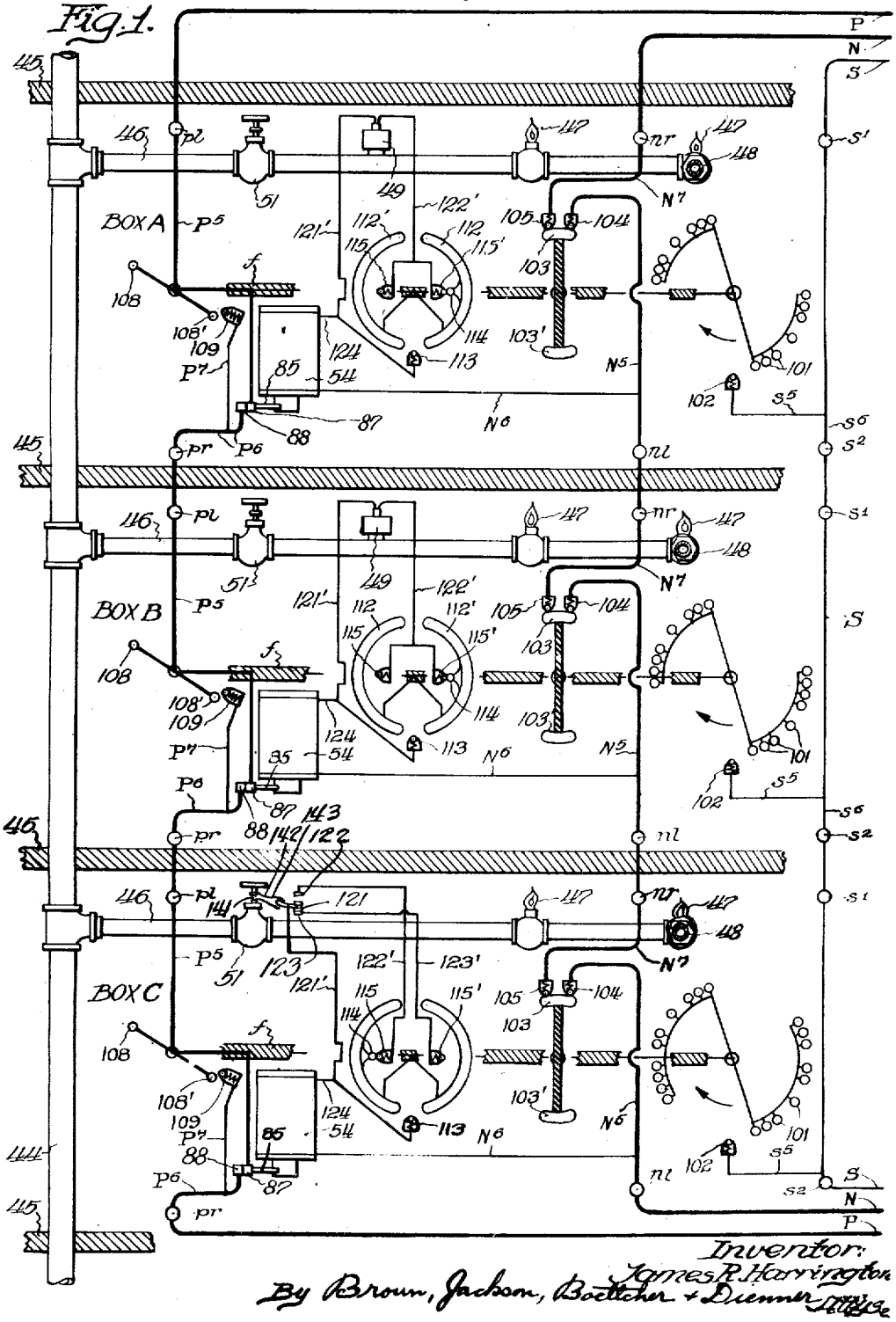
July 4, 1939. J. R. HARRINGTON 2,164,324

ELECTRIC SIGNALING, SUPERVISING, AND RECORDING SYSTEM

Filed July 14, 1931 15 Sheets-Sheet 1

Fig. 1.

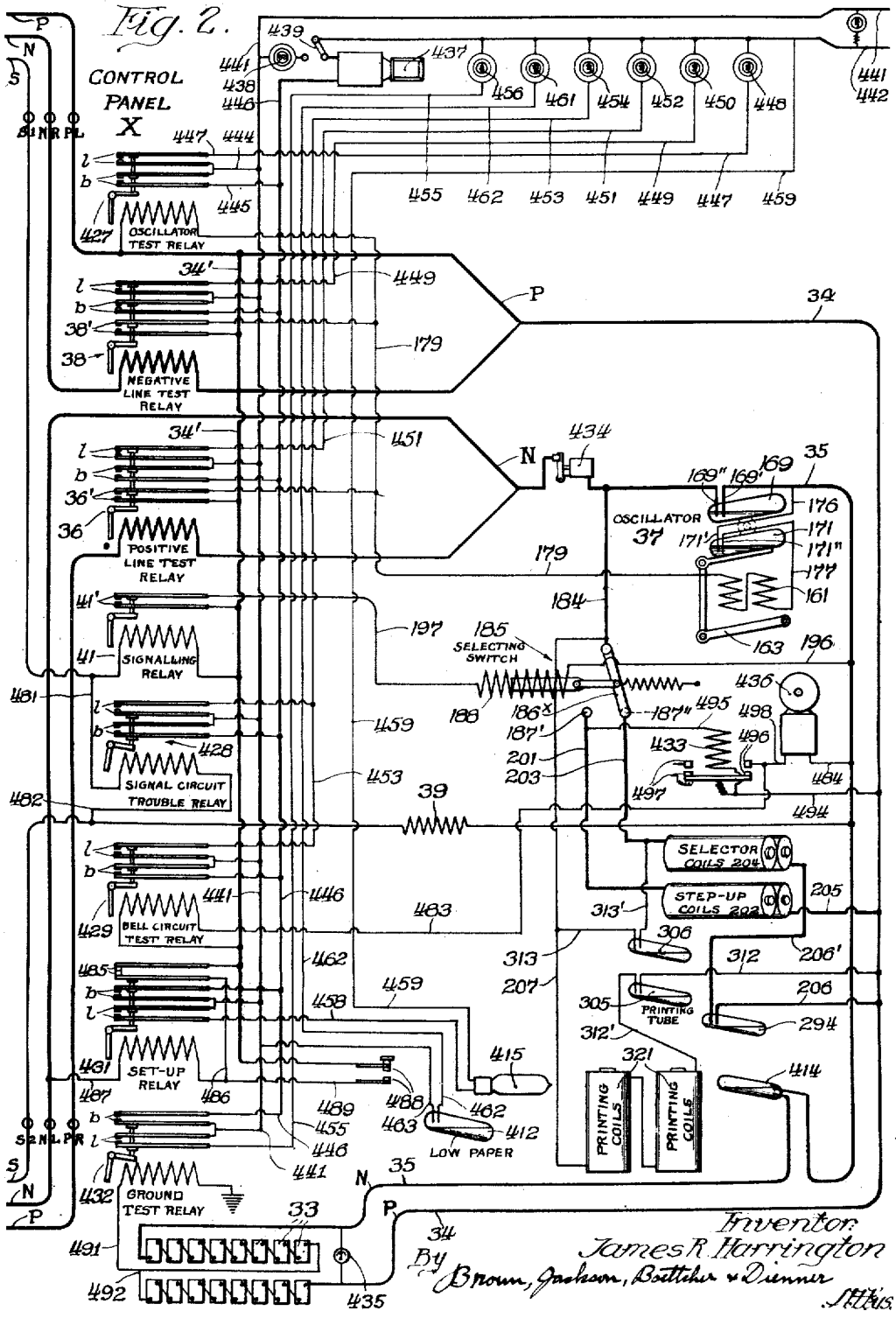


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ELECTRIC SIGNALING, SUPERVISING, AND RECORDING SYSTEM

Filed July 14, 1931 15 Sheets-Sheet 2



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ELECTRIC SIGNALING, SUPERVISING, AND RECORDING SYSTEM

Filed July 14, 1931 15 Sheets-Sheet 3

Fig. 4.

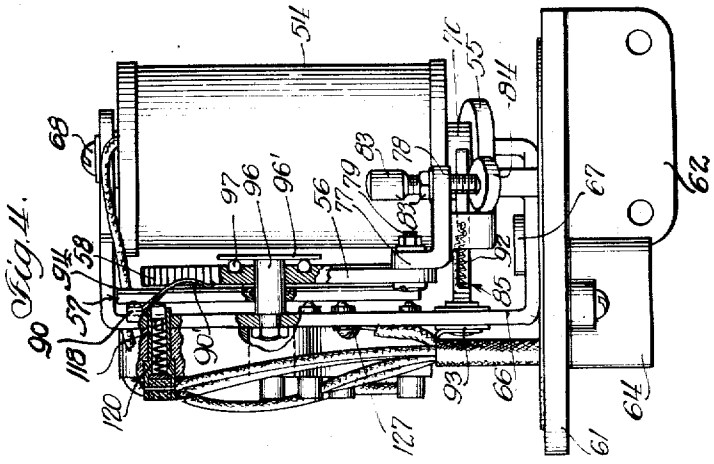
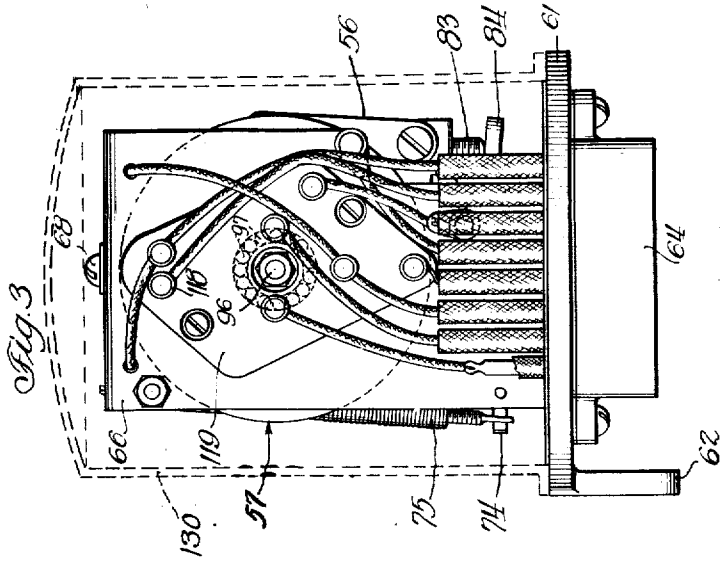


Fig. 3



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July 4, 1939. J. R. HARRINGTON 2,164,324

ELECTRIC SIGNALING, SUPERVISING, AND RECORDING SYSTEM

Filed July 14, 1931 15 Sheets-Sheet 4

Fig. 5.

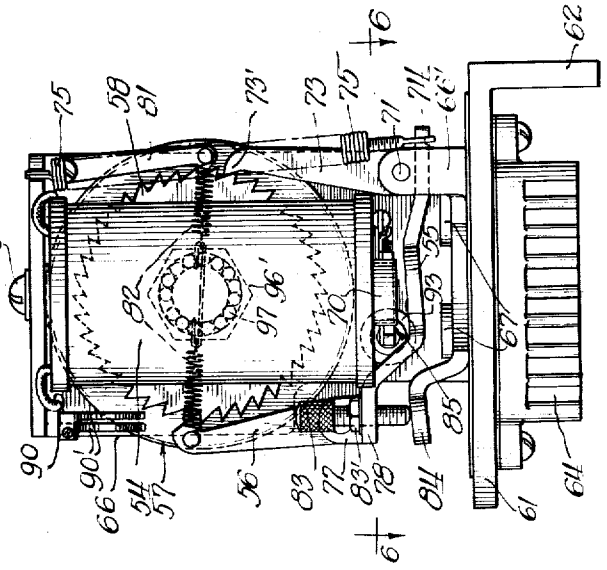
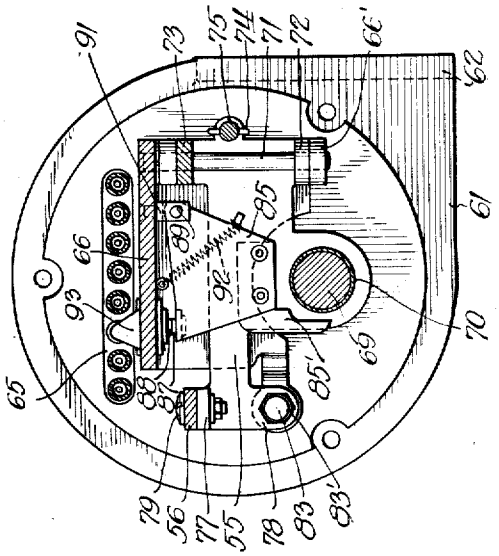


Fig. 6.



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July 4, 1939. J. R. HARRINGTON 2,164,324

ELECTRIC SIGNALING, SUPERVISING, AND RECORDING SYSTEM

Filed July 14, 1931 15 Sheets-Sheet 5

Fig. 7

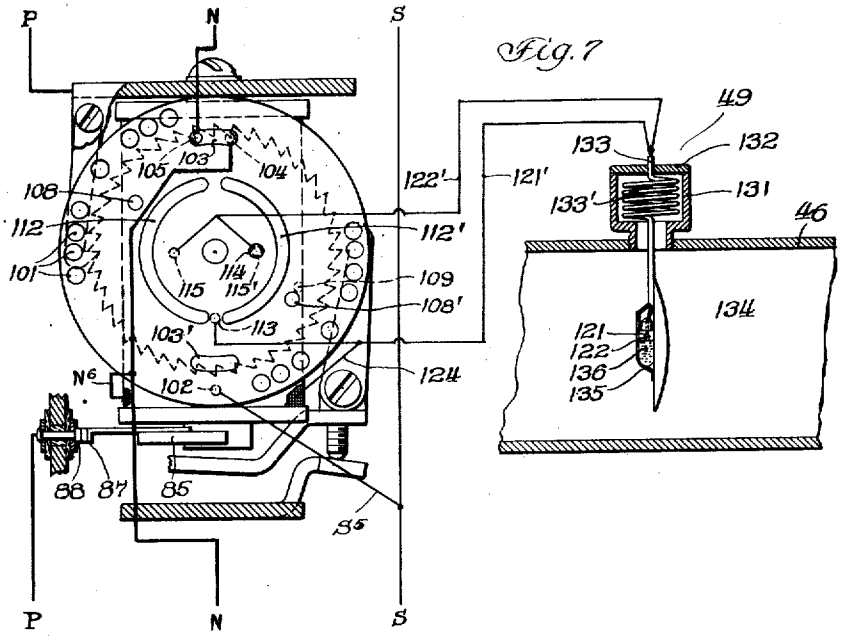
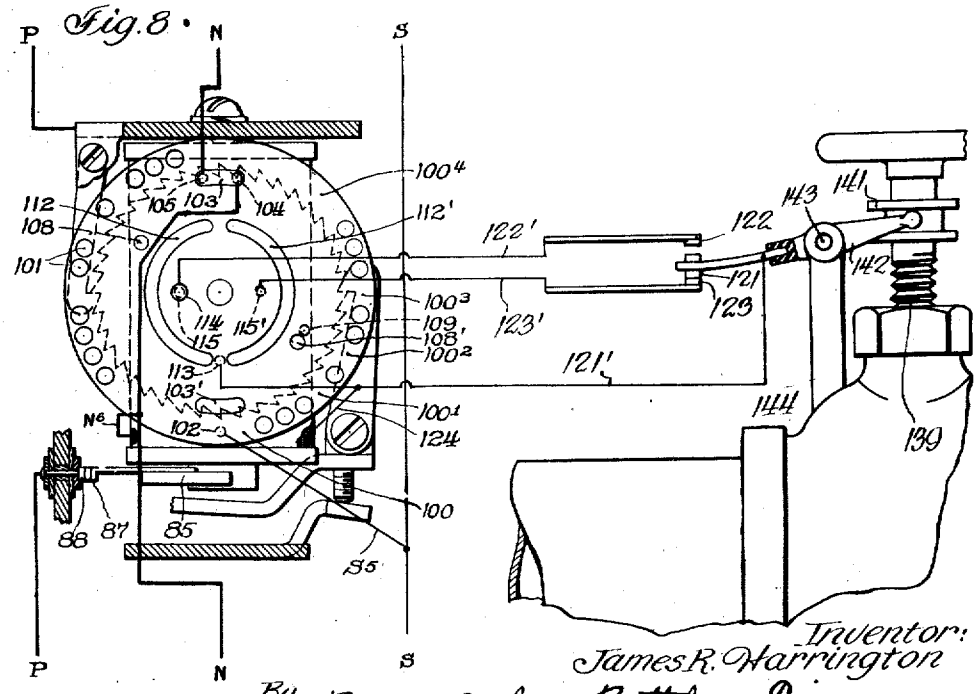


