bar 64 which is secured to the bar 61 by a number of machine screws, as seen in Figs. 65 12 and 8. The bar 64 is spaced away from the bar 61 by means of washers such as 66, the washers 66 being slightly thicker than the levers 58. Thus the operating levers are securely supported on the bar 61 in such a manner as to provide 70 for movement around the pivots 65.

The operating levers are moved on their pivots by the associated pen relays. Each lever 58 has a diagonal slot cut in the end thereof, and in this slot there is positioned a round pin 57, which is 75 securely attached to the operating spring 54 of

the associated pen relay. Considering the first pen relay 71, shown in Fig. 10, it will be seen that when the armature 56 is attracted the end of spring 54 carrying the pin 57 will be moved upward. This pin engages the side of the slot 5 in lever 58, associated with the first recording pen 60, and therefore moves the upper end of lever 58 to the right, as seen in Figs. 8 and 11. The member 58 is therefore rotated slightly on the pivot 65, and the pen 60 is moved to the left. 10 When the relay deenergizes, the spring 54 resumes its normal position and accordingly moves the pen 60 back to its normal position.

The slot at the lower end of each operating lever 58 is carefully cut so that its width is just 15 slightly greater than the diameter of the pen tubing. Each slot is enlarged at 59, as shown clearly in Fig. 4. Any pen which is not used may be raised off the paper and allowed to rest in the enlargement or side slot 59. 20

The ink reservoir and the arrangement for supporting the pens can be seen in Figs. 9 and 10, and in Fig. 14. The reservoir 901 is rectangular in cross section, as can be seen from Fig. 10, and is approximately equal in length to the driving roll 97. The reservoir may be made of heavy 25 sheet brass. As shown in Fig. 14 the rear wall of the reservoir is extended upward at both ends, forming two brackets or hangers 904 and 905 by means of which the reservoir is attached to the cross bar 42. For this purpose two screws 30 906 and 907 are provided, which pass through holes in hangers 904 and 905 and are threaded into the cross bar 42. At the left-hand end there is a filler tube 908, closed with a hinged cap. 35

To form a cover for the ink reservoir 901, and also to provide a support for the pens, there is provided a U-shaped channel member 902. As can be seen from Fig. 10, the lower side of this channel is made of the proper width to close the 40 top of the reservoir. Equally spaced holes are drilled through both sides of the channel member to receive the pens such as 60.

An enlarged view of one of the pens is shown in Fig. 15. The pen 60 is made preferably of nickel 45 tubing about .062 inch in outside diameter, bent to the shape shown in Figs. 15 and 10. The portion 113 of the pen passes down through the holes drilled in the upper and lower side members of channel 902, which thus provides bearings in 50 which the pen can rotate about the perpendicular portion 113 as an axis. The lower end portion 113 rests on the bottom of the reservoir and is cut away at an angle at 114, so as to permit the entrance of ink. The other end of the pen 55 60 is preferably reduced in size at 910 for a distance of about $\frac{1}{2}$ of an inch from the end, by a swaging operation. This substantially closes the bore of the tube, which is then carefully drilled out to the exact size required for the best results. 60 Very satisfactory operation has been secured with a pen point having an over-all diameter of .025 inch at the point 911, and a bore 912 of .0135 inch. The pen points could no doubt be made in other ways, but satisfactory operation seems 65 to require a reduced bore at the end of about the dimensions given.

Before operating the pen recorder the pens have to be filled with ink. A considerable quantity of ink may be put into the reservoir 901 by 70 way of the filler tube 908. The pen relay assembly is then tilted back on the pivots 45 and 46 so as to raise the pen points from the paper. A small rubber bulb is now required to which is attached a short length of fine rubber tubing. 75

The bulb is first pressed together, then the rubber tubing is slipped over the point of the first pen. Releasing the bulb will now draw ink up into the pen by suction. Each of the pens may be filled in turn the same way. The pen relay assembly is now restored to normal position, with the pens resting on the paper. There is no tendency for the ink to run back, and when once filled as described above the pens require no attention for a long time.

The stop screws 47 should be adjusted so that the pen points press lightly on the paper. It will be observed that with the relays all deenergized the recording pens will trace straight lines on the paper, and it will be seen that when any pen relay energizes the associated pen will be moved to the left, so that the line traced by that pen will be offset to the left from its normal position. The stroke of the pen relay armatures is preferably adjusted so as to provide for a pen movement of about one-eighth of an inch. That is, the line drawn by a recording pen when its associated relay is operated may be offset one-eighth of an inch from the position of the line when the relay is normal. It is preferable to use a special kind of ink which does not readily evaporate, manufactured for use in apparatus of this kind.

The reference numeral 80 indicates a terminal block, which may be mounted on the base 91, as shown in Figs. 8, 9, and 10. This terminal block is of the usual type such as is used in telephone systems on distributing frames. It comprises five rows of terminals which are set in hard rubber or fiber blocks as seen clearly in Fig. 8, which shows an end view of the block. There are preferably twenty terminals in each row. The terminals in the upper row are numbered from 101 to 120, the terminals in the second row from 121 to 140, and so on. It will be understood that in actual practice the terminals may be numbered from 1 to 100, but in order to avoid confusion in the drawings the terminals are numbered herein as stated.

Fig. 1 shows how the pen relays and lamps are wired to the terminal block. The conductors from the pen relays, the relay contacts, and the lamp terminals are preferably formed into cables which extend to the left-hand side of the terminal block shown at Fig. 8, or to the rear of the terminal block, where they are separated and soldered to their respective terminal pins. These conductors are shown in solid lines in Fig. 1. In order to simplify the drawing the terminals are not shown in Fig. 1 in their proper relative positions as they are located on the terminal block 80. This departure, however, is customary in wiring diagrams and will not cause any confusion. When the device is to be used, the proper connections to other apparatus and the necessary connections between the relays, lamps, etc., which are not a part of the permanent wiring, are made by means of jumpers and by means of strapping on the front side of the terminal block 80. Fig. 1 shows in dotted lines one particular system of strapping which is required for a certain particular use of the multiple pen recorder.

The line relay set shown in Fig. 2 comprises ten pairs of relays, of which only the first and eighth pairs are shown, and a common relay 207. Relays 201 and 202 constitute the first pair of the ten, while relays 203 and 204 are the eighth pair. There is also provided a terminal block with numbered terminals, similar to the block provided with the multiple pen recorder, to which the relays are wired as shown in the drawings.

The relays and terminal blocks are all assembled together on a suitable base. The reference letter S indicates a socket and P2 is a plug for connecting up to a source of commercial current.

Referring now to the time clock, Fig. 3, this comprises a set of time registers, with means for maintaining them set in accordance with the time of day, and means for testing for the time and transmitting it by means of current impulses to the pen recorder. The registers are a units minutes register UMR, a tens minutes register TMR, and an hours register HR. There is also a weeks register WR. Each register is an automatic switch of the type which advances its wipers on the release of the stepping magnet. Registers UMR, TMR, and WR are eleven point switches, while register HR is a twenty-five point switch. The stepping magnets for the three registers are indicated by reference characters 310, 311, 399, and 312, respectively. A suitable 11-point switch is disclosed in U. S. Patent No. 1,675,311, while a suitable 25-point switch is disclosed in U. S. Patent No. 1,693,027.

The reference character 300 indicates a small synchronous motor such as is commonly used in electric clocks. This motor drives a cam 309 by means of speed reducing gears enclosed in a gear box 301. The speed reduction is such that cam 309 makes one revolution per minute and transmits an impulse every minute by means of the associated contact springs.

The testing and time transmitting equipment referred to includes a distributor D1 and a plurality of relays 313—319, 349, and 350. The distributor is driven by a synchronous motor 302, similar to motor 300, through a speed reducing gear set 303, which is arranged so that the distributor shaft 308 makes six revolutions per minute. This speed is not critical and may be varied somewhat if desired. The shaft 308 carries a brush arm 304, which is shown broken off so as not to obscure the drawings. However, it will be understood that this arm carries the two brush sets 305 and 306, moving them in a clockwise direction over their respective rows of contacts. The distributor brushes have forty-two positions, or contact sets. Sufficient of these positions are indicated by numerals placed opposite the corresponding contacts in the outer row so that the operation can be readily followed.

All the apparatus shown in Fig. 3, including the two motors, the distributor, the register switches, and the relays, are mounted on a single base as a unitary piece of equipment. This base also carries a terminal block having numbered terminals to which the apparatus is wired as shown in the drawings.

The dater shown in Fig. 5 is somewhat similar to the time clock equipment shown in Fig. 3. It comprises a days register DR, a months register MR, a distributor D2, and five relays 508—512. The register switches are of the same type as those shown in Fig. 3, but differ as to the number of contacts in their banks. The distributor D2 is similar to D1, but is necessarily wired differently and has a somewhat different arrangement of contacts. It may be driven by motor 500, through speed reducing gearing 501, so that the brush arm 502 makes six revolutions per minute. All this apparatus is mounted on a suitable base having a terminal block to which the apparatus is wired as shown.

In some of the circuit drawings battery and ground symbols are used for convenience and in order to simplify the drawings. It will be under-

stood, however, that these symbols indicate connections to the battery and ground bus bars, respectively, and are not intended to indicate separate batteries or ground connections. In Fig. 2, for instance, the various battery symbols indicate connections to battery bus bar 261, while the ground symbols indicate connections to ground bus bar 262. In Fig. 3 the battery and ground bus bars are denoted by reference characters 365 and 366, respectively, and in Fig. 5 by reference characters 528 and 529, respectively.

The several equipment items having been briefly described, their operation in a typical installation will now be explained. For this purpose the case of a watchman's service system will be considered. A system of this kind may be installed in a factory or other industrial establishment in which a night watchman is employed. The watchman is assigned a regular route which he is required to cover at predetermined intervals, usually every hour. As the watchman arrives at each station on his route he reports in to the central station where a record is made of the time at which the report is made and the station reported from. The record is made automatically. The apparatus for recording the reports is usually sealed or locked against access by the watchman and affords his employers a means of checking up on the faithfulness with which his duties are performed. Systems of this general character are disclosed in U. S. Patents 1,529,902 and 1,540,786.

The system about to be described requires that the establishment be equipped with a local telephone system or private branch exchange, which may be an automatic exchange of the general type disclosed in U. S. Patent No. 1,580,490. This telephone system serves its usual purpose during working hours, and at night or during the watchman's tour of duty it provides the requisite number of reporting stations. These stations are local telephones distributed around the premises, a number of which located at strategic points are selected for this purpose. It will be assumed that twenty telephones are thus assigned as watchman's stations. They may be numbered consecutively from 1 to 20. These station numbers have no necessary relation to the telephone numbers.

The special equipment required includes one multiple pen recorder, Fig. 1, two line relay sets, such as the one shown in Fig. 2, one time clock, Fig. 3, and one dater, Fig. 5. This equipment may be suitably installed in a cabinet which is preferably located at the same point as the automatic switchboard.

The recording system comprising the equipment units mentioned is connected with the telephone system by means of the line relay sets. Two of these sets are required as stated because there are twenty stations and each set has a capacity of ten stations. The twenty stations are divided into two groups, group No. 1 comprising stations 1 to 10 and group No. 2 comprising stations 11 to 20.

The stations of group No. 1 are connected to line relay set No. 1, while the stations of group No. 2 are connected to line relay set No. 2.

Referring to Fig. 2 of the drawings and to Patent No. 1,580,490, the first station is connected up to the first pair of relays, Fig. 2, of the first line relay set, by running a jumper between the line switch associated with the first station and terminal 221. This jumper is preferably connected at the line switch in such manner that it will be grounded when an outgoing call is made but will not be grounded on an incoming call.

By referring to the drawings in the patent it will be seen that this result can be secured by adding an extra pair of normally open contact springs to the cut-off relay 16. One of these springs is grounded and to the other is attached the jumper from the line relay set. On each outgoing call the cut-off relay 16 operates and by closing the extra set of contact springs will extend ground to terminal 221. On an incoming call, however, although ground is applied to conductor 35 by the connector, the cut-off relay 16 is operated only part way and the extra contact springs are so adjusted that this partial operation will not close them. The jumper can be connected directly to the test conductor at the line switch, and the extra pair of springs dispensed with, if, as is usually the case, the establishment is closed down while the watchman is on duty. With all the employees away, there will be no calls made except by the watchman.

Stations 2 to 10 of group No. 1 are connected up the same way as above described to terminals 222 to 230, respectively, Fig. 2, of the No. 1 line relay set. Stations 11 to 20 are connected up similarly to terminals 221—230, respectively, of the No. 2 line relay set.

While the connections described in the foregoing can conveniently be made with jumper wire, as stated, the work can also be done with cable if desired which will make a better and more permanent installation. In case cable is used the line relay end can be fanned out and connected up to the two terminal sets 221—230 in the usual way. The other end of the cable is preferably fanned out onto a special terminal block at the automatic switchboard. Conductors from the line switches can be permanently wired to a similar block. Short jumpers can then be run between the two blocks, thus connecting up any desired telephone lines as watchman's stations.

The connections between the equipment units will now be explained, it being understood that they can be made with jumper wire, or in any approved manner.

Referring to the multiple pen recorder, Fig. 1, terminal 190 is connected to a source of direct current which may be the battery used in the telephone exchange. This battery is usually of 46 volts potential and has its positive pole grounded. Although the relay contacts are not used in this particular instance they may be strapped as shown and terminal 189 may be connected to ground. Plug P1 is inserted in socket S, Fig. 2.

At the No. 1 line relay set, see Fig. 2, terminals 211—220 are connected, respectively, to terminals 111—120, Fig. 1. Terminals 231—240 are connected, respectively, to terminals 161—170, Fig. 1. Terminal 251 is connected to terminal No. 1 of the group 332 in Fig. 3. Also the following connections are made: terminal 250 to terminal 344, Fig. 3, terminal 254 to terminal 343, Fig. 3, terminal 255 to terminal 522, Fig. 5, terminal 256 to terminal 341, Fig. 3, terminal 257 to terminal 337, Fig. 3, and terminal 259 to terminal 345, Fig. 3. Ground is connected to terminal 253. Plug P2 is inserted in a convenient socket which is wired to the commercial A. C. supply.

At the No. 2 line relay set, terminals 211—220 are multipled with the same numbered terminals of the No. 1 set, that is, they are connected to terminals 111—120, Fig. 1. Terminals 231—240 are connected, respectively, to terminals 171—180, Fig. 1. Terminal 251 is connected to terminal No. 2 of the group 332, Fig. 3. These are the group marking terminals and provision is made

for five groups, as can be seen. In the present case, since there are only two groups of stations and only two line relay sets, only the No. 1 and No. 2 terminals in group 332 will be connected to. The remaining terminals 250, 253, etc., may be connected in multiple with the corresponding terminals of the No. 1 line relay set. Plug P2 and socket S of the No. 2 set need not be used.

At the time clock, Fig. 3, in addition to the connections already mentioned, the following connections are made: terminal 331 to 520, Fig. 5, terminal 332 to 523, Fig. 5, terminal 340 to battery, and terminal 339 to ground. Plugs P3 and P5 are inserted in the sockets connected to the commercial A. C. supply, while plug P4 is inserted in socket S2.

Since it will be assumed that at least one set of relays, Fig. 4, is provided to enable the watchman to hear time signals, terminal 445 is connected to terminal 345, Fig. 3, terminal 446 to terminal 346, Fig. 3, and terminal 447 to terminal 347, Fig. 3.

At the dater, Fig. 5, in addition to the connections already mentioned, terminal 527 is connected to terminal 186, Fig. 1, and terminals 524 and 525 are connected to battery and ground, respectively. Plug P6 is inserted in a commercial A. C. socket.

Before starting the explanation of the system as a whole, the operation of the register switches in the time clock and dater, Figs. 3 and 5, will be described. The way the registers are shown in the drawings, Fig. 3, the time is 2:22 a. m.

In Fig. 5, the registers are set for Jan. 4th. On the assumption that the year is 1934, the weeks register WR, Fig. 3, is set for Thursday, the fourth day of the week.

To facilitate setting the registers when the apparatus is installed and to reset them if their operation is stopped for some reason, permitting them to get behind, each register may be provided with a key such as is shown associated with the stepping magnet 310 of the units minutes register UMR. By means of these keys the register switches are stepped around until they are set for the correct date, day of the week, and for a time several minutes ahead of the correct time, the motor 300 being disconnected. The cam 309 is turned by hand until it is just past the point where it closes the associated contact springs, as shown in the drawings. Then when the time for which the registers are set arrives the plug P3 is inserted in a socket connected to A. C. current and the motor 300 starts.

After the lapse of one minute, the cam 309 closes its contacts momentarily, or rather permits them to close, and thus sends an impulse to the stepping magnet 310 of register UMR. Magnet 310 energizes responsive to the impulse and deenergizes when the impulse is over. Upon deenergizing, the wipers 320, 321 and 322 are advanced one step to the third contacts in their respective banks. The time for which the registers are now set is 2:23 a. m.

Impulses continue to be transmitted to magnet 310, one impulse at the end of each subsequent minute. When seven minutes have elapsed, seven impulses will have been received, and wiper 320 will be standing on its ninth contact. The impulse received at the expiration of the next or eighth minute will cause the wiper 320 to be advanced to the tenth contact, whereupon a circuit is closed for stepping magnet 311 of register TMR. Upon energizing, magnet 311 closes a circuit for stepping magnet 310. The latter

magnet therefore energizes and since it interrupts its own circuit in this instance it instantly deenergizes again, thereby advancing the wipers 320, 321 and 322 to the eleventh or 0 contacts in their banks. The movement of wiper 320 from the tenth contact to the 0 contact breaks the circuit of stepping magnet 311, which therefore deenergizes and advances wipers 323, 324, and 325 to the third contacts of their respective banks.

The next impulse received will advance wiper 320 to the first contact in its bank, and one more impulse will move it to the second contact where it stood to begin with. Thus in an interval of ten minutes the wipers of register UMR make one complete rotation. During this operation one impulse is sent to the stepping magnet 311 of register TMR, causing the wipers of this register to be advanced one step.

Continuing with the operation, after two more ten minute impulses have been received by stepping magnet 311, the wipers of register TMR will be standing on the fifth contacts in their banks, and one more impulse will advance them to the sixth contact. Wiper 323 now closes a circuit for stepping magnet 312 of register HR. Upon energizing magnet 312 closes a circuit for stepping magnet 311. Since it interrupts its own circuit, magnet 311 deenergizes and advances its wipers one more step. Contacts 6 to 10 in the bank of wiper 323 are strapped together, with the result that magnet 311 continues to operate and rapidly steps the wipers of register TMR past contacts 7 to 10 and onto the 0 contacts, where the operation ceases. Upon leaving contact 10 in its bank, wiper 323 breaks the circuit of magnet 312, which thereupon deenergizes and advances wiper 326—330 one step.

Upon receiving two more ten minute impulses, magnet 311 will advance the wipers of register TMR to the second contacts in their banks, the starting position. Thus in six ten minute periods, or in one hour, the wipers of register TMR make one complete rotation. During each rotation one impulse is sent to the stepping magnet 312 of the register HR.