Fig. 8



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2

July 4, 1939. J. R. HARRINGTON 2,164,324

ELECTRIC SIGNALING, SUPERVISING, AND RECORDING SYSTEM

Filed July 14, 1931 15 Sheets-Sheet 6

Fig. 9

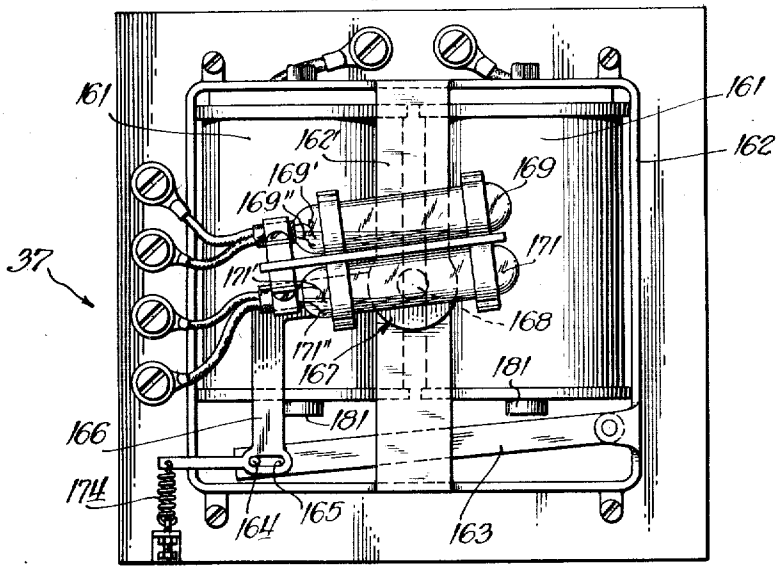


Fig. 10

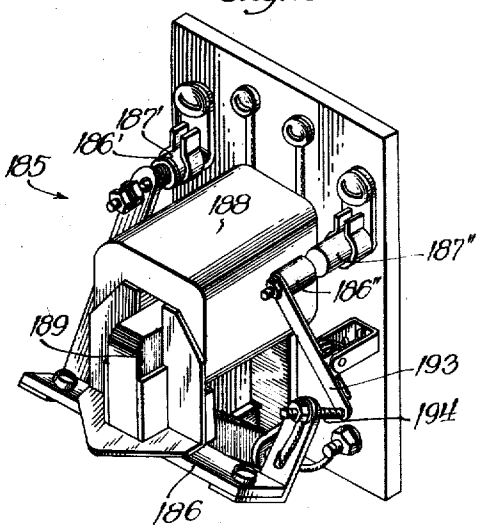
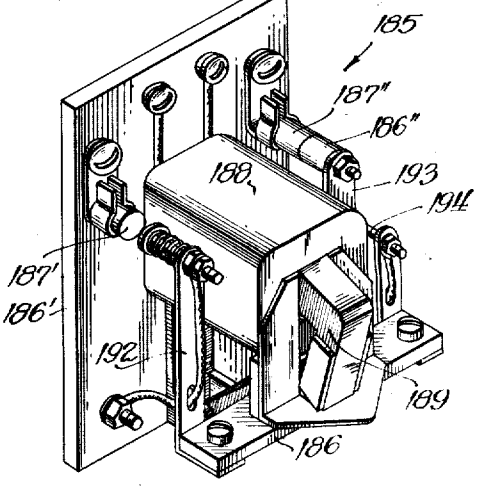


Fig. 11



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July 4, 1939. J. R. HARRINGTON 2,164,324

ELECTRIC SIGNALING, SUPERVISING, AND RECORDING SYSTEM

Filed July 14, 1931 15 Sheets-Sheet 7

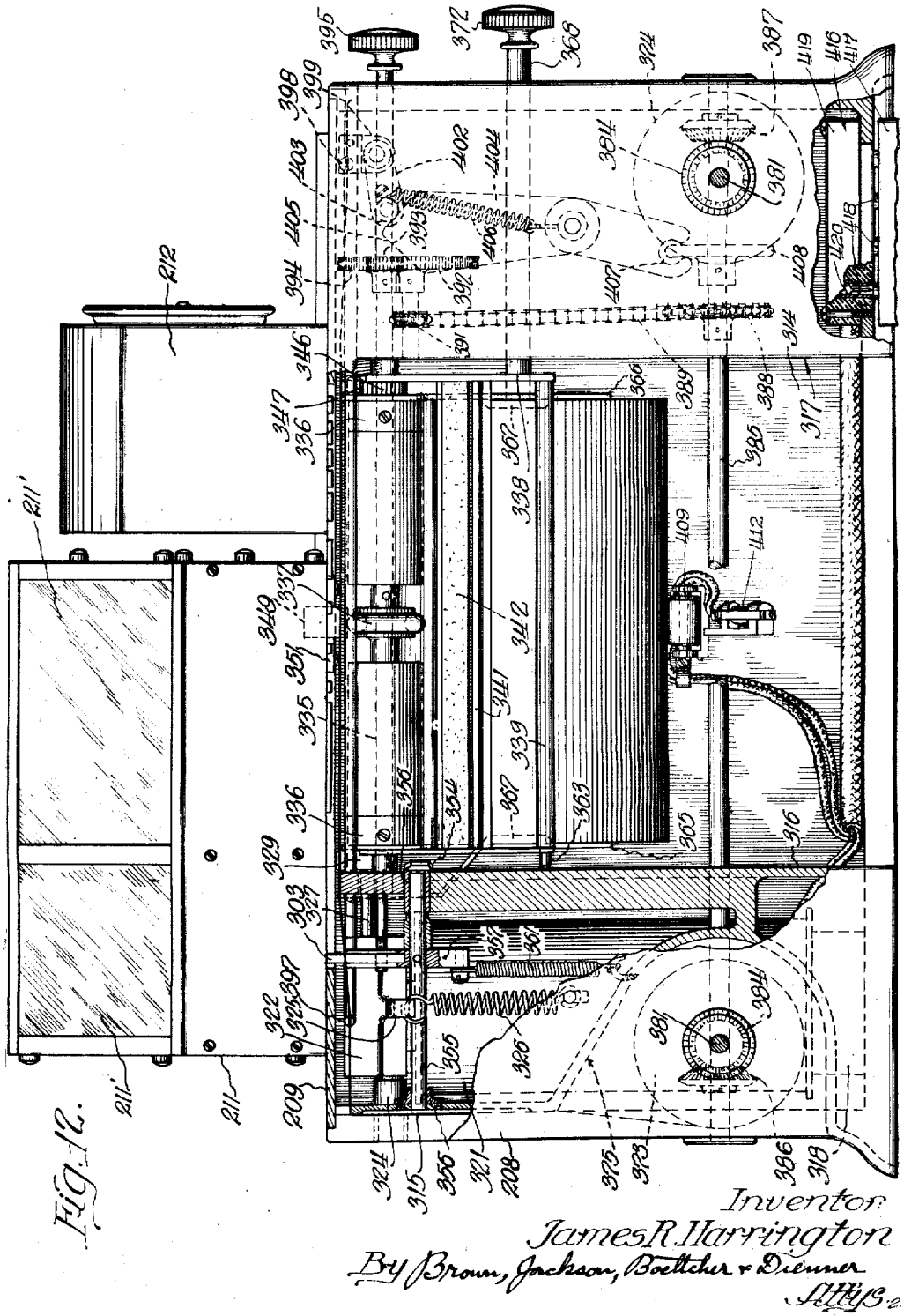


Fig. 12.

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July 4, 1939. J. R. HARRINGTON 2,164,324

ELECTRIC SIGNALING, SUPERVISING, AND RECORDING SYSTEM

Filed July 14, 1931 15 Sheets-Sheet 8

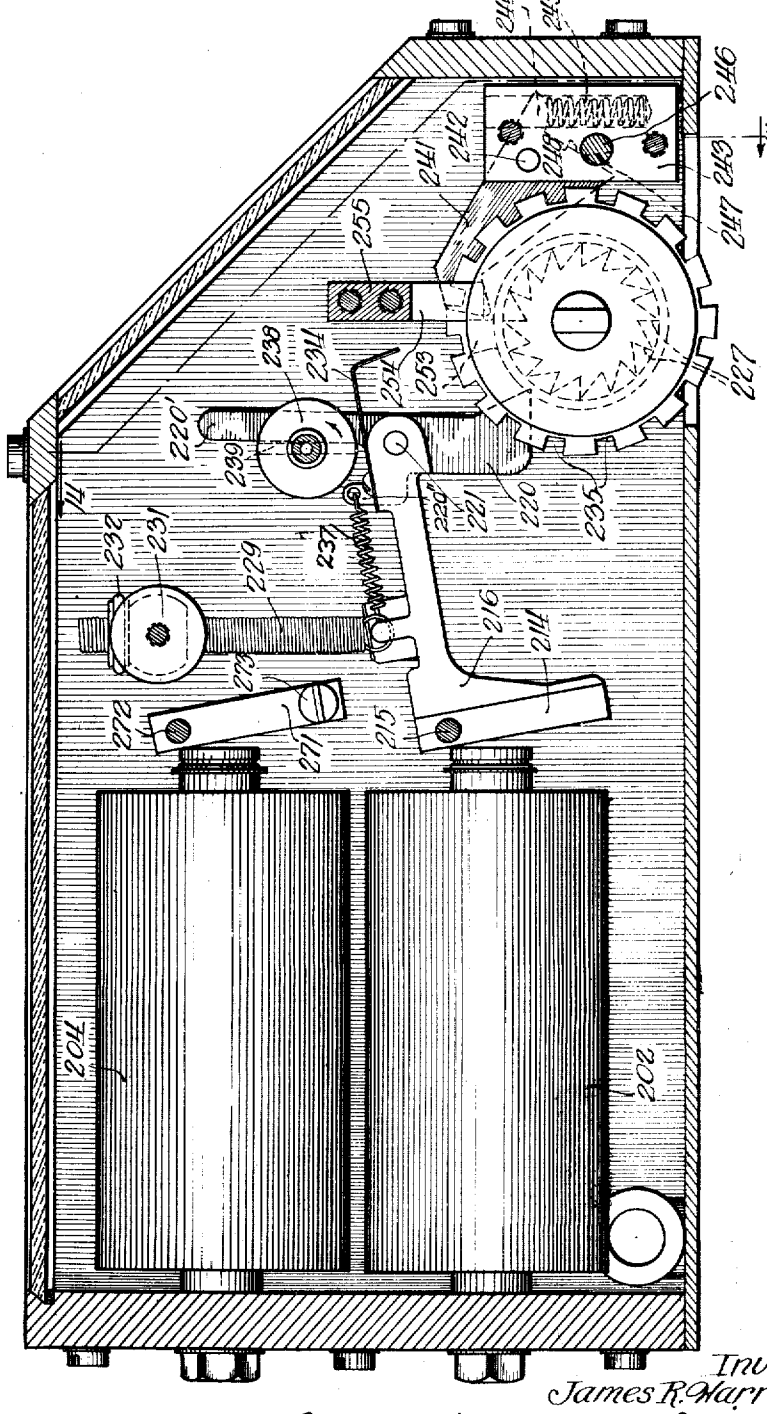


Fig. 13

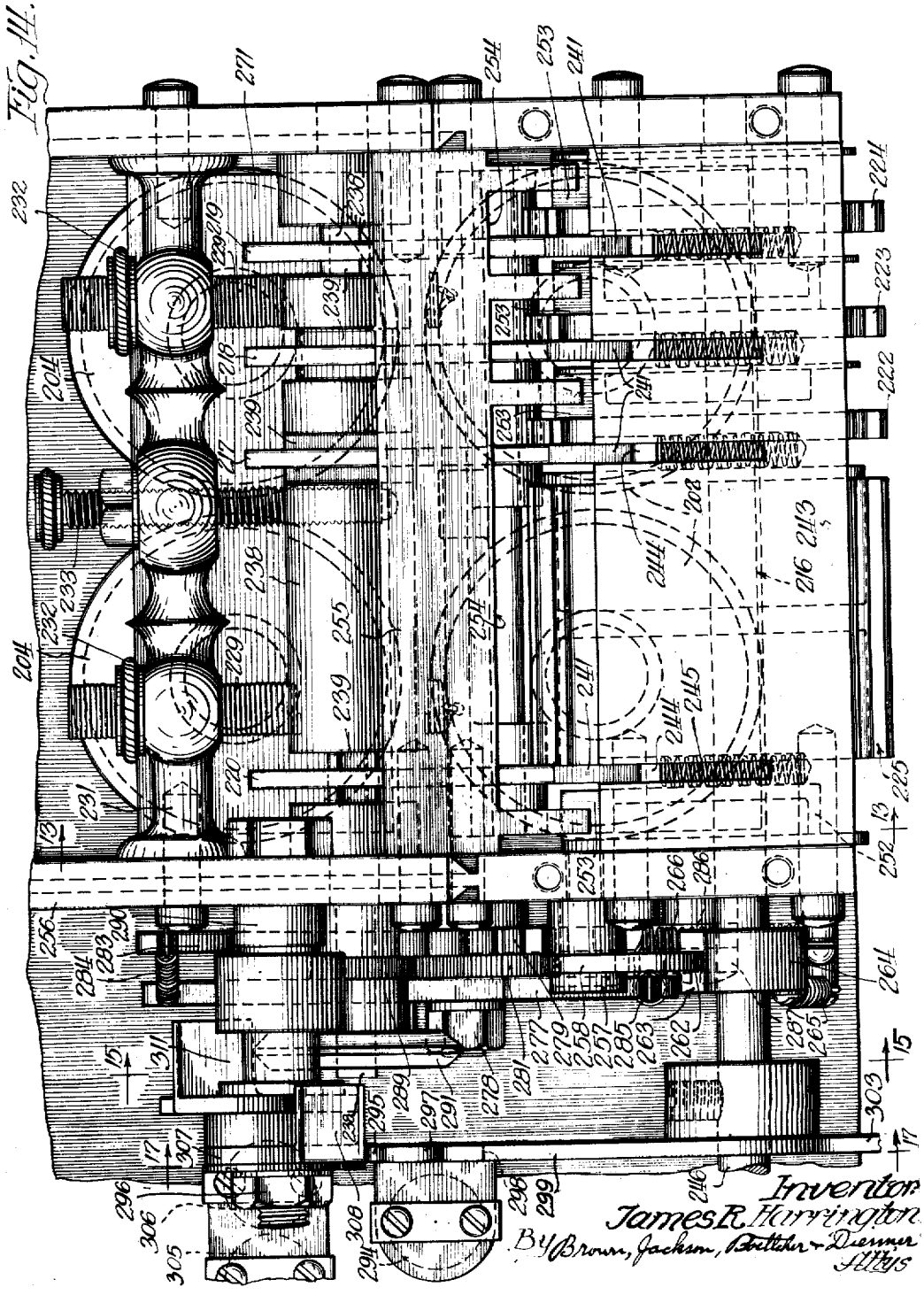
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July 4, 1939. J. R. HARRINGTON 2,164,324

ELECTRIC SIGNALING, SUPERVISING, AND RECORDING SYSTEM

Filed July 14, 1931 15 Sheets-Sheet 9

Fig. 11.



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July 4, 1939. J. R. HARRINGTON 2,164,324

ELECTRIC SIGNALING, SUPERVISING, AND RECORDING SYSTEM

Filed July 14, 1931 15 Sheets-Sheet 10

Fig. 15.