The hours register HR having received one impulse as described, nine more impulses will cause its wipers to be advanced to the twelfth contacts in their banks, marking the beginning of p. m. time. At the expiration of twelve hours more it will be midnight, or 12:00 a. m. In this period twelve impulses will be received, the last impulse coming in just at 12:00 midnight. These impulses cause the magnet 312 to advance the wipers 326—330 one step per impulse, so that when the hour of 12:00 midnight arrives, wiper 327 will be advanced to the twenty-fourth contact in its bank. A circuit is thus closed for stepping magnet 312. Since magnet 312 breaks this circuit upon energizing, it immediately deenergizes again and advances the wipers 326—330 to the twenty-fifth contacts in their banks. Here the wipers remain for another hour, when they are advanced to the first contacts in their banks, and after another hour to the second contacts in their banks, which is the point from which the operation started. Thus in twenty-four hours the register HR makes one complete rotation.

The weeks register WR is advanced one step every day at 12:00, midnight. At this particular time of day wiper 326 of the register HR rests momentarily on the twenty-fourth contact in its bank, thus sending an impulse to the step-

ping magnet 399. Responsive to the impulse, magnet 399 energizes, and upon the cessation of the impulse, it deenergizes to advance the wiper of register WR. Since there are seven days in a week only seven contacts are required in the register bank. The last four bank contacts are therefore strapped and are wired to the interrupter contact of stepping magnet 399 to provide for automatically advancing the register wiper past these contacts.

The days register DR of the dater, Fig. 5, is also controlled by wiper 326 of the register HR. Contact 24 of wiper 326 is wired to terminal 331, and since this terminal is connected to terminal 520, Fig. 5, an impulse will be transmitted to the stepping magnet 506 every day at 12:00 midnight. Magnet 506 responds to such impulses and advances the wipers 513-515 one step per day. Throughout the 31st day of January, wiper 514 will be standing on the thirty-first contact in its bank. At midnight another impulse will be received by magnet 506, which will advance wiper 514 to the thirty-second contact in its bank. This operation closes a circuit for the stepping magnet 507 of the months register MR. Upon the energization of magnet 507, a circuit is completed for magnet 506 of register DR, the circuit including wiper 515. Magnet 506 accordingly energizes, interrupts its circuit, and advances wiper 513-515 one more step. Wiper 515 now finds direct ground on the thirty-third contact in its bank, so that magnet 506 is reoperated to advance the wipers 513-515 another step, bringing them to the first contacts in their respective banks. The circuit of stepping magnet 507 is broken when wiper 514 leaves the thirty-second contact in its bank, with the result that the magnet deenergizes and advances wipers 516-518 one step.

The registers DR and MR of the dater, Fig. 5, are now set for Feb. 1st. Magnet 506 of register DR continues to receive an impulse every day and eventually will advance the wipers 513-515 to the twenty-eighth contacts in their banks, this point being reached on Feb. 28th. The next day is March 1st, and therefore when the next impulse is received by magnet 506, marking the end of February, the wipers 513-515 must be advanced to the first contacts in their banks. This is taken care of by wipers 517 and 518 of register MR, both of which rest on grounded contacts during the month of February, and ground contacts 29 to 31 in the bank of wiper 515. As a result of this arrangement, when wiper 515 is advanced from contact 28 in its bank to contact 29 (at the end of February) the said wiper will pick up ground on contact 29, and also on contacts 30 and 31, and magnet 506 will automatically operate to advance the register wipers to the thirty-second contacts of their banks. From this point on the operation is the same as previously described for the month of January, that is, the months register MR is advanced one step and the days register is advanced to first position.

It will be noted that wiper 518 of register MR finds ground only in February, as this is the only month in the year which does not have at least thirty days. The only function of wiper 518 is to pass the days register through positions 29 and 30 at the end of February. Wiper 517 is provided in order to pass the wipers of the days register through position 31 at the end of each month which has only thirty days. These months are April, June, September and November, being respectively the fourth, sixth, ninth, and eleventh

months. Wiper 517 is therefore arranged to find ground on the corresponding contacts in its bank.

With the arrangement shown the registers will be maintained correctly set indefinitely, or until some part wears out, assuming there is no interruption in the supply of current to motor 300. The only exception to the foregoing is during leap year, when the month of February has twenty-nine days. This could be taken care of automatically but the event occurs so seldom that it is not worth while. When leap year comes around, anyone having this equipment will cut the strap connecting contacts 29 and 30 of the contact bank associated with wiper 515 of register DR at least as early as Feb. 28th, and will replace it on March 1st, or before the end of February the next year. A key or switch can be provided for opening this strap if desired.

The operation of the complete system will now be described. It will be assumed that between the hours of 8:00 a. m. and 6:00 p. m. the regular working organization is in charge of the premises. The period when the watchman service is in operation, therefore, will extend from 6:00 p. m. until 8:00 a. m. During the working hours, when the watchman's service is not used, the apparatus is all inactive, except for motor 300 which keeps on sending impulses to the register UMR to maintain the timeclock and dater at the correct setting. The non-response of the apparatus to telephone calls during working hours is due to the fact that battery is disconnected from the line relays, Fig. 2.

When the time 6:00 p. m. arrives, a circuit is completed over the wiper 397 of the register WR, and wipers 322, 325, and 330 of registers UMR, TMR, and HR, respectively, for the lower winding of relay 349, Fig. 3. Relay 349 energizes and locks itself energized. At the upper contacts of relay 349, battery is connected to the line relays by way of terminal 340, terminal 338, relay contacts, terminal 337, and terminal 257, Fig. 2, terminals 337 and 257 being connected together as previously mentioned. Thus battery potential is supplied to bus 261, Fig. 2. As has also been mentioned before, the corresponding terminals such as 257 in the two line relay sets are multipled together, so that bus 261 in the second set will have battery potential also. The two sets operate as one and hence it will not be necessary to further consider the sets individually, except as regards the group identification of a station, which will be pointed out at the proper time.

At one minute past 6:00 p. m., ground is placed on terminal 333, Fig. 3, by wipers 321, 324, and 329, of registers UMR, TMR, and HR, respectively. Since terminal 333 is connected to terminal 523, Fig. 5, an energizing circuit is thus closed for relay 508. Upon energizing, relay 508 locks itself, starts the motor 500, and also grounds terminal 522. The latter is connected to terminal 255, Fig. 2, and a circuit is therefore closed for relay 207, which energizes and starts the motor 26 of the multiple pen recorder, Fig. 1. It will be recalled that plug P1 has been inserted in socket S, so that motor 26 will start as stated.

The pen recorder is now in operation, the paper being advanced past the pens preferably at a rate of about 18 feet per minute. The distributor D2 of the dater, driven by motor 500, is also operating. The function of the distributor is to send impulses to the recorder in accordance with the setting of the date registers, so that the date may be recorded at the beginning of the graphic rec-

ord which is to be made of the watchman's activities during the period just starting. A part of this record is shown in Fig. 6.

The distributor D2 advances its two brush sets 503 and 504 through positions 1 to 5 without effect. In position 6, the outer brush set 504 closes a circuit for relay 512, and the circuit remains closed until the brush set leaves position 7. As a result a long impulse is sent to relay 512, which operates and grounds terminal 527. This terminal is connected to terminal 186, Fig. 1, so a circuit is completed for the No. 12 pen relay 82. The twelfth pen is therefore displaced to the left for a brief interval and marks the paper as shown at 601, Fig. 6. This mark is a position mark and is always made just prior to recording the month.

In position 8, the outer brush set 504 again closes a circuit for relay 512, this time only momentarily, and causes the relay to send an impulse to pen No. 12 by way of terminals 527 and 186. The twelfth pen is therefore again deflected to the left for an instant, marking the paper as indicated at 602. When the inner brush set 503 arrives at position 9 a circuit is completed for relay 510, which includes wiper 516 of register MR in first or January position, the corresponding contact in the distributor bank, brush set 503 in 9th position, and the winding of relay 510. Relay 510 instantly energizes, being a fast operating relay, and locks. In energized position, relay 510 opens the circuit of relay 512, so that no further impulses can be transmitted by the latter relay while the distributor is passing through positions 9 to 19, inclusive. It will be observed that brush set 503 is set slightly ahead of brush set 504, which operates relay 510 in time to prevent the circuit of relay 512 being closed in the 9th position.

When the inner brush set 503 arrives at position 20 a circuit is closed in an obvious manner for relay 511, which operates momentarily and unlocks relay 510, permitting the latter to fall back and again connect up relay 512. In positions 22 and 23, therefore, another long impulse is transmitted by relay 512 to pen relay 82, causing the No. 12 pen to mark the paper as shown at 603. This is another position-mark which is always made just preceding the recording of the tens digit of the day of the month, if there is a tens digit. In the present instance the registers are set for Jan. 4th and hence there is no tens digit. In positions 1 to 9 wiper 513 of register DR grounds the 0 contact in position 24 of the inner distributor brush set 503 and hence when the brush set reaches position 24 a circuit is again closed for relay 510. Relay 510 locks itself as before and opens the circuit of relay 512, thus preventing this relay from sending any impulses while the distributor is passing through positions 24, 25, and 26.

In position 28, the inner brush set again closes the circuit of relay 511 to unlock relay 510. This again renders relay 512 operative, and in positions 30 to 33 of the distributor relay 512 transmits four impulses to pen relay 82, causing the No. 12 pen to mark the paper as shown at 604. When the inner brush set reaches position 34 a circuit is again completed for relay 510, the circuit including wiper 514 of the register DR standing on its fourth contact. Relay 510 energizes, locks itself and opens the circuit of relay 512, preventing any further impulses being transmitted by the latter in positions 34 to 39 of the distributor.

In position 41, the inner brush set again closes

the circuit of relay 511 to cause it to unlock relay 510. Also the outer brush set 504 closes a circuit for relay 509, which locks itself to the now grounded terminal 523 over which relay 508 was energized to start the distributor. Relay 509 now disconnects relay 508 from terminal 523 and alters the locking circuit of the relay by replacing direct ground with the circuit from the distributor over which relay 509 is initially energized. Ground is removed from this circuit as the outer brush set leaves position 41 and hence relay 508 falls back at that time, stopping the motor 500 and leaving the distributor brush sets in position 42, or approximately in that position, as shown in the drawings. Relay 509 remains locked up until ground is removed from terminal 523, which occurs one minute after it was applied, due to the advance of wiper 321 of register UMR.