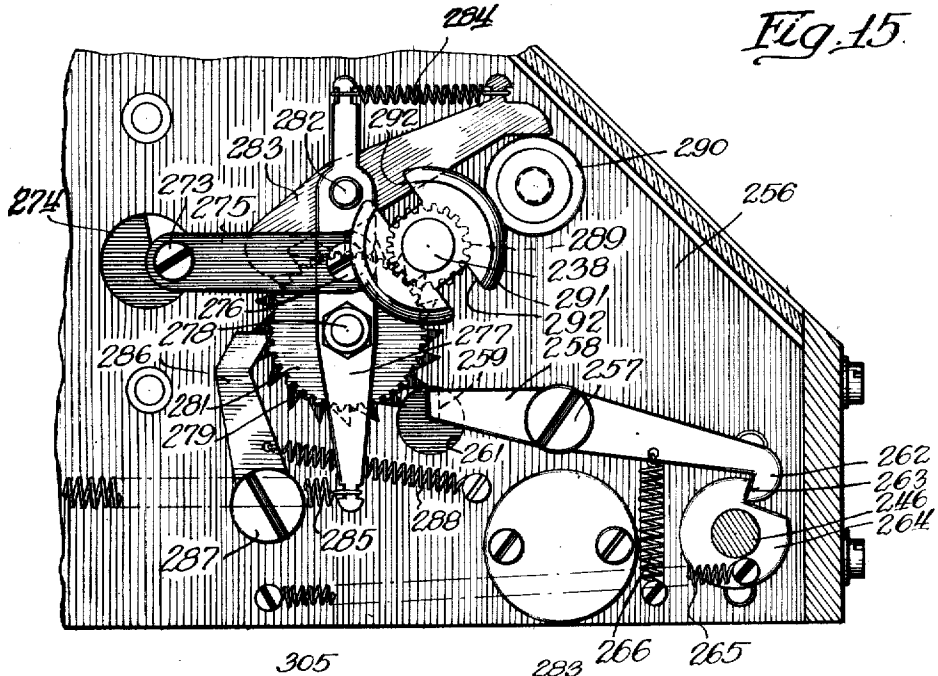
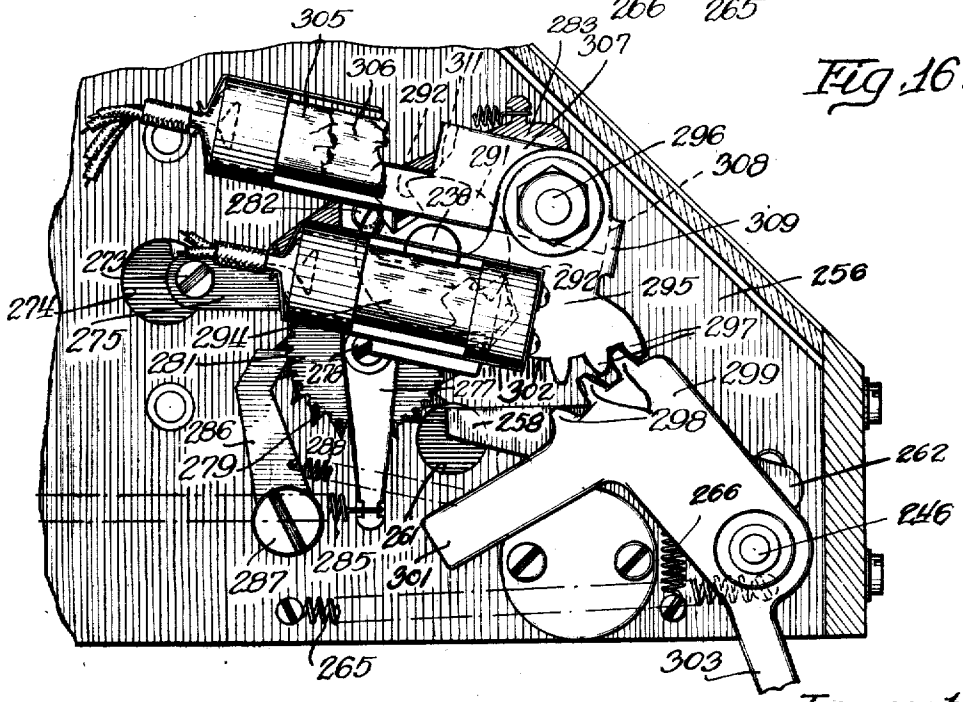


Fig. 16.

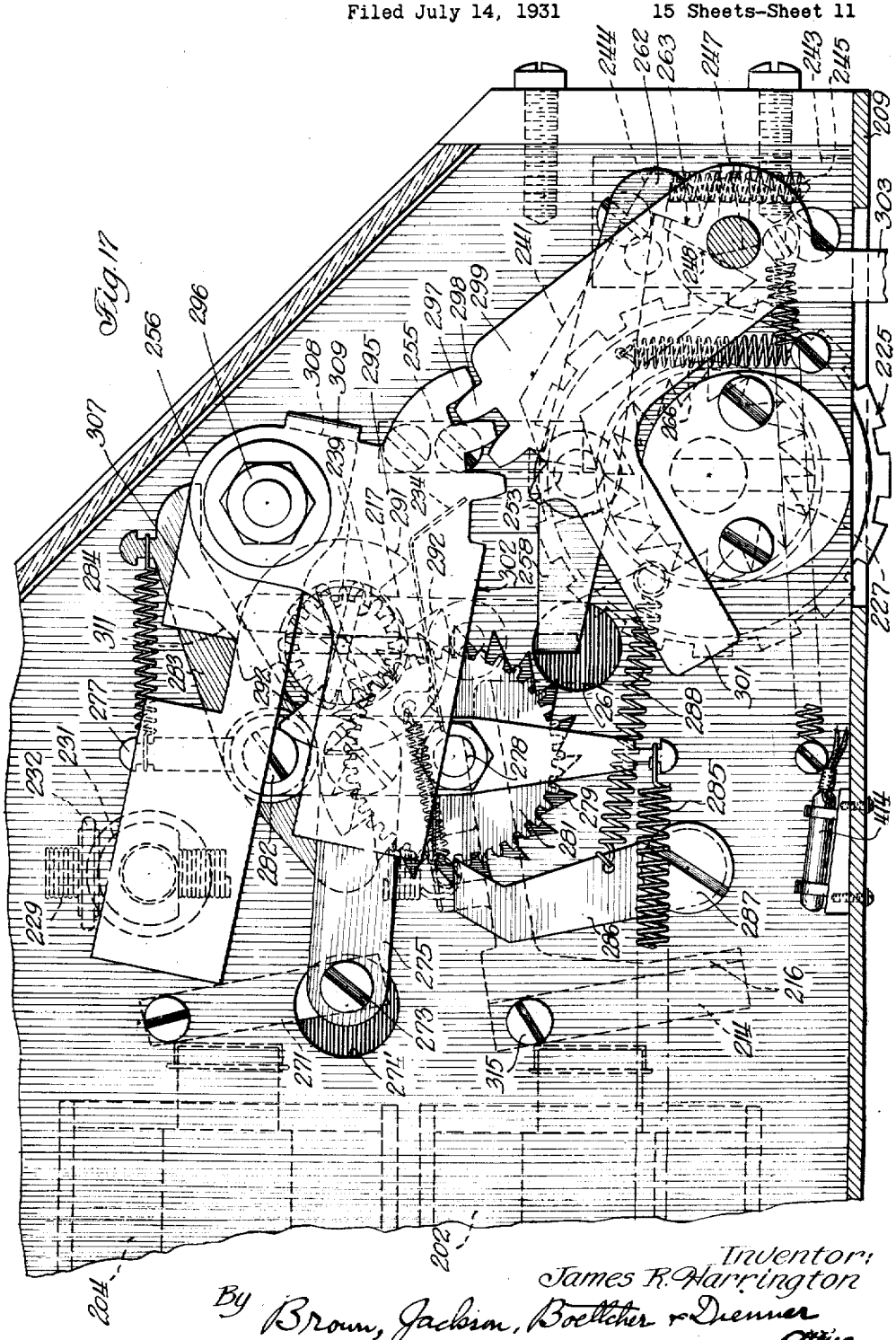


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ELECTRIC SIGNALING, SUPERVISING, AND RECORDING SYSTEM

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July 4, 1939. J. R. HARRINGTON 2,164,324

ELECTRIC SIGNALING, SUPERVISING, AND RECORDING SYSTEM

Filed July 14, 1931 15 Sheets-Sheet 12

Fig. 18

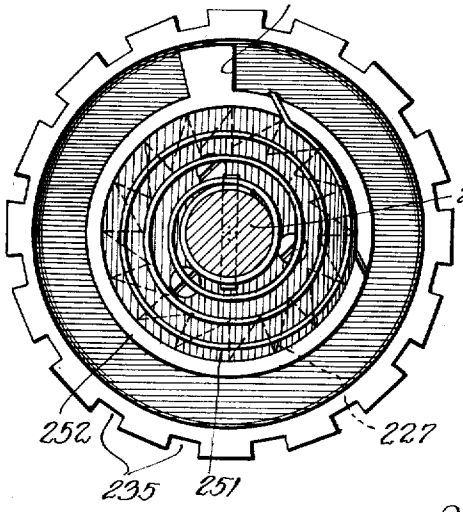


Fig. 19

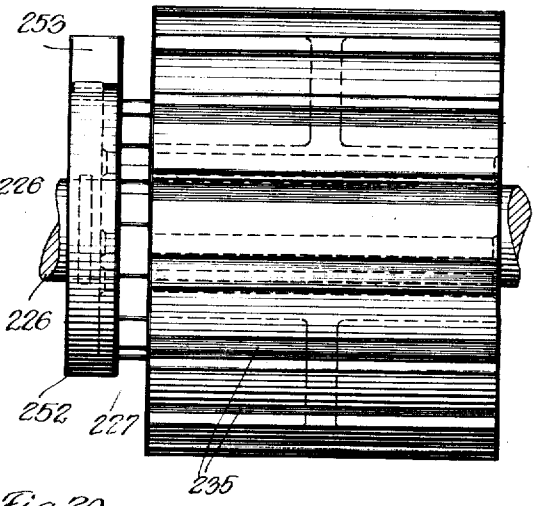


Fig. 20

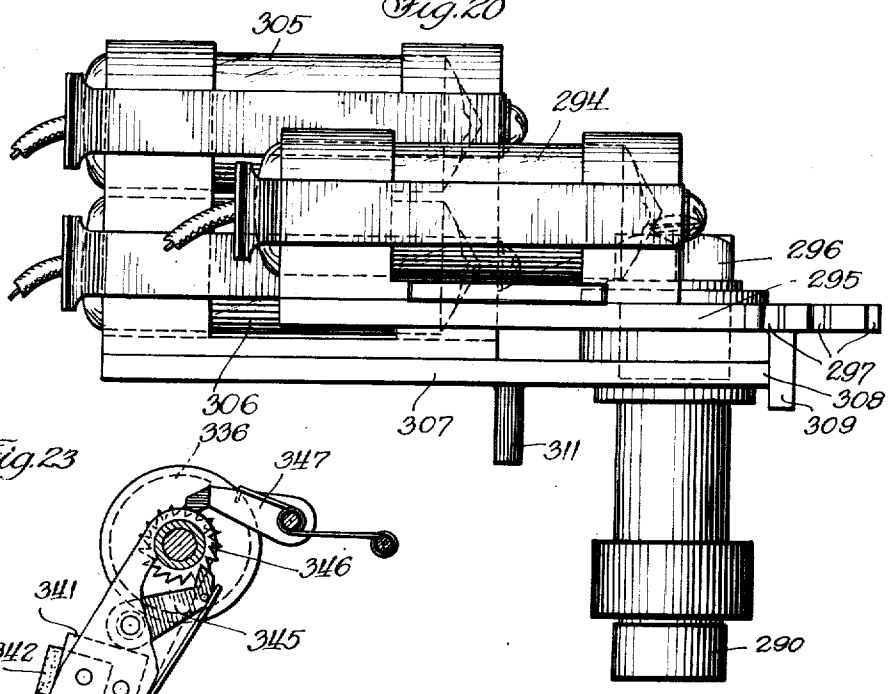


Fig. 23

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ELECTRIC SIGNALING, SUPERVISING, AND RECORDING SYSTEM

Filed July 14, 1931 15 Sheets-Sheet 13

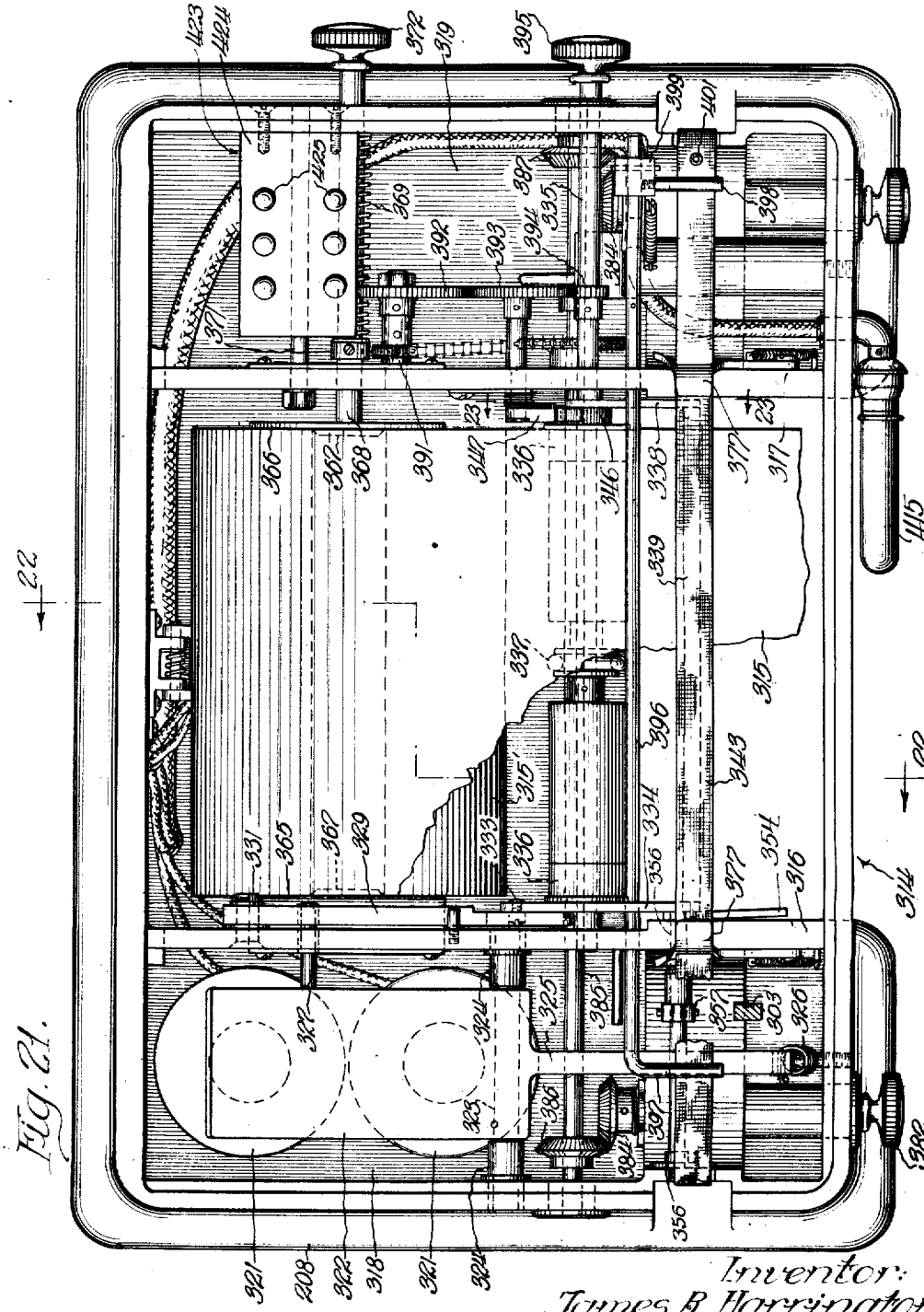


Fig. 21.