When relay 508 falls back it removes ground from terminal 522, thus breaking the circuit of relay 207, Fig. 2, and stopping the pen recorder, Fig. 1. It will be seen that while the pen recorder was running about three inches of paper was fed through and the No. 12 pen was controlled by the date to record the date. As stated hereinbefore, the pen recorder may be arranged to feed at the rate of about eighteen feet per minute and since the distributor makes one rotation in ten seconds the operation of recording a date will take about three inches of paper. The record shown in Fig. 6 is approximately accurate as regards the spacing of the marks. It is thought that the manner of transmitting and recording other dates will be clear from the example described. However, it may be stated that in positions 8 to 19 of the distributor D2, relay 512 sends from 1 to 12 impulses, corresponding to months January to December, under control of relay 510, which in turn is controlled by wiper 516 of register MR. In positions 24, 25, and 26, relay 512 sends from 1 to 3 impulses, or no impulses, as determined by the setting of the wiper 513 of register DR. In positions 30 to 39, relay 512 sends from 1 to 10 impulses, as determined by the setting of wiper 514 of register DR. Thus any date can be transmitted by sending three groups of impulses with the proper number of impulses in each group, which in any case are recorded by the No. 12 pen in the manner described. The date can be reoperated at intervals if desired, although it usually will be enough to operate it at the beginning of each watchman's period. If more frequent operation is wanted, say every hour that the watchman is on duty, terminal 333, Fig. 3, is connected to the proper additional contacts in the bank of wiper 329 instead of only one contact, as shown in the drawings. Since the watchman is generally required to make one round per hour the paper can be cut up into sections of one round each, and each section will be dated.

Continuing with the operation, the watchman starts his round at 6:00 p. m. or shortly afterward, and first visits station No. 1. The stations are visited in regular order from No. 1 to No. 20. Since the fragmentary record shown in Fig. 6 does not include the lines traced by the lower numbered pens, the operations which ensue when stations Nos. 1 to 7 are visited will be neglected, and the explanation will be started on the assumption that the watchman has arrived at station No. 8, which he probably will reach in about fifteen minutes or so. The first operation of the watchman, and the only operation he has to perform, is to remove the receiver from the tele-

phone. It may be replaced again immediately, or the watchman may dial the number assigned to time signalling if he desires to supervise the recording operation or obtain the time to check the rate at which he is progressing on his round. For the present, it will be assumed that the receiver is merely removed for a moment and then replaced.

The removal of the receiver operates the line switch in which the telephone line terminates at the branch exchange. See Patent No. 1,580,490. This operation extends ground potential to terminal 228, Fig. 2, closing a circuit for relay 203. Upon energizing, relay 203 locks itself at spring 272, and at spring 275 prepares a circuit for relay 204. Also at spring 273 ground is extended to terminal 259. Since terminal 259 is connected to terminal 345, Fig. 3, a circuit is thereby completed for distributor start relay 313, which energizes and locks in an obvious manner. In energized position relay 313 extends ground to the front contact of the armature of stepping magnet 310 of register UMR, so that in case an impulse is received by the magnet while the distributor is operating the magnet will be held up until the distributor returns to normal. This prevents any change in the setting of the registers during the operation of the distributor. The distributor is started by the energization of relay 313, as will be clear from the drawings, since plug P4 is now inserted in socket S2, as explained before.

When the outer brush set 306 reaches position No. 1, a circuit is completed for relay 318, which operates momentarily and grounds terminal 344, to close the pick up circuit for relay 204. This circuit includes terminals 344 and 250, which are connected, and a contact at 275 of relay 203 which was closed when relay 203 energized. Relay 204 accordingly energizes and locks itself over a circuit including springs 274 and 279, at the same time opening the pick-up circuit. Lamp L8, connected in parallel with relay 204 over terminals 238 and 168, is now lighted. At spring 277 relay 204 closes a circuit for relay 207, which relay pulls up and starts the pen recorder, Fig. 1. At springs 280, relay 204 closes a circuit for pen relay 78 which extends from ground at the upper contact of relay 317, Fig. 3, by way of terminal 341, terminal 256, spring 280, spring 271, terminal 218, terminal 118, and winding of pen relay 78 to battery at terminal 190. Pen relay 78 is accordingly energized and the No. 8 pen, assigned to stations Nos. 8 and 18, begins to draw an off-set line on the paper as the latter moves along. Relay 204 also alters the locking circuit of relay 203, substituting ground by way of the lower contact of relay 319, Fig. 3, terminal 343, terminal 254, and spring 276, for direct ground. Finally, relay 204 applies ground by way of spring 278 to terminal 251. This terminal is connected to the No. 1 terminal in group 332, Fig. 3.

When the outer brush set 306 of the distributor reaches position 2, a circuit is closed for relay 317. Due to the shape of the contacts in the outer row at this point the impulse received by relay 317 is a comparatively long one. Relay 317 responds to this impulse and at its upper contact spring removes ground from terminal 341, thus breaking the circuit of pen relay 78, and restoring the pen to normal for a short interval. This operation marks the paper as shown at 610, Fig. 6.

When the inner brush set 305 arrives at position No. 3, it finds the No. 1 group contact grounded, due to ground having been applied by way of

the No. 1 terminal of group 332, as previously mentioned, and closes a circuit for relay 316. This relay pulls up and locks and also opens the circuit of relay 317, thus preventing the latter relay from responding while the other brush set is passing through positions 3 to 6. Positions 2 to 6, it may be stated, are the group marking positions. It will be noted that a single U-shaped mark has been made at 610 by the No. 8 pen, indicating that station No. 8 is reporting. Explaining this further, the single mark indicates group No. 1, and since the mark is made by pen No. 8, this identifies the reporting station as the eighth station in group No. 1, which is station No. 8. The eighth station in group No. 2 is station No. 18, etc.

When the inner brush set 305 reaches position No. 7, it completes a circuit for relay 315, which energizes momentarily and unlocks relay 316. The latter relay on falling back places relay 317 in condition to respond in position 8 and subsequent positions assigned to the sending of the hours impulses. It follows, therefore, that while the outer brush set 306 is passing through positions 8 to 13 relay 317 will respond six times and will break the circuit of pen relay 78 six times, causing the No. 8 pen to mark the paper as shown at 611. Further response of relay 317 in positions 14 to 19 is prevented by the operation of relay 316 the circuit of which is closed by inner brush set 305 when it reaches position 14. The closure of the circuit of relay 316 at this point is due to the setting of wiper 326 of register HR, which stands on its eighteenth contact, corresponding to the hour of 6:00 p. m.

When the inner brush set reaches the twentieth position, relay 315 is energized again momentarily to unlock relay 316. This prepares a circuit for relay 317 as before.

It will be assumed now that the exact time is 6:16 p. m. It follows that wiper 323 of register TMR will be standing on contact 1 and wiper 320 of register UMR will be standing on contact 6. In position 22 of the outer brush set, relay 317 is operated once, thereby controlling the No. 8 pen to mark the paper as shown at 612. Relay 317 does not respond in positions 23 to 26 due to the energization of relay 316 in position 23, under control of wiper 323 of register TMR.

In position 27 relay 315 energizes again momentarily to unlock relay 316.

As the outer brush set passes through positions 29 to 34, relay 317 is operated six times, and controls the No. 8 pen to mark the paper as shown at 613. In position 35 of the inner brush set relay 316 is operated, due to the setting of wiper 320 of register UMR, and opens the circuit of relay 317. Relay 316 locks itself and holds this circuit open until the relay is unlocked in position 38 by the momentary energization of relay 315.

In position 40 of the outer brush set a long impulse is transmitted to relay 317, due to the fact that wiper 327 of register HR is standing on a contact in the p. m. section of its bank. Relay 317 accordingly controls the No. 8 pen to mark the paper as shown at 614.

In position 41, of the inner brush set relay 315 again operates, but without effect. In position 41 of the outer brush set a circuit is completed for relay 319. Upon energizing, relay 319 opens the initial energizing circuit of relay 313, and also alters the locking circuit of this relay, substituting ground from the distributor in position 41 for direct ground. As the distributor leaves position 41, therefore, relay 313 falls back. The

distributor then comes to rest with its brush sets approximately in position 42 as shown in the drawings. Relay 319 also has its circuit broken as the distributor leaves position 41, but is slow to release and holds the circuits of relay 313 open long enough to insure that this relay will fall back.

The energization of relay 319 also removes ground from terminal 343. This breaks the locking circuit of relay 203, Fig. 2, and relay 203 accordingly deenergizes, thereby removing ground from terminal 259. The latter terminal is connected to terminal 345, Fig. 3. Relay 319 is slow to release, as stated before, and holds the initial energizing circuit of relay 313 open until after ground is removed from terminals 259 and 345.

As a further result of the falling back of relay 203, ground is removed from the locking circuit of relay 204 at 274 and the incoming circuit from the line switch, connected to terminal 228, is substituted therefor. Whether relay 204 falls back now or not depends on whether or not the receiver has been replaced at station No. 8. Assuming that the receiver has been replaced, terminal 228 will not be grounded and relay 204 will fall back. This breaks the circuit of relay 207, which falls back and stops the pen recorder. It will be observed also that the deenergization of relay 203 breaks the circuit of pen relay 78 under these conditions, permitting the No. 8 pen to restore.

Assuming now that the receiver is still off at station No. 8 when relay 203 falls back, relay 204 is held up over the grounded terminal 228. Lamp L8 accordingly remains lighted. Also, although relay 203 is deenergized, the circuit of the pen relay 78 is now closed to ground at terminal 228, in parallel with relay 204. Relay 204 and pen relay 78 are thus held up as long as terminal 228 remains grounded, or as long as the receiver remains off at station No. 8. Since the pen recorder keeps on running until relay 204 falls back the No. 8 pen will continue to draw an off set line, making a record of the length of time the receiver remains off, if longer than the period required to record the time of day.

It will be seen from the foregoing that the act of the watchman in momentarily removing the receiver at station No. 8 initiates a series of operations which result in recording the report and the time at which it is made, as shown in connection with the line drawn by the No. 8 pen in Fig. 6. The record made includes a group marking which in conjunction with the pen by which the mark is made identifies the reporting station. The group marking is followed by other markings indicating the hour, the tens of minutes, and the units of minutes, and finally by a marking indicating p. m. time. The sample record in Fig. 6 shows that the report was made from station No. 8 at 6:16 p. m.

At 12:00 midnight the wiper 327 of the register HR will advance on to a contact in the a. m. section of its bank, leaving the contacts in the p. m. section ungrounded. As a result, whenever a report is made under these conditions, and the distributor D1 is operated to record the time, the outer brush set 306 will close no circuit for relay 317 in position 40 and the pen recorder will make no indication corresponding to 614, Fig. 6. The presence of the mark 614 therefore indicates p. m. time and its absence indicates a. m. time.

It is thought that the operation of the system will be sufficiently understood from the foregoing

without repeating the explanation in connection with the other stations. It will be clear that each time the watchman visits a station and removes the receiver to report, the apparatus will operate to make a record identifying the station and indicating the time the report was made.

The lamps L1—L20 are not strictly necessary and may be furnished or not as the customer desires. In the event that an attendant is stationed at the office where the equipment is located, as is often the case, these lamps afford him a convenient means of supervising the watchman as he proceeds from station to station on his route. The lamps are visible from some distance and can be observed by the attendant from time to time while engaged in some other task which would make it inconvenient to watch the pen recorder.

When the time of 8:00 a. m. arrives, which marks the end of the watchman's tour of duty on Friday morning, the wipers 322, 325, and 330, of registers UMR, TMR, and HR, respectively, will close a circuit for the upper winding of relay 349, by way of wiper 398 of register WR. Both windings of this relay now carry current, and since the relay is differentially wound, i. e., with opposing windings, it is at once deenergized. Upon the relay falling back, the circuits of the upper and lower windings are broken and the relay remains back. Thus battery is disconnected from terminal 337, and from terminal 257 connected thereto, so that during the ensuing hours the normal operation of the telephone system by the working force will not cause any records to be made by the pen recorder.

On Friday at 6:00 p. m., when wiper 397 of register WR will be standing on its fifth contact, relay 349 will be energized as usual, and it will be deenergized on Saturday morning at 8:00 a. m., wiper 398 then standing on the sixth contact. At 1:00 p. m. on Saturday, when wiper 397 will be on its sixth contact, relay 349 will again be energized. This arrangement is based on the assumption that Saturday afternoon is a half-holiday. The next morning, Sunday morning, when the hour of 8:00 a. m. arrives, the relay 349 will not be deenergized due to the fact that wiper 398 is now on its seventh contact, which contact is not connected up to the circuit from the bank of wiper 330 of register HR. Relay 347 will remain energized all day Sunday therefore. At 12:00 midnight on Sunday, wiper 397 will advance to its eighth contact, closing a self interrupted circuit for stepping magnet 399, which will automatically advance wipers 397 and 398 to the first contacts in their banks. Then on Monday morning, with wiper 398 on its first contact, relay 349 will be deenergized at 8:00 a. m.

The arrangement described enables relay 349 to be energized at any desired hour of the day and also enables the relay to be deenergized at any desired hour. The time of energization and deenergization is varied by hours by changing the connections to the bank of wiper 330 of register HR. To vary the time by smaller periods changes can be made in the connections at the banks of wipers 325 or 322 of registers TMR and UMR. Of course with the arrangement shown any change made at the bank of wiper 325, for instance, will affect both the time of energization and also the time of deenergization. If this will not meet the requirements, a separate chain circuit can be provided for the upper winding of relay 349 by adding

an extra wiper to each of registers UMR, TMR, and HR.

The time of energization and deenergization of relay 349 is varied for different days of the week by changing the connections of the banks of wipers 397 and 398 of register WR. It will be noted that wiper 397, whose primary function is to operate relay 349, is also used to pass the wipers of register WR over contacts 8 to 11 at 12:00 midnight on Sunday. This saves a wiper, and the expedient can be used because at this particular time of day relay 349 is energized. If some different timing is used, which causes relay 349 to be in deenergized condition at 12:00 midnight on Sunday, then wiper 398 can be used by connecting the interrupter contact of magnet 399 to the bank of wiper 398 instead of to the bank of wiper 397.

The fact has been mentioned that the system may be arranged so that the watchman can obtain time signals at any station, and the way in which the relays, Fig. 4, which are provided for this purpose, are connected up to the rest of the apparatus has been described. The contacts 450, 451, and 452 are connector bank contacts in one of the connector switches of the branch exchange, it being understood that there are other multiple connected contacts in the banks of the other connectors. Contact 451 is the test contact of the set, while contacts 450 and 452 are the negative and positive line contacts, respectively. In this connection, reference may be made to Patent No. 1,580,490.

It will be assumed now that when the watchman reports from station No. 8, he desires to ascertain the time. The correct time is obtained by dialling the number assigned for this purpose and listening in the receiver for the time signals. Since the signals are generated under control of the distributor D1 and the various time registers, which control the pen recorder, the provision of the time signalling feature in a watchman's system is useful not only to enable the watchman to obtain the time but also to enable him to check up on the operation of the recording equipment and assure himself that it is in working order.

Responsive to the dialling of the digits in the time signalling number, a connector switch is operated to move its wipers onto terminals 450, 451, and 452, Fig. 4. As described previously, the removal of the receiver operates the line relay equipment, Fig. 2, which is associated with station No. 8, with the result that the distributor D1 is started up to control the pen recorder. The distributor brushes, therefore, will ordinarily be part way around at the time that the connector completes its operation responsive to the dialling of the number. When the test wiper engages contact 451, a circuit is closed for relay 453, which engages and places ground on terminals 445 and 345, connected together as previously mentioned. Terminal 345, however, has already been grounded by way of terminal 259, Fig. 2. The connector switch remains in ringing position for the time being because the upper winding of buzzer relay 454 is of relatively high resistance, too high to operate the ring cut-off relay in the connector.

Very shortly the distributor D1 completes its operation and stops in position 42, as previously described, due to the energization of relay 319 in position 41. When this relay falls back, although ground has been removed from terminal 259, Fig. 2, terminal 345 still remains grounded by way of terminal 445, Fig. 4. Relay 313 accordingly energizes again and restarts the distributor. During the second rotation of the dis-

tributor brushes the condition of affairs at the line relay set, Fig. 2, is that relay 203 is back while relay 204 is energized. The pen recorder remains in operation to record the length of time the receiver remains off, but no additional time registration is made because the pen relay 78 is energized in parallel with relay 204 and not over the circuit which includes terminals 256 and 341, which circuit is interrupted by relay 317, Fig. 3, during the operation of the distributor.

In position 1 of brush set 306 a circuit is closed for relay 318. Upon energizing, relay 318 applies ground to terminal 346. This grounds the negative side of the line from the connector switch by way of terminal 446, and operates the ring cut-off relay of the connector. The ring cut-off relay locks itself and places the circuits of the connector in talking condition. The back bridge relay of the connector is not operated due to resistance 390, which is high enough to prevent the back bridge relay from pulling up, although the ring cut-off relay can operate over the circuit including this resistance.

The first signal transmitted is the group signal. In position 2 of brush set 306, a circuit is completed for relay 317. This relay energizes as previously described and applies ground to terminal 347, connected to terminal 447. Thus a circuit is completed for buzzer relay 454, which rapidly vibrates its armature so long as its circuit remains completed at relay 317. The rapid make and break of the circuit through the lower winding of relay 454 causes a tone current to be inducted in the upper winding of the relay. Since the upper winding is bridged across the talking circuit of the connector switch, the current is transmitted over the line and produces an audible signal in the receiver at station No. 8, where the watchman is listening.

The signals indicating the time of day are transmitted in a manner similar to the foregoing, the relays operating the same as has been previously described in connection with recording the time on the pen recorder. It will be noted that each time relay 317 opens the pen relay circuit including terminal 341, it also applies ground to terminal 347 to operate the buzzer relay 454. Thus in positions 8—13 of the distributor, six tone signals will be transmitted, in position 22 one tone signal will be transmitted, and in positions 29—34 six tone signals will be transmitted. Also in position 40 the p. m. signal, which is a long tone like the group signals, will be transmitted. The audible signals received by the watchman therefore duplicate the signals recorded on the pen recorder, unless there has been a change of time, which would make the audible signals one minute late; and not only enable the watchman to ascertain the time if necessary but also give him some assurance that the apparatus is functioning properly.

Relay 350 is a special relay which is provided in order to give a long tone signal indicating zero in case either the register TMR or UMR is standing in the 0 position. To explain this, it will be assumed that the time is exactly 6:00 p. m. When the distributor D1 operates to transmit the time signal, it causes relay 317 to operate as described in sending the group signal and the hours signals. Since register TMR is in position 0, however, when the inner brush set reaches position 21, a circuit is closed for relay 350 which pulls up and locks. Relay 350 applies ground to terminal 347 and therefore causes the

continued operation of buzzer relay 454 while the distributor brushes are passing through positions 22—26. In position 27, relay 315 is operated, unlocking relay 350. This relay energizes again in position 28, due to the setting of register UMR in position 0, and remains locked up through positions 29—37 producing another sustained operation of buzzer relay 454. Relay 315 is again operated in position 38 to unlock relay 350. Thus it will be understood that the time 6:00 is transmitted by sending six tone signals to give the hours followed by two long sustained signals to indicate zero minutes and tens of minutes. It will also be understood of course, that the long sustained signal is produced in either position separately as demanded by the time being transmitted. For instance, at 6:05 the time signals would consist of six short tone signals, followed by a long sustained signal, and then by five short signals.