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July 4, 1939. J. R. HARRINGTON 2,164,324

ELECTRIC SIGNALING, SUPERVISING, AND RECORDING SYSTEM

Filed July 14, 1931 15 Sheets-Sheet 14

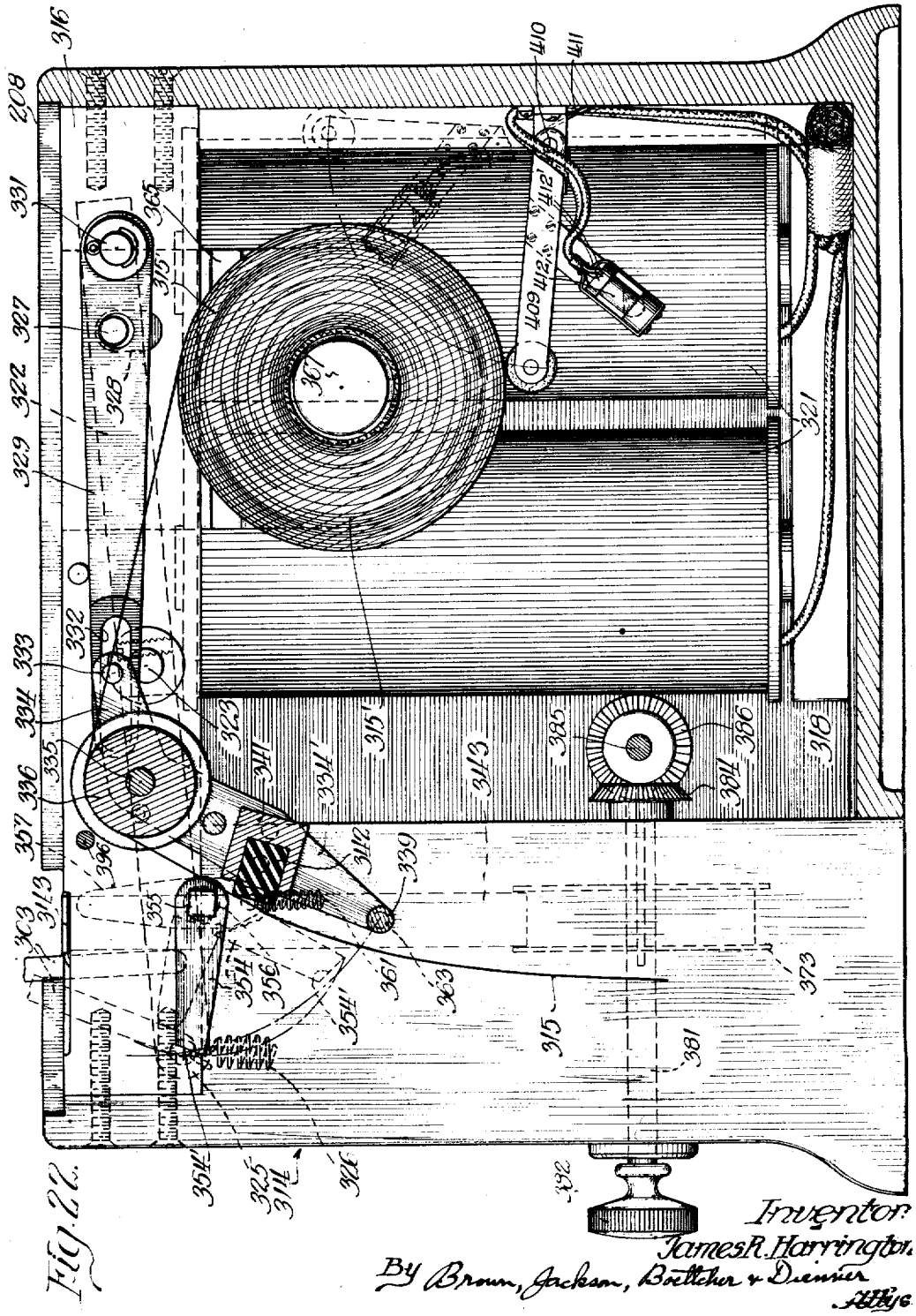


Fig. 22.

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July 4, 1939. J. R. HARRINGTON 2,164,324

ELECTRIC SIGNALING, SUPERVISING, AND RECORDING SYSTEM

Filed July 14, 1931 15 Sheets-Sheet 15

Fig. 24.

315

ALARM NO. 3	1	5	DOE & Co. 1931 JUNE 4	E6 25
ALARM NO. 3	1	5	DOE & Co. 1931 JUNE 4	E6 25
VALVE OPEN 3	1	2	DOE & Co. 1931 JUNE 4	E4 21
VALVE CLSD 3	1	2	DOE & Co. 1931 JUNE 4	E4 16
ALARM NO. 3	1	4	DOE & Co. 1931 JUNE 4	E4 15
ALARM NO. 3	1	4	DOE & Co. 1931 JUNE 4	E4 15

Fig. 25.

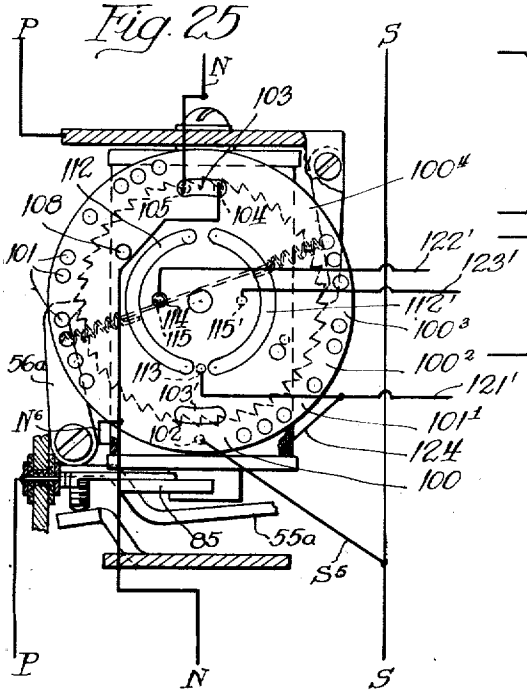
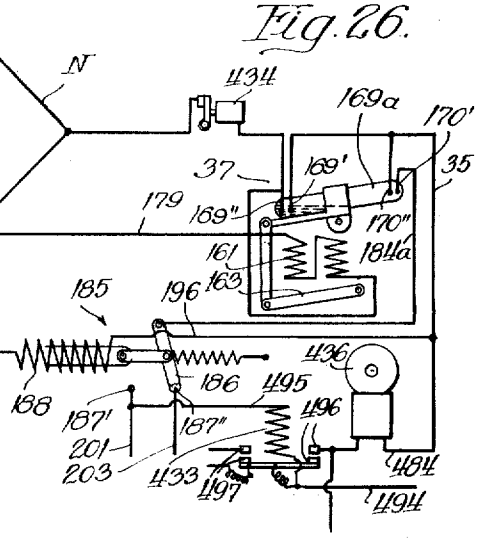


Fig. 26.



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Patented July 4, 1939 2,164,324

UNITED STATES PATENT OFFICE

2,164,324

ELECTRIC SIGNALING, SUPERVISING, AND RECORDING SYSTEM

James R. Harrington, Oak Park, Ill., assignor, by mesne assignments, to The Autocall Company, Shelby, Ohio, a corporation of Ohio

Application July 14, 1931, Serial No. 550,739

41 Claims. (Cl. 177—360)

The present invention relates to electric signaling, supervising and recording systems of the type characterized by a plurality of control boxes or stations interposed at different points in a connecting circuit and so arranged that when an alarm or like condition arises at or in the vicinity of one of these boxes, or when a change occurs in the condition of certain apparatus being supervised by the system, or when one of the boxes is manually energized, the system will function to give a signaling or supervisory indication, which indication may audibly designate the particular box which has been energized in the system, and will also make a permanent record designating the particular box and the condition which gave rise to the energization of that box.

The present invention embodies improvements on and developments of the electric signal system disclosed in my prior Patent No. 1,950,108, granted March 6, 1934.

Apparatus of the present type has application to sprinkler alarm systems, supervisory systems, fire alarm systems, burglar alarm systems, and other analogous systems where it is desired that a certain condition or operation occurring at any one or more points along the circuit shall give an alarm or signal indication, or shall exercise a supervisory or regulating indication or control in connection with apparatus associated with the signal system. The system forming the subject matter of the present application embodies certain improvements which are particularly adapted to the fire prevention apparatus of a building or buildings, including means for indicating when any branch or spray head of a sprinkler system is operating; for indicating when the air pressure on a pressure fed water supply system is high or low or when the water level, as of a gravity fed system, is high or low; for indicating when any of the main control valves of the sprinkler system are open or closed; for indicating when the power, as of an electrically operated pump, is available or has been interrupted; and for indicating when room temperatures rise excessively, or indicating other conditions having to do with a fire prevention system. Accordingly I shall describe the invention in such situation, but it will be understood that the fundamental features of the invention can also be embodied in any of the systems above mentioned, or in other systems and situations where like signaling or supervisory functions are to be exercised.

One of the principal objects of the invention is to provide improved means for recording the different operations of the system. More specifically, this recording apparatus makes a record of each alarm or supervisory indication, designating the particular box or boxes from which the indication was transmitted, the condition at that box which gave rise to the indication, and preferably the date and the time of day when the indication was transmitted. Such record is permanently printed on a sheet or preferably a continuous paper tape, so that it affords an instantaneous visual indication of the particular box operating and the condition at that box, and so that the record can be checked for past performance of the system, and for building maintainence and supervisory records.

Another object of the invention is to provide improved recording apparatus of the above general description which will function in a system of the successive, continuously repeating, non-interfering type. In this regard, it is a more specific object of the invention to provide recording apparatus for the general type of signaling system disclosed in my copending application above referred to. Certain of the fundamental principles, features and structures characterizing this prior system have been incorporated in the present system herein disclosed. For example, in such system interference between different boxes or stations is positively avoided. Thus, in the event that two boxes should be energized simultaneously, or in the event that one box should start to operate while another box is operating, no interference results between said boxes, but instead the two boxes take the line successively, one completing its indication on the circuit and the other box awaiting its turn and thereafter starting and completing its indication on the circuit. This successive, non-interferring operation will occur no matter how many boxes are energized either simultaneously or in overlapping sequence. Furthermore, in such system the boxes are successively operating and continuously repeating. Thus, in a long series of boxes, if box A should first be set into operation and box B should then attempt to operate, the latter would be compelled to await its turn until box A has completed its cycle of alarm or supervisory indication, when box B would begin operation and complete its cycle of indication; and if the condition which started the operation of box A had not been corrected up to such time, box A would again take up operation and complete a second cycle, and, similarly, if the condition which initiated the operation of box B had not been corrected up to this time, box B would again take up operation

and complete a second cycle,—this successive, continuously-repeating operation continuing indefinitely, or until the system is shut off or the abnormal conditions at the boxes are corrected. Moreover, such successive, continuously-repeating operation will occur irrespective of the number of boxes entering into operation and irrespective of the location of the boxes in the series, represented for example, by boxes A, C and D or B, E, F and G, etc. This continuously-repeating characteristic is of decided importance in safeguarding the system against all contingencies. For example, in prior systems where the alarm or supervisory indication is only sounded or indicated once or a limited number of times, if the watchman is absent from the building for only a short time and the alarm or other indication should occur during this interval the protective value of the system is nullified. A further feature of this system is that the movable transmitting element in each box is electrically driven. Heretofore, in the majority of these electric signal systems the signal wheel or like transmitting element has been driven by clock-work mechanism. Such mode of operation imposes definite limitations on the system. For example, the box cannot have a continuously repeating function because the clock spring motor runs down in a comparatively short time. Furthermore in the majority of these prior systems, after an operation of the system, the clock spring of each clock which has operated must be rewound immediately to restore the system to its former protective condition, which is an obvious disadvantage. In the system disclosed in this and in my prior application the transmitting element in each box is driven by power derived from an electric circuit passing through all of the boxes. Such circuit supplies energy to an electromagnetic motor element in each box which functions to drive the transmitter element through repeated cyclical movement as long as the alarm or supervisory condition continues at that box. Preferably, this electromagnetic motor element in each box is of the step-by-step type adapted to be advanced by current impulses transmitted over the box operating circuit, such intermittent impulses being created by a circuit breaker or pulsator which is automatically set into operation when one of the boxes is energized. This pulsator also establishes current impulses in the system which are used in appropriately advancing the printing wheels of the recording mechanism, from which the printed record is made.

The recording apparatus herein disclosed cooperates with the above described characteristic features of the system, in that this apparatus will record the successive operations of a group of concurrently or successively energized boxes, having any sequence in the series, such as boxes A, C and D or B, E, F and G, and in that this apparatus will record the continuously repeated operations of any one box or of a group of boxes operating successively, all without interfering with the above described operation of the boxes.

A further object of the invention is to provide improved means for enabling the transmitter of any energized box to move the printing elements of the recording apparatus to their proper positions for designating the energized box and also for designating the condition which caused the energization of that box. In this regard, one of the particular objects of the invention is to provide an improved method of and means for effecting a selector function whereby the code impulses designating the particular box and the condition prevailing at that box cause selective actuation of the different printing elements in their proper sequence for establishing the proper printing set-up in the recorder. For example, in a large installation the boxes are preferably designated by numbers having three or possibly more digits, such as box No. 313 or 315, the successive digits of which number are set up in printing position on three type wheels corresponding to hundreds, tens, and units wheels, and the first duty of the selector function is to transfer the code impulses selectively to the proper numeral wheels. The particular condition existing at that box is also set up in printing position on a separate type wheel which I have termed the "condition" wheel, and another duty of the selector function is to transfer the proper code impulses to this condition wheel for giving it the proper printing set-up. After the entire printing set-up has been established on the type wheels the printing operation automatically follows, whereupon all of the type wheels are then automatically restored to their initial positions, the paper tape is automatically advanced to the next printing position and the inked printing ribbon is also advanced. This cycle of selectively setting up the type wheels, automatically printing this set-up, and then automatically restoring the recorder parts for a later printing operation, is repeated as long as any energized box continues to repeat its signaling cycle, and in the event of a group of boxes operating concurrently the recorder apparatus will go through this same general cycle, modifying the set-up of the numeral and condition wheels, however, to correspond with the number and "condition" of the box then having the line so that the printed record will show exactly the sequence in which any number of boxes came into operation and the number of times and the order in which they repeated, all without interfering with the operation of the boxes.

With reference to the recorder apparatus, other objects of the invention are to provide improved automatically operating means for: (1) effecting the printing operation at the proper time in the cycle; (2) restoring the type wheels to their initial positions preparatory to again being set-up by the code impulses; (3) advancing the paper tape to its next succeeding printing position; (4) advancing the inked printing ribbon (and automatically reversing the direction of advance of the ribbon near the ends thereof); (5) indicating when the supply of paper on the feeding roll is low; and, (6) protecting the system during the interval of substituting a new roll of paper tape by opening the box-operating circuit and the selector or signaling circuit so as to prevent the transmission of any signaling impulses from any box which might be energized during this temporary non-operative condition of the recorder apparatus.

The selecting or sequence controlling function, by which the code impulses are selectively transferred to or made effective on first one and then another of the several type wheels, involves a unique relation between the circuit for operating the boxes and a second selecting or signaling circuit, together with certain selector or sequence appartus cooperating with the circuits. One group of code impulses is transmitted to a step-up electromagnet which steps up one of the

printing wheels to its printing position, then a selector or sequence electromagnet operates to render the advancing pawl of this wheel inoperative and to render the advancing pawl of another printing wheel operative, whereupon succeeding impulses advance this second wheel to its printing position, etc. This operation of having the step-up electromagnet advance the printing wheels and having the selector electromagnet determine the wheel which is to be advanced is followed until all of the wheels are stepped up to their printing positions, whereupon the printing operation follows. This selector function and its apparatus constitute one of the principal features of the invention.

Another object of the invention is to provide an improved system of the above general description wherein definite and positive synchronization is established between the operation of any signaling box and the operation of the recorder. This synchronization is effected electrically by a synchronizing device which is common to all of the boxes on the circuit and to the recorder; in the preferred embodiment herein disclosed such synchronizing device being the above mentioned oscillating circuit breaker or pulsator which transmits current impulses to the operating box and to the recorder. Difficulties of major importance have heretofore arisen in endeavoring to establish and maintain synchronized timing between the prior types of clock spring driven boxes and the prior types of recorders. Mechanical escapements have been associated with such boxes to control their speed of operation, and mechanical escapements and other like mechanical timing devices have been associated with the recorders to govern the selection or change-over from the energization of one coil to the energization of another coil. For example, when one of these prior signaling boxes is transmitting code impulses corresponding to two or more digits, it is the intention that in each group of impulses designating one of these digits there shall be a uniform time interval of relatively short duration between the successive impulses in this group, and that there shall be a relatively longer time interval between any two such groups of impulses. The timing device at the recorder is intended to distinguish between the length of time interval between impulses of a group and the length of time interval between groups of impulses, in order to select the proper coil for energization. Manifestly, however, there is always a great deal of uncertainty in the time intervals between impulses transmitted from a clock spring driven signaling box, arising from wear of the parts, changes of temperature affecting the lubrication, foreign matter collecting in the working parts, etc.; and these same conditions and uncertainties prevail in the case of the time measuring device at the recorder. Hence, there is no definite and positive synchronization between the box and the recorder, and errors frequently arise in the performance of the recorder, and always remain as potential sources of unreliability. These objections have all been avoided in my improved system wherein the oscillator functions as a synchronizing element common to the boxes and to the recorder for insuring that precisely the same time interval shall exist between successive operations of the box and the transmission of successive impulses to the recorder.

Another object of the invention is to safeguard the operation of the system by placing all of the circuits, relays and other apparatus under continuous test so that in the event of breakage of any of the conductors, or a ground being established on any of the circuits, or a fault arising in any of the apparatus, a trouble signal will instantly be energized to indicate that the system is not in its normally operative condition, and to designate the source of the trouble.

Another object of the invention is to provide an improved electrically operated step-by-step transmitter for use in each of the boxes or control stations, which requires less energy to operate, which is more reliable in its operation, and which embodies other controlled and controlling functions not disclosed in prior types of transmitters.

Another object is to provide an improved signaling system and improved box transmitter in which the current impulses transmitted over the box operating circuit are operative to actuate the transmitter armature, but wherein the code wheel or rotor element of the box is not advanced by the attracted movement of the armature on the current impulse, but instead is advanced by the recessional movement of the armature upon the cessation of the current impulse. This mode of operation has numerous advantages which I shall hereinafter describe.

Other objects and advantages of the invention will appear from the following detailed description of a preferred embodiment thereof. In the accompanying drawings illustrating such embodiment:

Figure 1 is a fragmentary circuit diagram illustrating schematically a series of signal boxes or control stations and the circuit wires connecting with these boxes, this figure representing the "line" portion of the system;

Figure 2 is a fragmentary circuit diagram illustrating the circuits and apparatus constituting the control panel or central station of the system, this diagram being adapted to be joined with the right-hand edge of Figure 1 for completing the entire system circuit;

Figure 3 is a rear elevational view of one of the step-by-step electromagnetic motor units employed in each of the signal boxes;

Figure 4 is a side elevational view of the same;

Figure 5 is a front elevational view of this device;

Figure 6 is a horizontal sectional view taken approximately on the plane of the line 6—6 of Figure 5;

Figure 7 is a view diagrammatically illustrating the electrical connections in a typical signaling box, particularly where such box has a flow indicating or fire alarm signaling duty;

Figure 8 illustrates the control circuit connections of a box having a typical supervisory duty;

Figure 9 is a front elevational view of the pulsator or oscillator which transmits the current impulses to the signaling boxes and to the recorder and system;

Figure 10 is a perspective view of the selecting switch or relay which directs these impulses selectively either to the selector coils or to the type step-up coils of the recorder;

Figure 11 is a perspective view of the other side of this same selecting or directing switch;

Figure 12 is a front view of the recording apparatus, a portion of the casing thereof being broken away to illustrate certain operating parts;

Figure 13 is a transverse sectional view through the mechanism for selecting and advancing the type wheels of the recording apparatus, this view

corresponding to a section taken approximately on the plane of the line 13—13 of Figure 14;

Figure 14 is a view taken approximately on the plane of the line 14—14 of Figure 13, and with the front and top portions of the housing removed, showing in front elevation this same mechanism for selecting and advancing the type wheels;

Figure 15 is a transverse sectional view taken approximately on the plane of the line 15—15 of Figure 14;

Figure 16 is a view from the same side as Figure 15, but also illustrating certain of the mercury tubes associated with the recording apparatus, and showing some of the mechanism which controls the tilting of these tubes;

Figure 17 is a sectional view on a larger scale, taken between the planes of Figures 15 and 16, approximately as indicated by the section plane 17—17 on Figure 14;

Figure 18 is an end elevational view of one of the type wheels, showing the return spring which restores the wheel to its normal position;

Figure 19 is a side elevational view of the same;

Figure 20 is an inverted view looking upwardly under the aforesaid mercury tubes, illustrating their mountings and some of their actuating mechanisms;

Figure 21 is a plan view showing the mechanism within the base portion of the recording apparatus, below the mechanism which selects and advances the type wheels;

Figure 22 is a transverse sectional view taken approximately on the plane of the line 22—22 of Figure 21, showing the operating relation of the parts which enter into the printing operation;

Figure 23 is a fragmentary transverse sectional view taken approximately on the plane of the line 23—23 of Figure 21, showing the pawl apparatus which advances the roller parts feeding the paper tape;

Figure 24 is a fragmentary view showing a portion of the paper tape having typical data recorded thereon; and

Figures 25 and 26 are diagrammatic views of modified constructions.

Referring first to Figures 1 and 2, the main operating units of the system consist of a series of signal boxes A, B, C, etc. and a control station or panel generally indicated at X, this control station or panel comprising a grouped arrangement of apparatus for recording the impulses transmitted from the boxes, for transmitting the intermittent current impulses over the circuit, for maintaining the circuit under continuous test, and for performing the various other functions hereinafter described. While Figure 1 only illustrates three boxes A, B and C, it will be understood that any number of boxes may be included in the system depending upon the number of locations or operating stations from which an alarm or supervisory indication is to be transmitted. The entire group of boxes is connected in series relation to a circuit consisting of three conductors P, N and S. It will be noted that these conductors loop back from both ends of the circuit, or from both ends of the series of boxes, to the control panel X. The circuit of the entire system is completed by placing Figure 2 in juxtaposition to the right-hand edge of Figure 1.

I shall first describe the structural details of one of the signal boxes, and then of the recording apparatus and of the other mechanical devices associated with the control panel, and shall then describe in detail the various circuit functions and operations in their relation to the several units of the apparatus. The explanation of the entire system will be most easily understood if we assume the system to be operating on direct current with certain conditions of polarity or directions of current feed, as this will enable the circuits to be traced through with respect to positive and negative. However, the same operation occurs when the system is operating on alternating current, and accordingly it will be understood that where I refer to "positive" and "negative" in this description and in the appended claims I am not using these terms in a limitative sense, but only for the purpose of differentiation and to facilitate understanding the invention. The system might be operated entirely off an ordinary lighting or power circuit but it would then be fallible because of the possibility of interruptions in the service line, and to avoid this I prefer to employ a battery 33 (Fig. 2) for energizing the more essential circuits of the system, this battery being floated across any suitable type of charging means. Leading from this battery are positive and negative feeders or buses 34 and 35 respectively, which have connection with the various devices and terminals at the control station X. The conductor P and N represent a box operating circuit for supplying operating current to the several boxes A, B, C, etc., and either polarity may be impressed on these conductors. It will be assumed, however, that positive polarity is impressed on conductor P, this polarity being supplied from the battery feeder 34 to the terminal designated PL ("positive line") on the control panel X. From here the polarity is fed through conductor P in a direction extending down through boxes A, B and C in the order named, and is thence conducted back to the terminal PR ("positive return") on the control panel. It will be observed that this corresponds to a counter-clockwise direction of flow in the particular circuit connections illustrated. It will also be assumed that the negative polarity from the negative battery feeder 35 is being placed on the opposite end of the conductor N through negative line terminal NL on the panel, so that this polarity is being fed up through the series of boxes C, B, and A in the order named, and is being returned to the negative return terminal NR on the panel. It will be observed that such corresponds in the diagram to a clockwise direction of impressed polarity. The positive return PR is connected to one end of the winding of a positive line test relay 36 and the other end of this relay winding is connected through a pulsater 37 and other apparatus to the negative feeder 35 of the battery. The negative return NR is connected to one end of the winding of a negative line test relay 38, and the other end of this winding has connection through positive polarity feeder 34 with the positive side of the battery 33. The arrangement is such that under normal conditions a small current flow is being passed continuously through the conductors P and N in the directions above stated. In the operation of the system the pulsator or oscillator 37 operates to transmit current pulsations over this box operating circuit P and N to the energized box for stepping the motor element of this box around in its cyclical movement, and these pulsations are also transmitted to the actuating coils of the recorder mechanism for advancing the type wheels. The conductor S functions as a signaling or selecting conductor, extending in

a loop through the series of boxes and connecting at its ends with the terminals S^1 and S^2 on the control panel X. Normally a testing current is being passed continuously through this conductor, the positive polarity of this testing current being conducted through positive feeder branch 34' and being impressed on the conductor S at the terminal S1, and the negative polarity being conducted through resistance element 38 and being connected to the signal conductor at the terminal S2. This conductor S controls a signaling or selecting relay 41. The control panel connections between the various relays, pulsator, recorder actuating coils, etc. will be hereinafter described in the more specific description of the circuit connections.

Referring now to the general adaptation of the present signaling and supervising system to a typical fire prevention sprinkler installation, the riser of such an installation is indicated at 44 in Figure 1. This riser extends up through the different floor levels of the building, such floor levels being indicated at 45, and serves to conduct the water to horizontally extending floor branch mains 46 which extend out from the riser generally below the ceiling of each floor level. These floor branch mains may have the conventional sprinkler heads 47 mounted thereon, although most generally they connect to various "stringers" 48 radiating out in different directions, which stringers have these sprinkler heads mounted thereon. As is well known, these sprinkler heads are designed to open automatically in the event of fire to produce a sprayed discharge of the water over the fire area. In a building of even moderate size there are usually several risers 44 from which radiate floor branch mains 46 at each floor level. The present invention contemplates associated an individual signal box with each floor branch main leading from each of these risers, so that when any sprinkler head in the system begins operating such fact is indicated by the present alarm system, and the location of this particular head is also signaled in the alarm, as by a code which designates the particular riser and the floor branch main with which this head is associated. Similarly, if different heads in different parts of the building commence operating either simultaneously or in sequence the alarm signal will designate the different sections of the building in which these heads are located. This feature of announcing or signaling the exact location of the operating head or heads is obviously of great advantage as it enables the fire to be located at once, which is of extreme importance in large or widely scattered buildings, and moreover in the event of a sprinkler head opening accidentally, it enables this head to be located promptly before great water damage can be done. As will hereinafter appear, the designation of the particular floor branch main is effected by an individual code in which the alarm is sounded and also recorded. If desired, separate signal boxes might also be associated with each stringer 48, but this is not usually necessary. The main fire alarm duties of the system are exercised by boxes associated with each floor branch main, and made responsive to the flow of water through that main, under the control of flow responsive switches generally indicated at 49. In Figure 1 I have shown the boxes A and B as having this alarm duty in connection with floor branch mains with which they are associated. In exercising its supervisory duties in connection with a sprinkler system, separate signal boxes may be associated with different apparatus and mechanisms having to do with a typical sprinkler installation, whereby the system will have a supervisory function in indicating the conditions of such other apparatus and mechanisms. For example, it is quite a common practice to provide a manually controlled valve 51 in each floor branch main 46 at a point adjacent to the riser 44 so that the floor branch main can be cut off in the event of an accidental opening of one of the sprinkler heads, or for the purpose of making repairs, extensions, etc. Naturally, a critical hazard is immediately introduced if this manually controlled valve should be closed and then forgotten. The present system provides means for positively preventing any such possibility by exercising a supervisory control for indicating the condition of each of these valves. For example, in Figure 1 I have shown the box C in a supervisory duty for indicating when the valve 51 is closed and for indicating when this valve is opened. As I shall hereinafter explain, this particular supervisory duty is merely typical of a large number of other supervisory functions which may be embodied in the present system, as for indicating high and low water levels in a storage tank, the existence of air pressure on a pressure fed system, and such other supervisory functions as I have generally referred to in the forepart of this specification.

Signal boxes

The term "signal box" or "signal station" is hereinafter used in its generic sense as designating each of the devices from which the signal or control function emanates when said device is energized either manually or automatically. The operating parts of all of these signal boxes A, B, C, etc. are duplicates, with the single exception of the arrangement of the code or signaling contacts, and hence a description of one box will suffice for all. Referring to Figures 3, 4, 5 and 6, the principal elements of each box include an electromagnetic coil 54, an armature 55, a pawl 56 oscillated by the latter, and a rotary element 57 having a ratchet wheel 58 to which a step-by-step advancement is imparted by the pawl 56, and which rotary element 57 governs the coaction between certain contacts associated with the box operating circuit and with the signaling or selecting circuit. Referring more specifically to the detailed construction, the device is assembled upon a supporting or base plate 61 having a downturned flange 62 at one side by which the plate can be secured to any suitable support. Secured to the bottom of said plate in an insulating connector block 64 in which are mounted the connector terminals adapted for connection with the box operating and signaling circuits and with the circuit or circuits which govern the energization of the box. Wires extending from these terminals pass up through an insulating bushing 65, passing through the base plate, and extend up to their respective contacts and connections associated with the rotary element 57, as I shall hereinafter describe.

The coil and armature assembly is carried by a C-shaped plate 66, the lower arm of which is secured to the base plate 61 by the insulated bolts or studs 67. The electromagnetic coil 54 is suspended from the upper arm of the C-shaped bracket 66 by a screw 68 passing down through said arm and threading into the core 69 of the coil. A cap 70 composed of copper or like non-magnetic material is secured over the projecting

lower end of the core so that when the coil is deenergized the armature 55 will be sure to separate from contact with the lower end of the core, thereby preventing the possibility of slight residual magnetism delaying the downward movement of the armature. The portion of the armature adjacent its pivot axis is made relatively wide to give considerable width of bearing support, this pivot mounting comprising a pivot pin 71 passing through the back of the bracket 66 and through the extension arm 66' of said bracket. As shown in Figure 6, this pivot pin passes through a pivot lug 72 bent up from the front edge of the armature 55 and through an arm 73 bent up from the back edge of said armature. Said arm constitutes an overthrow preventing pawl, having a nose 73' at its upper end which is adapted to swing into the teeth of the ratchet wheel 58, in the downward wheel advancing movement of the armature, so as to prevent overthrow of the ratchet wheel.

The armature has a short arm 74 extending outwardly beyond the pivot axis 71 (Figure 5) and connected between this arm and the upper arm of the mounting bracket 66 is an adjustable tension spring 75 which acts to normally swing the main portion of the armature downwardly away from the electromagnet. The C-shaped supporting bracket 66 is preferably of a magnetic material to complete the magnetic circuit from the top of the coil 54 down to the magnetic armature 55. The main swinging end of said armature has an upwardly sloping arm portion from the end of which projects a vertically extending apertured lug 77 and a laterally extending threaded lug 78. A pivot bolt 79 passes through the vertical lug or ear 77 and pivotally supports the advancing pawl 56 on this portion of the armature. This advancing pawl has a downwardly hooked nose adapted to engage with the downwardly traveling ratchet teeth at this side of the ratchet wheel 58. On the upstroke of the armature when the coil 54 is energized the pawl merely slides up to the next tooth but on the downstroke of the armature when the coil is deenergized the ratchet wheel is advanced one tooth in a counterclockwise direction (Figure 5) by the tension stored in the spring 75. Retrograde motion of the wheel is prevented by a pivoted detent pawl 81. Two link connected tension springs 82, extended between pins projecting from both pawls, serve to hold the two pawls engaged against the ratchet wheel teeth. The other apertured lug 78 on the armature carries a stop screw 83 which threads down through said lug and is adapted to have its lower end contact with a fixed stop 84 projecting from the mounting bracket 66. Adjustment of the screw 83 adjusts the downward limit of movement of the armature 55, said screw being held in adjusted position by a suitable lock nut 83'. The upward limit of movement of the armature may also be defined by an adjustable stop screw, although I preferably have the armature strike the copper cap 70 on the end of the magnet core.