The equipment shown in Fig. 3 can be used in an automatic telephone system to give regular time service to the subscribers. When installed for this purpose, the various connections to the equipments shown in the other drawings will be omitted, since these equipments are not furnished. An exception to the foregoing is the equipment shown in Fig. 4, which is essential. These circuits are installed in sufficient number to provide for the maximum number of simultaneous calls, and may be made accessible to the subscribers through so-called rotary connectors as is well known. These rotary connectors are similar to the connectors shown in Patent No. 1,580,490, except that provision is made for a hunting movement which makes it possible to assign the same number to all the circuits such as Fig. 4 and have any connector operated in accordance with such number establish connection with an idle circuit. The terminals 445, 446, and 447 of all the circuits are multiplied together and connected to terminals of Fig. 3, as previously described. Also terminals 335 and 336 are connected together.

When a subscriber makes a call for the purpose of ascertaining the time of day, the connector switch in use will establish connection with a set of bank contacts such as 450, 451, and 452, belonging to an idle circuit such as Fig. 4. Relay 453, accordingly, operates and grounds terminal 345 to start the distributor Fig. 3, assuming that it is not already running. It will be noted that the distributor will operate continuously, except for momentary stops in position 42, as long as any relay such as 453 is energized. When the distributor reaches position 1, relay 318 is operated. This grounds terminal 346 to cut off the ring at the connector in use or any other connectors which may be waiting. Also in position 1, the inner brush set 305 closes a circuit for relay 314, terminals 335 and 336 now being connected together. Relay 314 pulls up and locks and at the same time it opens the circuit over which relay 317 sends impulses to the buzzer relays such as 454 via terminal 347. Relay 317 is thus prevented from sending out any group impulses in positions 2—6 of the distributor. Relay 314 is unlocked in position 7 by the operation of relay 315. In positions 8—37, the time signals are transmitted as previously described. In position 39, relay 314 is again energized and held up until unlocked by relay 315 in position 41, so as to prevent relay 317 from sending a p. m. signal. The group and p. m. signals are omitted because the former would obviously have no significance while the subscriber

usually would know whether the time is a. m. or p. m. However, if it is desired to omit only the group signal, this can be done by permanently grounding the No. 0 terminal in group 332, which will operate relay 316 before any group impulses can be sent out by relay 317. Terminals 335 and 336 are not connected, so relay 314 does not function to cancel the p. m. signal.

In a situation where the number of watchman's stations does not exceed the number of recording pens a somewhat simpler and more economical arrangement than the one just described may be employed. A modified system of this character will now be described.

The equipment required is one multiple pen recorder, Fig. 1, one relay circuit, Fig. 2A, a time clock and distributor Fig. 3, and a dater, Fig. 5. The manner in which this apparatus is connected up for service in a typical installation will first be explained.

As in the system previously described, it will be assumed that the premises where the watchman's system is installed have a branch exchange telephone system in service, and that certain selected telephones are assigned as watchman's stations. The line switches in which these telephone lines terminate are equipped with extra pairs of contact springs as previously described. There may be ten watchman's stations and therefore there will be ten conductors coming from the respective line switches of these stations, each conductor being grounded when the associated line switch is used on an outgoing call. These ten conductors are connected, respectively, to terminals 111—120 of the multiple pen recorder, Fig. 1, that is, directly to the pen relays 71—80.

As regards the remainder of the connections at the pen recorder, Fig. 1, terminals 101—110, and 185 are connected to battery terminal 190, and the latter is connected to terminal 337, Fig. 3. Terminals 131—140 are connected to ground terminal 189. Terminals 141—150 are respectively connected to terminals 161—170. Terminals 151—160 are connected together and terminal 151, instead of being connected to terminal 190 as shown, is connected to terminal 283, Fig. 2A. Ground is connected to terminal 189, and plug P1 is inserted in socket Sa, Fig. 2A.

Referring now to Fig. 2A, plug P2a is inserted in a socket wired to commercial A. C. supply, and terminals 288 and 289 are connected to ground and battery, respectively. Terminal 281 is connected to terminal 182, Fig. 1. Terminals 282, 284, 285, and 286 are connected, respectively, to terminals 344, 345, 343, and 341, Fig. 3. Terminal 287 is connected to terminal 522, Fig. 5.

At Fig. 3, in addition to the connections already mentioned, terminal 331 is connected to terminal 520, Fig. 5, and terminal 333 is connected to terminal 523. Terminals 339 and 340 are connected to ground and battery, respectively; also terminal 338 is connected to battery. Terminal 0 of the group 332 is connected to ground. Plugs P3 and P5 are inserted in commercial A. C. sockets, and plug P4 is inserted in socket S2.

At the dater, Fig. 5, the following connections are made, in addition to those already mentioned. Terminal 527 is connected to terminal 186, Fig. 1, and terminals 524 and 525 are connected to battery and ground, respectively. Plug P6 is inserted in a commercial A. C. socket.

It will be assumed that the various registers in Figs. 3 and 5 are properly set in accordance with the date and the time of day. The apparatus is started functioning by the operation of relay 349,

Fig. 3, which, pulls up at 6:00 p. m. as previously explained, or at any other desired time; locks itself in energized position, and connects battery to terminal 337. The latter being connected to terminal 190, Fig. 1, battery is supplied to the pen relays of the pen recorder.

The dater is next set in operation by the application of ground to terminal 333, which is connected to terminal 523, Fig. 5. The operation of the dater has been explained and it will not be necessary to go over the details again. Relay 508 pulls up and starts the distributor D2 and also applies ground to terminal 522 to start the pen recorder, which is accomplished by energizing relay 299 over terminals 522 and 287.

The distributor D2 makes one revolution and then stops automatically. During its operation it sends three sets of impulses to relay 512, which are repeated to pen relay 82, Fig. 1. The No. 12 pen associated with pen relay 82 is accordingly controlled to mark the paper as indicated at 700, Fig. 7. The date recorded is March 26th. When relay 508 falls back to stop the distributor D2 it removes ground from terminal 522, which stops the pen recorder.

The watchman proceeds on his first round and visits the stations in regular order, beginning at station No. 1. In order to explain the process of recording a report it will be assumed that the watchman has arrived at station No. 10. Upon the removal of the receiver, the line switch in which the telephone line terminates operates in the usual manner and places ground on terminal 120, Fig. 1. Pen relay 80 accordingly operates and the No. 10 pen moves to the left, as indicated at 701, Fig. 7. Pen relay 80 also closes its spring contacts and thus completes a circuit extending from ground via terminals 189 and 140, springs of pen relay 80, terminals 150 and 170, lamp L10, terminals 160 and 283, Fig. 2A, and winding of relay 296 to battery. Lamp L10 lights up and relay 296 operates, closing circuits for relays 297 and 299 in parallel. Relay 299 operates and starts the pen recorder. Since the No. 10 pen is in deflected position, due to the energization of pen relay 80, it begins to trace an offset line 702. Relay 297, upon energizing, locks itself to ground in an obvious manner, and also, at spring 291, it grounds the circuit of relay 299 to maintain it energized. Also at spring 292 relay 297 prepares a circuit for relay 298 and at spring 290 it grounds terminal 284.

By the application of ground to terminal 284 a circuit is completed for start relay 313, Fig. 3, by way of terminals 284 and 345. Relay 313 functions as previously explained, and starts the distributor D1. In position 1 of the outer brush set 306, a circuit is closed for relay 318, which energizes and grounds terminal 344. This closes a circuit for relay 298, Fig. 2A, via terminals 344 and 282. Upon energizing, relay 298 locks itself at spring 293, and at spring 294 it causes relay 297 to be locked to grounded terminal 285 instead of to direct ground. Also since relay 297 is energized, relay 298 at its upper contact springs closes a circuit for pen relay 81, Fig. 1. This circuit extends from ground by way of terminals 341 and 286, springs of relays 298 and 297, terminals 281 and 182, and winding of pen relay 81 to battery. The No. 11 pen is therefore deflected to the left and begins to mark an offset line as indicated at 704, Fig. 7.

In positions 2—6 of the distributor D1, no impulses are transmitted to relay 317, due to the

fact that the terminal 0 in group 332 has been grounded. Since there is only one group of stations, with an individual pen per station, the group marking is not used.

It will be assumed that the time is 6:24 p. m. In positions 8—13, therefore, the distributor D1 sends six impulses to relay 317, which interrupts the circuit of the pen relay 81 six times, causing the No. 11 pen to mark the paper as indicated at 705. The impulsing is stopped by relay 316 under control of register HR in position 14 of the distributor. In positions 22 and 23, two impulses are transmitted to relay 317, and in positions 29—32, four impulses. Responsive to these two groups of impulses relay 317 controls the No. 11 pen to mark the paper as indicated at 706 and 707. Finally, in position 40, relay 317 is operated once to cause the No. 11 pen to mark the paper as indicated at 708. Thus the correct time is recorded as 6:24 p. m.

In position 41 of the distributor a circuit is closed for relay 319. Upon energizing, relay 319 unlocks start relay 313, which falls back as the distributor leaves position 41 and permits it to stop in position 42. Relay 319 also removes ground from terminal 343, thus breaking the circuit of relay 297, Fig. 2A. Relay 297 accordingly de-energizes, and removes ground from terminal 284. Assuming now that the watchman has replaced the receiver already, as indicated at 703, the pen relay 80 and relay 296 will be deenergized, and when relay 297 falls back no holding circuit will be established for relay 298. This relay therefore falls back also. When relay 297 falls back the circuit of the pen relay 81 is broken, causing the No. 11 pen to restore, and also the circuit of relay 299 is broken, since relay 296 is back. Relay 299 therefore falls back and stops the pen recorder.