Referring to Figure 6, at the instant that a magnetic flux starts to build up in the energization of the electromagnet 54, a secondary armature 85 is magnetically actuated to separate two contacts 87 and 88. This secondary armature may be mounted in any suitable relation to respond to the flux created by the electromagnet, but in the arrangement shown it is mounted at the lower end on the vertical back wall of the bracket 66, at the lower end of the coil. Said armature or switch is pivoted at 89 to a suitable stud or mounting projection 91 on said back wall, and comprises a yoke shaped portion 85' of magnetic metal which is adapted to be attracted into contact with the side of the copper cup 70. A tension spring 92 suitably connected between a lug on the armature and a fixed point of attachment on the bracket 66 tends to normally hold the armature in the position illustrated with the contacts 87 and 88 in engagement. The contact 87 is grounded to the bracket 66 through the armature and the stationary contact 88 is mounted in an insulated bushing 93 in the bracket 66.

This secondary armature is of relatively light inertia and it responds instantly to the energization of the electromagnet. The two contacts 87 and 88 are open by the time the main armature 55 has started to move upwardly, and since it is the downstroke of this main armature that advances the rotary element it naturally follows that the opening of the two contacts 87 and 88 has a lead of operation over any contact change or contact operation effected by the rotary element. The manner in which this lead of operation is advantageously utilized in the control of the system will be hereinafter described. In this regard, I may use the apparatus for controlling the transmission of positive polarity from one box to another such as I have disclosed in my prior Patent No. 1,950,108, dated March 6, 1934.

The rotary element 57 comprises a disk of insulating material to the back side of which the ratchet wheel 58 is rigidly pinned. Also secured to the back side of this insulating disk, and disposed between said disk and the ratchet wheel, is a thin metal plate 94 (see Figure 4) which serves as a common connecting element for connecting together certain of the contacts disposed on the front face of the insulating disk. This rotor assembly is revolvably mounted on the enlarged hub portion of a bearing screw 96 which has a reduced end non-rotatably mounted in the upright portion of the bracket plate 66. Ball bearings 97 track in an annular groove in the face of the ratchet wheel 58 and bear against the outer head 96' of the pivot screw 96, thereby providing an antifriction bearing for the rotor and also antifrictionally carrying the end thrust which is imposed on the rotor by the spring pressed contacts bearing against the front face of the insulating disk 57. The ratchet wheel 58 and the metallic connector disk 94 are electrically connected to the frame support 66, through the pivot mounting and through a connector brush 90 (Figure 5) which is fastened to the frame support 66 in electrical connection therewith and which has spring fingers 90' bearing against the metallic disk 94. This frame support 66 has no connection with "ground", since in the preferred embodiment of the system no "ground" is used.

Referring to the diagrammatic illustration of Figure 7, the front face of the insulating rotor disk 57 carries a series of signaling or selecting contacts 101 adjacent to the outer periphery of the disk. These contacts preferably consist of a series of spaced pins extending back through the body of the insulating disk and all riveted over or otherwise connected with the metallic connector disk 94 on the back side of the rotor. Said pins are arranged in a code combination designating the particular box; for example, the arrangement of pins illustrated in Figure 7 transmits signaling or selecting impulses corresponding to 3—1—4 for

designating that particular box. I prefer to have each box so arranged that a half revolution of the rotor disk 57 gives one complete signaling cycle and the other half revolution gives another complete signaling cycle. By this arrangement one box may be utilized to signal two distinct supervisory conditions, i. e., one of the half revolutions can be used to signal that a certain valve is closed and the other half revolution can be used to signal that this same valve is opened. In such arrangement there are two of these series of signal contacts 101 disposed on diametrically opposite halves of the code wheel. In an alarm box the two series are preferably identical, but in a supervisory box there is a different arrangement of the contacts on one side than on the other to signal the two different conditions. While I prefer this construction wherein a half revolution constitutes a complete signaling cycle, it will be understood that if desired the construction may be such that a whole revolution of the rotor will be required for a complete signaling cycle. Coacting with these rotating signal contacts 101 is a stationary signal contact 102, such comprising a spring pressed contact supported in an insulating bushing which is mounted in the vertical portion of the bracket 66 (the details of which I shall hereinafter describe), this spring pressed contact preferably bearing against the lower portion of the insulating disk, and being engaged successively by the contact pins 101 in the rotation of the disk. Insulating gaps or blank portions 100, 100^1, 100^2, etc., on the face of the code wheel precede the signal contacts and separate the contacts into appropriate signaling groups, such gaps also effecting a selecting operation, as I shall hereinafter describe.

Spaced inwardly at a smaller radius than the aforesaid pins are two diametrically opposite shunting or bridging contacts 103 and 103'. These contacts do not have electrical connection with the connector disk 94 on the back side of the rotor, but merely consist of inserts anchored in depressions in the front face of the insulating disk 57. Such shunting contacts are adapted to make and break a bridging connection between two spring pressed contacts 104 and 105 which are supported by the bracket 66 preferably in a position to engage the upper portion of the rotary element. In the normal position of the rotary element the two contacts 104, 105 are bridged by the shunt 103. A one step advancement of the rotor from its normal position breaks this shunt, but thereafter, upon the completion of 180 degrees of movement of the rotor, the shunt is again reestablished by the other bridging contact 103'.

Spaced inwardly from the arc of the two shunting contacts 103, 103' are two diametrically opposite pin contacts 108 and 108' which extend back through the insulating disk and are electrically connected to disk 94 and ratchet wheel 58. Coacting therewith is a stationarily mounted spring pressed contact 109 which is preferably arranged substantially in the angular relation shown in Figure 7 with respect to the rotating contacts 108 and 108'. In the normal position of the rotor shown, one or the other of the rotating contacts 108 or 108' lies in a position one step in advance of the stationary contact 109, in the direction of rotation of the rotor. That is to say, in any one cycle operation or half revolution of the rotor from the normal position shown, one or the other of the moving contacts 108 or 108' will engage the stationary contact 109 one step in advance of the rotor completing its cycle or half revolution. The engagement of said contacts establishes a temporary shunt across the armature contacts 87, 88 for transmitting positive polarity down through the series of boxes toward the C end thereof to test if another box in this direction has been energized and is ready to take the line. This will be described more in detail later.

Spaced inwardly from the two latter contacts 108, 108' are two arcuate contacting segments 112, 112'. Both of these segments are secured to the signaling rotor by connectors which extend through the rotor and connect both segments to the back connector disk 94. Coacting with both of these segments is a stationary spring pressed contact 113 which, when the rotor is in its normal position, presses against one of the two diametrically opposite insulating gaps between the opposite ends of the contact segments.

Spaced inwardly from the radius of these contact segments is an inner contact 114 which also extends through the insulating rotor for connection with the ratchet wheel and connector disk 94. Coacting with this innermost rotating contact are two diametrically opposite spring pressed contacts 115 and 115', mounted on the bracket plate substantially in the angular relation shown in Figure 7. In the normal position of the rotor as the same is illustrated in this figure, the moving contact 114 is in engagement with the stationary contact 115', being adapted to make a later engagement with the other contact 115 when the rotor has revolved through approximately 180 degrees.

Figure 4 illustrates one of the stationary spring pressed contacts in cross section, and this typically represents the construction of each of the other spring pressed contacts 102, 109, 110, 113, 115, and 115'. Each of these contact devices comprises a guide sleeve or bushing 118 suitably anchored in a hole in an insulating mounting block 119 secured to the vertical portion of the bracket 66. The contact ball or plunger moves in this metallic guide sleeve, being urged against the face of the rotor disk 57 by a compression spring 120 confined between the contact and the outer end of the metallic sleeve. The wire connecting with this contact is extended into a diametrical hole or slot in the outer end of the guide sleeve 118 and is soldered thereto. As shown in Figure 3, any suitable box or housing 130 encloses all the operating parts of the signal box.

Where any one box is intended to signal only one condition, such as fire, only two contacts 121 and 122 are employed to control the box, as illustrated in Figure 7. These two contacts may be embodied in the flow responsive switch 49, in which case they close a control circuit to energize the box when water flow occurs in the branch pipe 46, the box then signaling that there is a fire at this location. Figure 7 illustrates one typical construction of flow responsive switch. Screwed into or otherwise secured to an opening in the upper side of the floor branch main or stringer 46 is a housing 131 having a cover 132 secured to the top thereof by a water-tight joint. A length of resilient metallic tubing 133 has its upper end sealed in a watertight joint in the cover 132. Below this cover the tubing is formed into a helical coil 133', and the lower end of the tubing is secured to a paddle or baffle 134 which is movably suspended in the conduit 46. The tubing opens into a shell 135 which is secured to one side of the baffle or movable vane 134 and mounted in this shell is a mercury tube 136. The two

control contacts 121 and 122 are a part of this mercury tube, both either being disposed above the normal level of the mercury, or one contact being immersed in or grounded to the mercury and the other being above the normal level of the mercury, whereby when the baffle 134 is hanging in its normal position with no water flowing there will be no circuit established between the contacts 121 and 122, but as soon as a water flow occurs the baffle will be deflected and the mercury will establish a circuit between said contacts. The coiled section 133' of the tubing gives a large degree of resiliency or freedom of movement to the mounting of the baffle 134 so that the latter will always be deflected as soon as any water flow occurs, even though it be of low velocity. It will be noted that increase or decrease of pressure in the pipe will not affect the operation of the flow indicator. Leading from the contacts 121 and 122 are two conductors 121' and 122' which pass up through the tubing 133, the conductor 121' then extending to spring pressed contact 113 and the other conductor 122' branching to the two spring pressed contacts 115 and 115'. A wire 124 extends from contact 113 to one end of the electromagnet coil 54 for conducting positive polarity to this end of the coil when the box is energized.

In the case of a burglar alarm, police alarm or any other like situation the two control contacts 121 and 122 may be made to respond to burglar detecting devices, etc. Also these two contacts may be in the form of a manually actuated switch where it is desired to manually initiate the alarm or other signal.

Where any one box is intended to signal two conditions the control of the box is governed by three contacts 121, 122 and 123, as illustrated in Figure 8, such corresponding to a supervisory duty of the box. For example, the box can then be employed to indicate two distinct conditions such as "Valve open" or "Valve closed" (as in the case of the manually controlled valve 51)—"Pressure O. K." or "Pressure low"—"Power off" or "Power on"—"Water O. K." or "Low Water", etc. In the supervisory duty of the box using the three contacts 121, 122, and 123 (Figure 8) the contact 121 is connected to the same spring pressed contact 113 as before, but the other two contacts 122 and 123 are each connected individually through the conductors 122' and 123' with the spring pressed contacts 115 and 115', respectively.

In Figure 8 I have schematically illustrated one method of having a supervisory box respond when a valve is opened and closed, corresponding to the function of box C in connection with the valve 51 of Figure 1. In this schematic showing, the stem 139 of the valve 51 has a grooved collar 141 fastened to the stem to move up and down therewith. A yoke 142, having inturned ends engaging in the grooved collar, is pivotally mounted at 143 on any suitable stationary support 144. The movable contact 121 has insulated mounting on the outer end of the swinging arm or yoke. When the valve stem is screwed upwardly to open the valve the movable contact 121 is swung down into engagement with the lower contact 123, and when the valve stem is screwed downwardly to close the valve this movable contact is swung up to engage with the upper contact 122.

Referring now to the circuit connections through the boxes, and with particular reference to Figures 1, 2 and 7, positive conductor P, leading from positive line terminal PL on the control panel has a positive polarity continuously impressed thereon from the positive battery feeder 34. The conductor P conveys this positive polarity to the first box A where said conductor connects to positive line terminal *pl* (Figure 1) on the terminal block 64 and from this terminal a wire P5 extends to a screw 127 (Figure 4) having electrical connection with the supporting bracket 66, whereby this polarity from the positive line side of the box operating circuit is conducted to the ratchet wheel 58 and metallic connector disk 94. In Figure 1 the cross-sectioned lines or portions *f* of each box symbolically represent the frame connection established through the supporting bracket 66, metallic connector disk 94, etc. The connection through these parts is, however, individual to that box and is not a ground for the entire system. Assuming the box A and its coil 54 to be in their normal non-energized condition, the positive polarity is transmitted on through the box by frame connection with contact 87, thence through contact 88 and thence through wire P6 to the positive return terminal *pr* on the terminal block 64 of the box A. A wire P7 also leads from the spring pressed contact 109 to the return terminal *pr* but since neither of the pin contacts 108 or 108' is under the contact 109 at this time the positive polarity is not conducted through these contacts. Hence the transmission of positive polarity through the box at this time is controlled entirely by the contacts 87 and 88 which are responsive to the secondary armature member 85 and which are normally closed. From the return terminal *pr* on the box A, the positive polarity is conducted over the positive conductor P to the positive line terminal *pl* of the next box B and passes through this box over the same circuit path traced out in connection with box A. In the same manner the positive polarity is conducted through the entire series of boxes and then returns to positive return terminal PR on the control panel. From this terminal the loop of the positive conductor continues through the winding of the positive line test relay 36 to the main contactor tube of the oscillator 37 and thence to the negative battery feeder 35. Accordingly, it will be seen that normally a continuous testing current is flowing from positive feeder 34 out over the conductor P and down through the series of boxes (in a counterclockwise direction as viewed in Figures 1 and 2) and back through the winding of the positive line test relay 36 and through the oscillator 37 to the negative feeder 35. In the foregoing tracing of the positive polarity through the boxes it will be remembered that no coil winding 54 of any box in the series had connection with this positive polarity, such only being established when the box is energized, through the contacts 121—123 and 112, 112' and 113 and wire 124, as I shall presently describe.

Tracing the negative polarity through the boxes, the negative conductor N extending from the negative line terminal NL on the control panel normally has a continuous negative polarity impressed thereon from the negative battery feeder 35 through oscillator 37. The conductor N conveys this polarity to the first box in the series from the negative end, which is shown as box C. Here the conductor N connects with negative line terminal *nl* on the terminal block 64 of said box C. From this terminal the negative polarity is transmitted

through wire N5 to spring pressed contact 104 (or 105). Also leading from this same negative line terminal, or contact, is a wire N6 which is connected to one end of the winding of coil 54 of the box C, so that this coil normally has negative polarity impressed on one end thereof. With the box in its normal condition, negative polarity is transmitted on to spring pressed contact 105 through the shunting contact 103 carried by the rotor, which shunting contact has bridging relation across the two spring pressed contacts 104 and 105 at this time, as previously described. From the latter contact 105 a wire N7 leads to the negative return terminal *nr* on the terminal block 64 of the box C, and connecting with this negative return terminal is that portion of the negative conductor N leading to the negative line terminal *nl* of the next box B. The negative polarity is conducted through the box B and through all of the remaining boxes in the series in the same manner (in a clockwise direction as viewed in Figures 1 and 2) and is finally conducted back through negative return terminal NR on the control panel and through the winding of negative line test relay 38 to the positive battery feeder 34. It will be seen that as long as negative polarity is transmitted to each box it is effective on one end of the electromagnetic coil 54 of that box and that under normal conditions this negative polarity is transmitted from a point beyond the coil on to the next box through the bridging shunt 103, but that as soon as this shunt is moved out of contact with the spring pressed terminal 104 the transmission of negative polarity to the next box is interrupted until such time as the succeeding shunt 103' moves into position to bridge the contacts 104, 105.