If the watchman should delay replacing the receiver until after the time is recorded, the pen relay 80 and relay 296 will still be energized when relay 297 falls back. Relay 298 therefore remains locked up to ground at relay 296, and relay 299 also remains energized. The pen recorder is thus kept going to record the length of time that elapses before the receiver is replaced. The end of this interval will be marked on the paper by the restoration of the No. 10 pen upon the release of pen relay 80 when the receiver is hung up. When relay 80 finally falls back it breaks the circuit of relay 296, which in turn breaks the circuits of relays 298 and 299, the latter relay stopping the pen recorder when it falls back.

It will be seen that in the system just described, there is a recording pen individual to each station and during the time that the receiver is off at any station the associated pen marks the paper with a continuous offset line. The time at which the reports are made is marked by the No. 11 pen, which is common to all the stations. The No. 11 pen will therefore mark a series of time reports one after the other and the station concerned with any time report can always be ascertained by noting which pen was drawing an offset line when the report was made. Thus it is obvious that the time report 704—708, Fig. 7, was made responsive to removal of the receiver at station No. 10.

The watchman's system is cut out of service at the proper time by the deenergization of relay 349, as previously described.

As stated previously herein, the equipment provided by this invention is capable of being connected up in various ways aside from those specifically described, in order to make a given re-

recording system meet different requirements, or to build different types of recording systems adapted for different purposes. From what has been said already a large number of the changes and modifications that are possible will be apparent; at any rate it would unduly extend the specification to describe them all in detail. However, it may be advisable to consider briefly one other type of recording system that has been mentioned, a system adapted to record the operation of circuit breakers in a power distribution system.

In a power system, circuit breakers are employed at various points to isolate specific parts of the system in case of trouble. These breakers may be of the type which automatically restore after a time interval or they may have to be restored by hand. In any event it is very desirable to have means for making a record of the time each circuit breaker goes out and the length of time it remains out. According to the present invention a system can be provided which makes such a record in graphic form without any attention or trouble on the part of the operating force, who are therefore left free to concentrate on their ordinary duties.

The apparatus required is a multiple pen recorder, Fig. 1, several line relay sets, Fig. 2, depending on the number of circuit breakers, a time clock, Fig. 3, and a dater, Fig. 5. This apparatus is connected up the same as in the watchman's system first described, except for slight changes which will be pointed out.

The circuit breakers are divided into groups and are numbered consecutively as described in connection with the watchman's stations. To each group is assigned one of the line relay sets, Fig. 2. Each circuit breaker is usually provided with contacts for grounding an alarm circuit when the breaker goes out. These contacts are used to ground individual conductors extending from the circuit breakers to the line relay sets, where they are connected to terminals such as 221—230, Fig. 2. If the circuit breakers are not already provided with contacts as described, a suitable pair of contacts is added to each breaker.

Since the system will have to be in condition to function all the time, battery is connected to terminal 257, and relay 349, Fig. 3, is not used, or at least not for the purpose of cutting the system in and out of operation. Then whenever a circuit breaker goes out, ground is extended to the corresponding terminal such as 221, Fig. 2, and the associated relay such as 201 will pull up. The distributor D1, Fig. 3, is then started and the other relay of the pair, such as relay 202, will pull up. This starts the pen recorder and closes the pen circuit. The proper pen is then controlled in the manner already described to record the group and the time of day.

The operation of the dater is taken care of by connecting terminal 523 to terminal 346, Fig. 3, instead of to terminal 333. With this hook-up, when distributor D1 reaches position 1 and pulls up relay 318, the relay extends ground to relay 508 of the dater by way of terminals 346 and 523. Thus the dater will control the No. 12 pen and record the date concurrently with the recording of the time.

It is well known that in the ordinary operation of an electrical distribution system there will be a good many days when no circuit breaker goes out. An excellent alternative arrangement for the dater therefore, is to connect terminal 523 to terminal 333, Fig. 3, and arrange the chain in-

cluding wiper 329 so that terminal 333 will be grounded say at 12:00 midnight. This will operate the dater every day, which will prevent the accumulation of dust on the contacts and keep it in good working condition. Other schemes for operating the dater can be worked out, as any circuit connection which will apply ground to terminal 523 will operate it. For instance, terminal 523 can be connected to terminals 333 and 346, which will operate the dater every day and also whenever a breaker goes out.

Various arrangements can also be employed for exercising the time clock equipment, Fig. 2. For instance, the chain including wipers 322, 325, and 330 can be used to ground a terminal such as 221 of a vacant pair of line relays, i. e., a pair not assigned to any circuit breaker. With this hook-up, when the chain is closed by the register wipers the time clock equipment will be operated the same as if a circuit breaker had gone out. On inspecting the record, however, the fact will be evident that the record was not produced by an actual circuit breaker operation, because the record will identify the particular pair of relays by which the production of the record was initiated.

It will be clear now that the system described can be used to record events or changes in condition in connection with any machines or devices as well as circuit breakers, so long as such machines or devices are or can be arranged to extend the necessary ground potentials to terminals such as 221—230. If battery potentials instead of ground potentials are available the condition can be taken care of by inserting the necessary translating relays or by reversing the battery and ground connections at the recording equipment. It will be understood also that the second described modification, which employs the No. 11 pen to make all time records, is suitable for use in connection with circuit breakers or other machines or devices. This type of system can readily be expanded to take care of any number of circuit breakers, or other devices, by providing a plurality of pen recorders, so that an individual pen will be available for each circuit breaker.

Having described the invention, what is considered to be new and is desired to be protected by Letters Patent will be set forth in the following claims.

What is claimed is:

1. In a recording system, a pen recorder, time registers, means responsive to the occurrence of an event to be recorded for starting said pen recorder, means controlled by said registers for transmitting impulses to the pen recorder, and means in said pen recorder responsive to such impulses for recording the time the event occurs.

2. In a recording system, a multiple pen recorder, time registers, a plurality of circuits over which signals may be received indicative of a change in condition in any of a plurality of devices, means for associating each circuit with a particular pen of said recorder, means responsive to the receipt of a signal for starting the pen recorder and for rendering operative the pen associated with the circuit over which the signal is received, and means controlled by said time registers for causing the operative pen to make a graphic record indicative of the time the signal is received.

3. In a recording system, a pen recorder com-

prising a plurality of pens, a relay controlling each pen, time registers, circuit controlling means controlled by said time registers, and means for selectively associating said means with any one of said pen relays.

4. In a recording system, a multiple pen recorder, a plurality of relays for controlling the pens of said recorder, respectively, time registers, a pen control circuit, a distributor cooperating with said registers to control said pen control circuit, and means responsive to the occurrence of an event to be recorded for starting said distributor and said pen recorder and for selectively associating said pen control circuit with one of said pen relays.

5. In a recording system, a pen recorder including a marking pen and a magnet for displacing it to change the position of the line drawn by the pen, means responsive to the occurrence of a condition to be recorded for closing a circuit for said magnet and for maintaining it closed while the condition endures, time registers, and means controlled by said time registers for producing interruptions in the magnet circuit to cause the pen to make a record of the time.

6. In a recording system, a plurality of groups of devices, a multiple pen recorder having pens each of which is common to devices in different groups, means responsive to the operation of any device for causing the corresponding pen to record the operation, and means for controlling said pen to make a record indicative of the group to which the operated device belongs.

7. In a recording system, a pen recorder, time registers, means including said registers for causing said recorder to make a record indicative of the time a certain condition begins, and means including a set of relays for preventing repeated recording of the time responsive to said condition if the condition continues beyond the time required to make said record.

8. In a recording system, a multiple pen recorder, a plurality of magnets for operating the pens, respectively, a plurality of circuits for controlling a plurality of said magnets, respectively, a time circuit leading to another of said magnets, time registers, and means responsive to the closure of any one of said plurality of circuits for causing time signals to be transmitted over said time circuit under control of said registers.

9. In a recording system for recording the occurrence of events in connection with a plurality of devices, a pen recorder including a pen individual to each device, means responsive to the occurrence of the event at any device for causing the associated pen to record it, another pen included in said pen recorder, time registers, and means responsive whenever one of said individual pens records an event for causing said other pen to record the time the event occurred under control of said time registers.

10. In combination, a recording system for use only during a certain period of the day, time registers, and means controlled by said time registers for cutting the recording system in and out of service at predetermined times of the day.

11. In combination, a recording system for use only during a certain period of the day, the period varying with the different days of the week, time registers, means controlled by said time registers for cutting the recording system in and out of service at predetermined times, and a weeks register cooperating with said time registers on a certain day of the week to change the time at

which the recording system is cut in or out of service.

12. In a recording system, a pen recorder, a dater comprising a months register and a days register, and a distributor cooperating with said registers to operate said pen recorder to record the date set up on said registers.

13. In a recording system, a pen recorder, a time clock, a dater, means controlled by the time clock for starting the dater, means controlled by the dater for starting the pen recorder, and means whereby the dater controls the pen recorder to record the date.

14. In a recording system, a multiple pen recorder, a time clock, a dater, means whereby the time clock causes the dater to control a particular pen of said pen recorder to make a record indicative of the date, and means responsive to the occurrence of an event to be recorded for causing said time clock to control a different pen of said pen recorder to make a record indicative of the time the event occurs.

15. In combination, an hours register, a minutes register, means whereby said minutes register controls said hours register, a weeks register, means whereby said hours register controls said weeks register, and a control circuit including serially related contacts in each of said registers.