Now tracing the path of the signal or selector circuit through the boxes, positive polarity is transmitted from the positive battery feeder 34 through the branch feeder 34' to one end of the winding of signaling relay 41 and continuing through this winding to the terminal S1 on the control panel. From here the signal conductor S transmits the positive polarity out over the line to the signal terminal *s1* on the terminal block 64 of the first box A, from which a wire S5 conducts the signal current to the spring pressed contact 102 of that box. This contact is normally out of engagement with the signaling contacts 101 so that no circuit is completed through these contacts at this time. Leading from the spring pressed contact 102 is a second wire S6 extending to the other signal terminal *s2* of the box A, and from the latter leads the other portion of the signal conductor S extending to the next box B. The signal conductors extends through the entire series of boxes in this same manner and then returns to the terminal S2 on the control panel, from whence the current passes through the resistance element 39 and back to the negative battery feeder 35. Thus the signal current is normally impressed on the spring pressed contacts 102 of all the boxes, each of which contacts is at this time out of engagement with the cooperating signaling contacts 101.

With the specific construction of the box and a general understanding of its circuit connections in mind, it is opportune at this point to give a brief description of the operation of one of the boxes, before taking up in detail the recorder and other parts. Referring to one of the alarm boxes A or B (Figs. 1 and 7) we shall assume that starting from a normal condition, the control contact 121 is caused to complete a circuit through the companion control contact 122 in response to an alarm condition arising at the box. It will be seen that positive polarity will immediately be transmitted through contact 121, and wire 121' to the spring pressed terminal 113, such positive polarity being received from contact 122 which at this time has connection with the connector disk 94 through wire 122' and contacts 114 and 115. The positive polarity thus transmitted from the grounded disk 94 to the spring pressed contact 113 is conducted from said contact through wire 124 leading to one end of the coil winding 54. Since the other end of this coil continuously had negative polarity impressed thereon, the transmission of positive polarity to the opposite end of the coil, through the closing of the contacts 121 and 122, will result in immediate energization of the coil. Prior to or at the very instant that the main armature 55 starts its first upward movement, the secondary armature 85 is attracted toward the magnet core so that the secondary armature contacts 87 and 88 are separated, with the result that the transmission of positive polarity through wire P6 to the next succeeding box is instantly interrupted. The main armature completes its upward movement whereby its advancing pawl engages the next succeeding ratchet tooth. The opening of contacts 87 and 88 and the consequent interruption of the transmission of positive polarity back to the control panel functions to deenergize the positive line test relay 36 and to energize the pulsator 37 (as I shall hereinafter describe more in detail), resulting in the transmission of negative polarity to the energized box being interrupted. This causes the main armature to move downwardly and such movement of its advancing pawl results in a one step advancement being imparted to the rotor 57 in the direction indicated by the arrow. This moves the rotor contact pin 114 out of engagement with the spring pressed contact 115 but at the same instant the grounded contact segment 112 is moved into engagement with the spring pressed contact 113 so that positive polarity is transmitted through the latter contact and through wire 124 to the coil. At the end of this one step advancement the shunting contact 103 has separated from contact 105, thereby interrupting the transmission of negative polarity in the opposite direction to the next succeeding box. This first step advancement of the rotor does not bring the first of the signaling contacts 101 into engagement with the spring pressed contact 102, such occurring only on the second one step advancement occurring later. An insulating blank or gap portion 100 on the rotor is normally under the contact 102 and continues under said contact at the end of the first step advancement. The interrupting of the continuity of conductor P (at 87, 88) in a direction toward one end of the series of boxes and the interrupting of conductor N (at 104, 105) in the opposite direction with respect to the series of boxes, functions through the positive line test relay 36 and the negative line test relay 38 to cause the pulsator 37 to operate, whereupon current pulsations are transmitted over the effective portions of the box operating circuit P, N for successively energizing the coil 54 of the active box. The second upward movement of the main armature occurs on the first of these pulsations, and on the return of said armature the completion of the second one step advancement of the rotor 57 brings the first signaling contact 101 under the spring pressed contact 102. Since these rotor

contacts 101 are all grounded to the connector disk 94, the aforesaid engagement with the contact 102 establishes a shunt between the positive line conductor leading to the box and the signal conductor S which is connected to contact 102. The establishment of this shunt between the box operating circuit and signal circuit functions through the signaling or selecting relay 41 to control the transmission of actuating impulses to the recording apparatus, whereby upon the establishment of such shunt these recorder actuating impulses will first act to step up the first numeral wheel of the recorder. This will be later explained after the description of the recording apparatus. For the operation of the box, it will suffice to say that with the continued stepping around of the rotor 57 in response to the successive current pulsations transmitted over the box operating circuit, the hundreds numeral wheel of the recorder will be advanced to numeral 3 corresponding to the first three signal contacts 101 in the group; then the shunt between the box operating circuit and the signal circuit will be broken by the gap 100^1 following these three contacts, resulting in a selector operation occurring at the recorder so that when the single signal contact 101 of the second group moves under the spring contact 102 the tens numeral wheel of the recorder will be stepped up to numeral 1. The next gap 100^2 on the code wheel results in another selector actuation at the recorder so that the last four signal contacts result in the units numeral wheel being stepped up to numeral 4. Thus the motion of the group of signal contacts past the spring pressed contact 102 in the half revolution of the code wheel has resulted in a set-up of the numerals 3, 1, 4 on the printing type wheels of the recorder, this numeral set-up designating the box that is then operating. In the case of the box for signaling and recording a fire alarm, such as boxes A and B of Figure 1, the half portion of the code wheel representing one cycle of operation will have no further contact pins immediately following the contacts which resulted in the last numeral wheel being stepped up to its predetermined number, but in the case of a box intended to give a supervisory indication, such as box C, one or more signal contacts 101 will follow the last numeral contact, with a gap 100^3 in between, these latter contacts being arranged to cause the stepping up of a condition wheel at the recording apparatus, which condition wheel indicates the condition of the apparatus or device being supervised by that box. After all of the type wheels at the recorder have been set in their proper positions, a printing operation is performed for recording on a paper tape the number of the box operating and the condition, whether it be alarm or supervisory, at that box.

The rotor or code wheel 57 continues to advance without changing the condition of the box operating circuit until this rotor reaches a point one step short of the completion of a signalling cycle. A half revolution constitutes a signalling cycle, and in the particular construction shown this constitutes a movement of twenty steps or teeth on the ratchet wheel 56. At the nineteenth step the contact pin 108 moves under the spring pressed contact 109, thereby reestablishing the transmission of positive polarity over conductor P to the other boxes in a direction toward the C end of the series of boxes. This is a testing transmission of positive polarity to see if any of the other boxes in this direction in the series have been energized for the transmission of a signal. It will be noted that this nineteenth step does not bring the shunting contact 103' into engagement with both spring pressed contacts 104 and 105, so that negative polarity is not transmitted over conductor N in a direction toward the opposite end of the series of boxes. Hence, only an energized box in a direction toward the C end of the series can take the line on this nineteenth impulse. Assuming that no other box has been energized or placed in condition for operation by its control contacts 121—123, the previously operating box moves through its twentieth step and this brings contact 108 out of engagement with contact 109, and completes the shunt between contacts 104 and 105 through bridging contact 103'. The circuits are now in the same condition as at the start of the cycle, the two sides of the rotor of the alarm box A or B which was then operating being merely transposed. In the case of a box for signaling a fire alarm, if an energizing circuit is still maintained between control contacts 121 and 122 the box immediately continues through a second cycle.

In the case of a box for indicating a supervisory condition, if the condition has been corrected or reversed from that giving rise tc the first signal cycle then the contact 121 will have moved back into the engagement with contact 123, whereby the rotor will continue through its second cycle for transmitting a condition indication to show that the condition has been corrected or changed. This is illustrated by referring to Figure 8. If the valve is closed by screwing down the stem 139 the movable contact 121 is moved up into engagement with contact 122, and thereupon positive polarity is transmitted from the frame through rotating contact pin 114, through stationary spring contact 115, with which pin 114 is then engaging, thence through wire 122', contacts 122 and 121 and through wires 121' and 124 to the positive end of the box electromagnet. The box then starts to operate and the box rotor revolves through its complete cycle, corresponding to a half revolution, and in so doing signals that this particular valve has been closed. The rotor is compelled to complete this half revolution, even though the valve should be instantly opened again, because the segment 112' engages with spring pressed contact 113 after the first step advancement and continues to supply positive polarity to the box electromagnet. Assuming the valve to have been left closed, the rotor will stop at the end of this first cycle or half revolution because the diametrically opposite gap between the segments 112, 112' will then move over the contact 113, and also at this time contact pin 114 will be over spring contact 115' which cannot transmit positive polarity because control contacts 121 and 123 are separated. As soon as the valve is opened, however, these control contacts 121 and 123 engage and hence positive polarity is again transmitted from rotating pin contact 114 through said control contacts to the electromagnet, which causes the box to operate through its next half revolution or complete signaling cycle. This cycle will signal that this same valve has now been opened, such resulting from the fact that there are a different number of "condition" contacts 101 on one half of the rotor than there is on the other half. When the rotor finishes this cycle it will again stop and remain inactive until the valve

is again closed, whereupon the foregoing operation will be repeated.

Oscillator

As shown in Figure 9, the pulsator or circuit breaking device 37 for transmitting intermittent current pulsations over the box operating circuit comprises two electromagnetic coils 161 mounted in a frame 162 and arranged to oscillate a vertically swinging armature 163 mounted below the coils. A pin 164 projecting laterally from this armature plays in a substantially horizontal slot 165 provided in the end of a rocking arm 166. This arm constitutes an extension of a rocker member 167 which is pivotally supported at 168 on a vertical bar portion 162' of the frame 162. Suitably supported by this rocker member for conjoint movement are two mercury tube contactors 169 and 171 each having a pool of mercury therein adapted, when the tube is tilted in one direction, to close a circuit through contacts at one end, and, when the tube is tilted in the opposite direction to open the circuit through these contacts. Both tubes have their contacts at the same end, the tube 169 having the contacts 169' and 169'', and the tube 171 having the contacts 171' and 171''. When the present system is in its normal condition this pulsator is deenergized, and at that time a spring 174 functions to swing the armature and mercury tubes downwardly to the position illustrated, the mercury pools in both tubes closing the circuit connections through the contacts 169'—169'' and 171'—171'' at this time. Energization of the pulsator results in the armature swinging upwardly and in the tubes being tilted in the opposite direction, which causes the mercury pools to break the circuits through said contacts. Hence, as the coils 161 are energized and deenergized the tubes are tilted first in one direction and then in the other, causing the mercury in each tube to complete the circuit through that tube and then to flow to the other end of the tube and open this same circuit.

Referring to the circuit diagram of Figure 2 it will be seen that the contacts 169'—169'' of the tube 169 are interposed in series in the negative battery feeder 34, with the circuit normally closed through these contacts. When one of the boxes is energized the pulsator is automatically caused to oscillate and the alternate tilting of the tube 169 transmits current pulsations out over the box operating circuit to the energized box for advancing the electromagnetic motor element thereof step-by-step. As shown in Figure 2, the pulsator also makes and breaks its own coil circuit through the contacts 171'—171'' of the tube 171. A wire 176 leading from the negative battery feeder 35 at a point short of the tube 169 connects with the contact 171', and extending from the other contact 171'' is a wire 177 having connection with one side of the electromagnet coils 161. Thus with the mercury tube 171 in its normal position tilted downwardly at the left negative battery potential is normally effective on one end of the coils. Extending from the other side of the coils is a conductor 179 which connects with one of the lower pairs of contacts 36' of positive line test relay 36 and which also connects with one of the lower pairs of contacts 38' of negative line test relay 38. The other contacts of each of these pairs 36' and 38' are connected with a positive branch feeder 34' which connects with the positive battery feeder 34 and extends along the bank of relays for continuously supplying positive polarity to different windings and contacts thereof. It will therefore be seen that the deenergization of either or both relays 36, 38 will result in positive battery potential being transmitted through the wire 179 to the other side of the pulsator coils, causing the pulsator to start operating. The attraction of the armature 163 tips the tube 171 in the opposite direction with the result that the mercury pool therein flows down to the end of said tube, thereby interrupting the supply of negative polarity to the coils through contact 171'' and wire 177. Immediately, the pulsator deenergizes and the tube tilts in the opposite direction, thereby completing the coil circuit and resulting in a second energization, this intermittent operation continuing as long as positive potential is supplied to the coils from the positive and negative line test relays 36 and 38 through the wire 179. This second tube 171 might be eliminated entirely by connecting wire 177 from the coils 161 up to the contact 169'' of tube 169, thus having this tube perform all circuit breaking duties, but the arrangement illustrated is preferred because it distributes the current interrupting load. The closing of the contacts 169'—169'' concurrently transmits a current impulse down to the step-up or selector coils of the recording mechanism, as I shall presently describe, one of these impulses being transmitted with each oscillation of the pulsator. The pulsator is designed to be relatively slow acting, that is to say, its rate of oscillation is preferably such that approximately eighty or ninety pulsations are transmitted per minute. This comparatively slow oscillation follows from the provision of copper slugs or caps 181 at the lower ends of the coil cores, and from the gravitational effect of the mercury. Of course, if desired, the speed of oscillation may be adjusted to be relatively fast or relatively slow. Instead of such oscillator I might use the motor driven type of circuit breaker disclosed in my prior patent above mentioned.

Referring now to the pulsations which are transmitted from the pulsator to the recording apparatus, it will be seen that the contact 169'' of the tube 169 is connected with a wire 184 through which a negative current impulse is transmitted to the recorder every time that the mercury pool in said tube closes the contacts 169'—169''. Interposed in the path of this negative impulse is a selecting relay 185 which determines whether said impulse will be transmitted to the type wheel step up coils or to the selecting coils of the recorder. As will hereinafter more clearly appear, following the description of the recorder, it will be seen that the pulsator 37 functions as a synchronizing device for electrically synchronizing the operation of any operating box with the operation of the recorder. This follows from the fact that the box operating impulses which are transmitted out over the box operating circuit P—N, and the recorder operating impulses which are transmitted over the recorder operating circuit, represented in part by the wire 184, both originate from a common controlling device, viz., the pulsator 37. Therefore, the box operating impulses and the recorder operating impulses are always in a definite timed relation, determined by the speed of operation of the pulsator.

Selecting relay

As shown in Figure 11, this relay comprises a pair of contacts 186'—187' which are open when

the relay is deenergized, and a second pair of contacts 186''—187'' which are closed when the relay is deenergized. The energization of the relay reverses the relation by closing the contacts 186'—187' and opening the contacts 186''—187''. The relay may be of any desired construction for securing this operation, but in the preferred form shown the energization of the winding 188 draws an angularly shaped armature core 189 into a central opening in the winding, thereby oscillating a rocker member 186. The contact 186' has spring mounting on an arm 192 extending from said rocker member, and the contact 186'' has a lever mounting 193 arranged to be engaged by a screw 194 carried by the rocker member whereby rocking of said member upon the energization of a relay engages the contacts 186'—187' and separates the contacts 186''—187''. In the circuit diagram of Figure 2 I have illustrated this relay diagrammatically, wherein the rocker armature 186 and the two movable contacts 186' and 186'' are schematically illustrated as a single switch element 186x, and as shown therein one side of the relay winding 188 is connected through wire 196 with the negative battery feeder 35, and the other side of the relay winding is connected through a wire 197 with one of the contacts 41' of the signaling relay 41. The other contact 41' is connected with the positive branch feeder 34'. The signaling relay 41 in its normally energized condition holds the contacts 41' open so that the selecting relay 185 is normally deenergized, at which time the contacts 186x—187'' (corresponding to 186''—187'' in Figures 10 and 11) are closed. When the signaling contacts 101 of any operating box establish a shunt between the signal circuits and positive line P, as previously described, the signaling relay 41 is shunted out, closing the contacts 41', energizing the relay 185, and thereby opening the contacts 186x—187'' and closing the contacts 186x—187'. Wire 184 extending from the pulsator 37 connects with both front contacts 186'—186''. A wire 201 extends from the back contact 187' down to one end of the step-up coils 202 of the recorder, and a wire 203 extends from the other back contact 187'' down to one end of the selector or transfer coils 204 of the recorder. The step-up coils 202 (which advance the type wheels of the recorder) continuously have positive polarity impressed on their other end through wire 205 leading from the positive battery feeder 34, and hence these coils are energized each time that the relay or selecting switch 185 diverts one of the negative impulses from the pulsator 37 down the contact 187' and wire 201 to said coils. The selector coils 204 (which select or govern the sequence in which the type wheels are advanced) are adapted to have positive polarity impressed on their other end through a wire 206, 206' leading from the positive battery feeder 34, but controlled by a mercury tube which I shall later describe. Hence, assuming that these selector coils have positive polarity through said wire 206, 206' and mercury tube, it will be seen that said coils will be energized each time that the diverting switch 185 diverts one of the negative impulses from oscillator 37 down through contact 187'' and wire 203 to said coils.