16. In combination, a plurality of registers, means for maintaining said registers set in accordance with the time of day, a distributor, a control circuit in which said distributor produces current variations under control of said registers, a start circuit for the distributor, and circuit arrangements whereby if the distributor is started responsive to a momentary closure of said start circuit it will complete its operation and whereby if started responsive to a sustained closure of said start circuit it will not reoperate.

17. In combination, a days register, a months register, means for advancing the days register, means controlled by the days register for advancing the months register, and means whereby the months register automatically advances the days register in those months which have less than the maximum number of days.

18. In combination, a register switch having a series of contacts each corresponding to a unit of time, the number of such contacts being equal to the number of such units that are contained in the next larger unit, means for advancing said switch periodically so that it stands on each of said contacts for a length of time equal to said first mentioned time unit, another contact, means for causing said switch to rest on said other contact for a period less than said first mentioned time unit, another register having contacts corresponding to said larger unit, and means whereby the first register controls the second register when the first register is positioned on said other contact.

19. In a combined recording and signalling system, time registers, a distributor, a pen recorder, a signalling circuit, a generator for producing tone currents in said signalling circuit, and means controlled by said distributor in cooperation with said time registers for simultaneously controlling said pen recorder and said tone generator.

20. In a recording system, a pen recorder including a movable tape and a marking pen, means for starting and stopping said tape, whereby said pen draws a line thereon while the tape is moving, time registers, and means controlled by said

registers for causing said pen to record the time of day by drawing groups of short lines perpendicular to said first line.

21. In a recording system, a pen recorder, time registers, means controlled by the said time registers for rendering said recorder operative only during predetermined periods, and means responsive to the occurrence within such a period of an event to be recorded for operating said pen recorder under control of said time registers to record the time of day the event occurred.

22. In a recording system, a pen recorder including a movable tape and a marking pen, means for starting movement of said tape, whereby said pen begins to draw a line thereon, time registers, means controlled by said registers for sending impulses to said pen, and means responsive to each impulse for moving the pen in the plane of said tape in a direction substantially perpendicular to said line.

23. In a recording system, a pen recorder including a movable tape, a dater comprising date registers, means for maintaining said registers set in accordance with the time of day, means for periodically operating said dater to send groups of impulses to said recorder, and means controlled by said dater for causing the movement of said tape to enable said recorder to record said impulses.

24. In a recording system, a pen recorder including a movable tape, a group of registers maintained set in accordance with different units of time, an impulse sender, means for operating said sender under control of said registers to send groups of impulses to said recorder, and means for automatically starting movement of the tape prior to the beginning of the impulses and for stopping it when the impulses are finished.

25. In combination, a time controlled impulse sender, a first minutes register controlled by said sender, a second minutes register controlled by said first minutes register, an hours register controlled by said second minutes register, a days register controlled by said hours register, a months register controlled by said days register, a pen recorder, and means for operating said recorder under control of all said registers.

26. In combination, a time controlled impulse sender, a first minutes register controlled by said sender, a second minutes register controlled by said first minutes register, an hours register controlled by said second minutes register, a days register controlled by said hours register, a months register controlled by said days register, an impulse sender controlled by said minutes and hours registers, a second impulse sender controlled by said days and months registers, a pen recorder, and means for causing said senders to independently control said recorder.

27. In combination, a register switch having a series of contacts each corresponding to a unit of time, another contact in the bank of said switch, means for periodically stepping said switch from contact to contact, another register switch having contacts corresponding to larger units of time, a circuit for advancing said second switch closed whenever the first switch is stepped to said other contact, and means responsive to the operation of said second switch for stepping said first switch off said other contact.

28. In combination, a register switch having contacts in its bank corresponding to the hours in a day, means for stepping said switch every hour, a second register switch having contacts in its bank corresponding to days, an extra con-

tact in the bank of said first register, means for automatically stepping the register off said extra contact when it reaches said contact under control of said first stepping means, and means for operating said second register once every time said first register passes said extra contact.

29. In combination, a weeks register having two wipers, contacts in the banks of said wipers corresponding to the days in a week, means for advancing said register one step every day, a relay, a circuit for energizing said relay including one wiper of said register, and a circuit for deenergizing said relay including the other wiper.

30. In a recording system, a pen recorder, time controlled means for cutting said recorder out of service during a specified period every day, and means whereby said first means is rendered ineffective on a specified day each week.

31. In combination, a plurality of registers each having contacts representing units of time, a distributor having groups of contacts connected in multiple with the contacts of said registers, other groups of contacts having the same angular position in said distributor as said first groups of contacts, a sending relay controlled by the distributor through the contacts of said last mentioned groups, and a stop relay controlled by said distributor through the contacts of said first mentioned groups.

32. In a watchman's recording system, a plurality of marking pens each corresponding to a different station, a group of time registers, means for maintaining said registers set in accordance with the time of day, impulse sending mechanism, and means responsive to a call from any station for operating said sending mechanism under control of said registers to transmit impulses to the pen which corresponds to the calling station.

33. In a watchman's recording system, a plurality of marking pens each corresponding to a different station, time controlled means responsive to a call from any station to operate one of said pens to record the time the call is made, and means for insuring that the operated pen is the one which corresponds to the station from which the call is made, whereby the time record is identified with a particular station.

34. In a watchman's recording system, a plurality of marking pens each corresponding to a station in each of several groups of stations, means responsive to a call from any station for rendering the corresponding pen operative, and means also responsive to the call for causing the operative pen to make a record indicative of the group in which the calling station is located.

35. In a watchman's recording system, a plurality of marking pens each corresponding to a station in each of several groups of stations, means responsive to a call from any station for rendering the corresponding pen operative, means also responsive to the call for causing the operative pen to make a record indicative of the group in which the calling station is located, time registers maintained set in accordance with the time of day, and means controlled by said registers for causing said operative pen to make a record indicative of the time the call is made.

36. In a watchman's recording system, a multiple pen recorder including a movable tape, time registers, date registers, means controlled by said time registers for rendering said recorder operative at the beginning of the watchman's tour of duty, means controlled by the date registers for momentarily running the tape and for causing the pen recorder to record the date, and means re-

sponsive to a call from the watchman for momentarily running the tape and for causing the pen recorder to record the time the call is made.

37. In a watchman's recording system, a pen recorder, a dater comprising date registers, means for maintaining said registers set in accordance with the date, and time controlled means for periodically causing said dater to send impulses to said pen recorder to operate the same to make a record of the date.

38. In a watchman's recording system, a pen recorder, a dater comprising date registers, means for maintaining said registers set in accordance with the date, an impulse sender, and means for operating said sender under control of said registers to send groups of impulses to said recorder to operate the same to make a record of the date.

39. In a watchman's recording system including a plurality of stations, a pair of relays individual to each station, a pen recorder having a pen individual to each station, a time controlled impulse sender common to all the stations and pens, and means including the relays associated with a calling station for temporarily associating said sender with the pen individual to such station and for operating said sender to send impulses to such pen indicative of the time the call is made.

40. In a watchman's recording system including a plurality of telephones connected to an exchange, a pen recorder having a pen assigned to each telephone, a time controlled impulse sender, and means responsive to the momentary removal of the receiver at any telephone for initiating the operation of said sender and for maintaining it operating after the receiver is replaced to send groups of impulses indicative of the time to the pen associated with the telephone at which the receiver was removed.

41. In a watchman's recording system including a plurality of telephones connected to an exchange, a multiple pen recorder, means responsive to a call from any station for operating the pen recorder to record the time the call was made and the telephone used, and means for sending time signals over the telephone line to the watchman to notify him of the time of day.

42. In a watchman's recording system including a plurality of telephones connected to an exchange, a multiple pen recorder, means responsive to the removal of the receiver at any telephone for operating said pen recorder to record the time of day and the telephone where the receiver is removed, and means responsive to the calling of a particular number for sending time signals over the telephone line to the watchman.

43. In a watchman's recording system including a plurality of telephones connected to an exchange, a multiple pen recorder, means responsive to the removal of the receiver at any telephone for operating said pen recorder to record the time of day and the telephone where the receiver is removed, means responsive to the calling

of a particular number for sending time signals over the telephone line to the watchman, and means for continuing the operation of the pen recorder during the signalling operation to record the total length of time the receiver is off.

44. In a recording system, a pen recorder, an hours register, means controlled by said hours register for sending impulses to said recorder to operate the same to record the hour of the day, and means also controlled by said hours register for sending an additional impulse to said pen recorder if the hour is p. m.

45. In a recording system, a pen recorder including a movable tape and a marking pen, an hours register, means controlled by said register for causing said pen to record the hour by marking the tape a variable number of times depending on the setting of the register, the number of such marks being the same whether the hour is a. m. or p. m., and means also controlled by the hours register for causing the record to show whether the hour is a. m. or p. m.

46. In combination, a days register having a different position for every day of the month, a months register having a different position for every month of the year, time controlled means for advancing said days register every day from its instant position to the next, means responsive to the periodic advance of the days register for advancing the months register at the beginning of each month, and means for automatically compensating for the variation in the number of days in successive months to maintain the correct positioning of the days register.

47. In combination, a days register, a months register, means for periodically advancing the days register, means responsive to a particular setting of said days register for advancing the months register, and means included in the months register for advancing the days register when necessary to insure that the said setting is reached at the beginning of each month.

48. In combination, a days register comprising a step-by-step switch, a driving magnet for said switch, a circuit for said magnet closed once per day, a months register also comprising a step-by-step switch, a driving magnet for said months register controlled through a wiper of the days register, and a second circuit for the driving magnet of the days register which includes a wiper of the months register.

49. In combination, a days register comprising a step-by-step switch, a driving magnet for said switch, a circuit for said magnet closed once per day, a months register also comprising a step-by-step switch, a driving magnet for said months register controlled through a wiper of the days register, a second circuit for the driving magnet of the days register which includes a wiper of the months register, and a third circuit for the driving magnet of the days register which includes another wiper of the months register.

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