From the foregoing it will be evident that during that operating interval when the signal circuit S has a normal current flow therethrough the relay 41 will be energized, the relay 185 will be deenergized, and negative current pulsations coming down from the oscillator 37 will be diverted through contacts 186x—187'' and wire 203 to the selector coils 204. When selecting type wheels, generally only one, two or possibly three such impulses is transmitted to the selector coils at one time or in succession. As soon as a shunt is established between the signal circuit S and positive line P through the signaling contacts 101 and 102 of the operating box, the signaling relay 41 is deenergized, the selecting relay 185 is energized, and the negative pulsations coming down from the pulsator through wire 184 are diverted through contacts 186x—187' and wire 201 to the step-up coils 202. With reference to the cooperation of the relays 41 and 185, it will be apparent that the signaling relay 41 might be provided with opening and closing contacts so that this relay itself could transpose the negative impulses from one wire 201, 203 to the other without the use of the selecting relay 185, but the provision of this latter relay is preferable because it can be made of a relatively heavy duty type for handling the relatively heavy current flow required for the various coils of the recording apparatus.

A wire 207 leads from the wire 184 down to printing coils (to be later described) within the recorder whereby negative pulsations can be transmitted by the oscillator down to these coils, independently of the selecting relay 185. When these coils receive positive polarity through the closing of a printing coil mercury tube switch the next succeeding negative pulsation through wire 207 is operative to energize said coils.

Recorder

Referring now to the construction of the recorder, illustrated in Figures 12 to 22 inclusive, it will be seen from the complete assembly view in Figure 12 that this device comprises a base casting 208 within which is housed the printing platen, the printing coils for actuating the same, the printing ribbon and its reels, etc. Hinged to the open top of this base casting is a cover 209, on the top of which is secured a housing 211 enclosing the printing wheels, step-up and selector coils, etc., and also secured to this cover is a housing 212 enclosing the time stamp apparatus. Referring to these step-up and selector coils and the printing wheels within the housing 211, it will be observed from Figures 13, 14, etc., that the step-up coils 202 consist of two coils disposed side by side and secured to the back wall of the housing. The selector or sequence coils 204 also consist of two coils disposed side by side above the step-up coils 202. Responding to the step-up coils is an armature 214 which extends across the core ends of both coils and is pivotally supported at 215 in the side walls of the housing. The armature comprises a forwardly extending plate portion 216 having vertical notches in its front edge, in which notches four advancing pawls 217, 218, 219 and 220 are pivotally mounted on a pivot pin 221. Referring to Figure 14, the pawl 217 operates the hundreds numeral wheel 222; the pawl 218 operates the tens numeral wheel 223; the pawl 219 operates the units numeral wheel 224; and the pawl 220 operates the condition wheel 225. All of these type wheels are coaxially mounted on a common shaft 226 (Figures 18 and 19) and each type wheel carries a ratchet wheel 227 adapted to be engaged by its individual step-up pawl 217—220.

The armature 214 is normally held in its raised position, illustrated in Figure 13, with all four

pawls clear of their respective ratchet wheels, through the action of two tension springs 229 which have adjustable connection at their upper ends with a stationary cross-bar 231 disposed above the armature. Nuts 232 or any other suitable adjusting means may be arranged for adjusting the tension of these springs 229. The upper limit of movement of the armature is determined by a stop screw 233 (Figure 14) having adjustable threaded mounting in the cross-bar 231. Secured to the front portion of the armature plate 216 is a plate 234 having a downturned front edge which is adapted to swing down into peripheral notches 235 formed between the type blocks on the printing wheels. This member 234 is adapted to move into one of these notches on the advancing type wheel just at the completion of the downstroke of the advancing pawl, whereby to prevent overthrow of the advancing wheel. Each pawl has two arms 217', 217''—218', 218'', etc. extending upwardly through slots in the armature plate 216 and detent plate 234, and connected to the rear one of these arms 217'', 218'', etc. on each pawl is a tension spring 237 having fixed attachment at its rear end to the armature plate, this spring normally tending to swing the lower nose of the pawl forwardly into a position to engage the ratchet teeth 227 of its respective type wheel. Whether the pawl is allowed to engage the teeth on its downstroke is determined by the angular position of a transverse shaft 238 which is arranged to coact with the front arms or fingers 217', 218', 219', etc., of each advancing pawl. Immediately in rear of each upper pawl finger this shaft 238 is notched out on opposite sides and is formed with diametrically opposite wing portions 239 which control the operativeness of the pawl. When these wing portions extend in substantially vertical parallelism with the rear edge of the pawl finger, the lower nose portion of the pawl is allowed to assume an operative position with respect to its own ratchet wheel, but when the shaft 238 is rotated slightly to swing one of the wing portions 239 forwardly against the pawl finger the pawl is oscillated against the tension of the spring 237 to a position where it is incapable of engaging its ratchet wheel on the downward stroke of the armature. As successive angular movements are imparted to the shaft 238 in this same direction, the pawl will still be held at its inoperative angle with respect to the armature plate 216 until the shaft 238 has been advanced through a half revolution, which again brings the wing portions 239 parallel with the pawl finger, allowing the pawl to resume an operative position with respect to the armature. The wing portions 239 cooperating with the pawl for the tens wheel 223 are at a slightly different angle than the wing portions cooperating with the pawl associated with the hundreds wheel, and this applies to the wing portions associated with the other pawls. In the normal position of the parts the hundreds wheel pawl is the only one in operative position; after the required number of steps have been imparted to the hundreds wheel the shaft 238 is rotated in a counterclockwise direction through a small angular movement and this renders the hundreds wheel pawl inoperative and the tens wheel pawl operative. Thereafter further oscillation of the armature imparts step-by-step advancement to the tens wheel until the shaft 238 is again rotated in this same direction, at which time the tens wheel pawl is rendered inoperative and the units wheel pawl is rendered operative. This same procedure follows in transferring impulses to the condition wheel 225. It will thus be seen that the shaft 238 functions as a selector element which, by its angular position, determines what pawl is operative and the order in which these pawls are made operative. Motion is imparted to this shaft from the selector coils 204 through mechanism which I shall presently describe.

Cooperating with the ratchets 227 of the four type wheels are four similar checks or holding pawls 241 which are pivotally mounted at 242 in slots formed in a transverse mounting bar or block 243. The nose of each holding pawl is adapted to swing down into the ratchet teeth of its associated type wheel to hold the type wheel after each step-by-step advancement. A tail 244 on each pawl bears against the top of a compression spring 245 seated in a cylindrical pocket in the mounting block 243, this spring normally tending to swing the nose of the pawl down into the ratchet teeth. At the conclusion of a printing operation all four holding pawls are simultaneously swung up to releasing position out of the ratchet teeth through the oscillation of a transverse shaft 246, which is journaled in the block 243. Splayed in said shaft are flat faces 247 which cooperate with shoulders 248 on the holding pawls. When these flat faces are substantially parallel with the shoulders 248, the pawls are permitted to swing down into their ratchets under the action of the springs 245, but when the shaft 246 is rotated counterclockwise to bring rounded portions of the shaft against the shoulders 248 all four pawls are swung upwardly to releasing positions. When this occurs at the end of a printing operation such type wheels as have been advanced are immediately restored to their original positions by the action of spiral springs 251 associated with each type wheel. Referring to Figures 18 and 19, one of these springs is enclosed within a drum or spring housing 252 at the end of each type wheel, the inner end of the spring being secured to the shaft 226 and the outer end being secured to the housing. The springs all tend to rotate the advanced type wheels in a clockwise direction back to their original positions, which original positions are determined by radially projecting shoulders 253 on the spring housings striking stop fingers 254 which extend from a cross bar 255 down into the path of these shoulders.

Referring to Figure 14, it will be seen that a vertical partition plate 256 is disposed intermediate the end walls of the housing 211, and disposed in the space between this partition plate and the left-hand wall of the housing are certain operating mechanisms and contact tubes which I shall now describe. Pivotally mounted at 257 on this partition plate is a tripping pawl 258, Figure 15, which is adapted to release the shaft 246 which allows the holding pawls 241 to engage the ratchets 227. A laterally bent end 259 on this tripping pawl 258 projects through a hole 261 in the partition plate into a position in the path of the armature plate portion 216 so that the first downward movement of the armature at the beginning of a recording operation strikes this end 259 and oscillates the pawl. Such movement swings a hook 262, at the other end of the pawl, out of engagement with a shoulder 263 formed in a notched wheel 264 secured to the shaft 246. With this releasing of the notched wheel 264 a tension spring 265, connected to said wheel, quickly oscillates the wheel and shaft in a clock-

wise direction for turning the flat faces 247 into registry with the shoulders 248 to permit the holding pawls 241 to swing down into operative engagement with their respective ratchet wheels 227. As before described, this first actuation of the stepping armature 214 operates through the advancing pawl 217 to advance the hundreds wheel 222 one step; this wheel is retained in that position by its holding pawl 241, all of which pawls have been dropped to operative position in the downstroke of the armature plate 216 before the operative advancing pawl 217 starts to move back and before the spring 251 can start to rotate this hundreds wheel backwardly. Thus, both operations of advancing the first numeral wheel and tripping the holding pawls to hold this and the other wheels, occur on the first current impulse transmitted to the stepping coils 202. Thereafter each succeeding one step advancement imparted to the type wheels is retained by the holding pawls, until the completion of the printing operation. Immediately following a printing operation another instrumentality rocks the shaft 246 in the opposite direction, allowing the hook 262 of the tripping pawl 258 to swing down into engagement with the shoulder 263 under the action of a tension spring 266, and concurrently therewith swinging all of the holding pawls 241 up to their released positions and locking them in this position, until the next downward oscillation of the armature 214 at the beginning of another recording operation, whereupon the pawl or lever 258 is again tripped and all of the holding pawls are again allowed to swing down to their operative positions, as above described.

Referring now to the mechanism by which the energization of the selector magnets 204 impart advancing movement to the selector shaft 238, it will be observed from Figure 13 that these two magnets attract an armature 271 which is pivotally mounted at its upper edge at 272. A pin 273 projects laterally from the lower edge of the armature and extends out through an opening 274 in the partition plate 256. Here this pin is pivotally connected to a link 275 which is pivotally connected at 276 to the upper arm of a lever 277. Said lever is pivotally supported on a stud 278 projecting outwardly from the side of the partition plate 256, and also mounted on this stud, but rotatable independently of the lever 277, is a ratchet wheel 279 and a spur gear 281, both integral. Pivotally mounted at 282 on the upper arm of the lever is a pawl 283, having a hook-shaped nose adapted to impart clockwise advancement to the ratchet wheel 279 when the lever 277 is oscillated clockwise. A tension spring 284 connected between the upper tail end of the pawl and the upper arm of the lever 277 functions to hold the hook end of the pawl in engagement with the ratchet teeth. A relatively heavy spring 285 is connected between the lower arm of the lever and a fixed point of attachment, such spring tending to oscillate the lever in a clockwise direction. A detent pawl 286, pivotally mounted at 287 and having a tension spring 288 connected thereto, is arranged to engage in the ratchet wheel 279 to prevent retrograde movement of the latter in the oscillation of the lever 277. The spur gear 281 meshes with a spur pinion 289 which is secured to the selector shaft 238, the pinion being one-half the diameter of the spur gear 281.

It will be evident that when the selector coils 204 are energized the movement of the armature 271 will operate through the link 275 to oscillate the lever 277 and pawl 283 in a counterclockwise direction, the pawl merely slipping idly over the next ratchet tooth in this movement. When the selector coils are deenergized the spring 285 quickly oscillates the lever 277 in a clockwise direction and in such movement the pawl 283 advances the ratchet wheel 279 and spur gear 281 through a distance equal to one ratchet tooth. Any suitable stop means may be provided for determining both limits of throw of the lever 277 so that such movement always results in a one tooth advancement of the ratchet wheel. Figure 15 illustrates this stop means as a stud 290 engaged by the pawl 283. With the clockwise movement of the spur gear 281 the selector shaft 238 is advanced in a counterclockwise direction, this shaft making one complete revolution for each half revolution of the spur gear 281. Mounted on the end of shaft 238 is a wheel or cam 291 having diametrically opposite notches 292 therein, which notched wheel controls certain of the mercury tubes associated with the recorder, as I shall presently describe.

One of these mercury tubes, indicated at 294 in Figures 16 and 20, is provided for controlling the transmission of positive battery potential to the selector coils 204, this tube being rocked to closed circuit position on the initial impulse of the step-up armature 214. This tube is suitably attached to a rocking plate 295 which is pivotally mounted on a stud 296 projecting laterally from the partition plate 256. A gear sector 297 is formed in the lower edge of the plate, these gear teeth meshing with sector teeth 298 formed in the upper edge of a swinging arm 299 which is secured to the end of holding pawl releasing shaft 246. During the normal non-signaling condition of the system the parts are in the positions illustrated in Figures 15 and 16 and at this time the tube 294 is held tilted upwardly at the left, which leaves the mercury pool removed from the contacts at the left-hand end of the tube 294. As previously stated, this interrupts the transmission of positive battery potential to the selector coils 204, which will be evident from the circuit diagram of Figure 2 wherein one end of these coil windings is connected through wire 206' with one of the contacts of the tube 294, and extending from the other tube contact is a wire 206 which connects to positive battery feeder 34. Hence, during this normal condition of the system even though the closed position of the oscillator 37 and the normal position of the selecting switch 185 are at this time directing negative polarity down to these selector coils 204 the latter are not energized because of the normally open condition of the tube 294. With the first energization of the step-up coils 202, consequent upon the first signaling contact 101 of the energized box engaging the stationary contact 102, the actuating movement of the armature 214 trips the retaining pawl 258, releasing the shaft 246 which is immediately oscillated clockwise under the tension of the spring 265, this also oscillating the gear arm 299 thereby swinging the selector tube 294 down to its closed circuit position. Thereafter the selector coils 204 have positive potential from the battery, but they are not energized until they receive negative potential consequent upon the first gap in the series of signaling contacts 101 moving under the contact 102 of the box transmitter. Extending laterally from the sector member 299 is an arm 301 which is adapted to engage the bottom edge 302 of the rocking

plate 295 to limit the downward tilting movement of the tube 294. Extending downwardly from the sector member 299 is an arm 303 which passes through a slot in the hinged cover 209 and extends into the base portion 208. This arm is arranged to be oscillated in a forward direction by the return movement of the printing platen at the end of the printing operation (by mechanism which I shall hereinafter describe) so that at the end of the complete type set-up and printing operation, the sector member 299 and shaft 246 will be rocked in a counterclockwise direction for restoring the parts to their original positions, with all of the holding pawls 241 raised to inoperative position and with the selector tube 294 tilted upwardly to its open circuit position.

Mounted above the tube 294 are two other mercury tubes 305 and 306, the former of which controls the energization of the printing coils in the base portion 208, and the latter of which serves as a selector return switch for restoring the selector mechanism to its original condition. Both tubes are mounted for conjoint swinging movement on a plate 307 which is pivotally supported on the same pivot axis 296 as the lower tube plate 295. The pivoted end of the upper plate 307 is formed at the front with a square shoulder 308, and projecting laterally from the lower plate 295, across the front of this shoulder 308, is a lug 309 forming a push surface cooperating with said shoulder. These two surfaces function to restore the tubes 305, 306 to their normal open circuit positions when the tube 294 is restored to its open circuit position. A section of the upper plate 307 is punched out and bent back to form a rider lug 311 for riding on the periphery of the notched wheel 291 mounted on the selector shaft 238. When the lower tube 294 tilts down to its closed circuit position upon the initial actuation of the step-up armature 214, the shoulder 309 separates from the shoulder 308 leaving the position of the upper tubes 305, 306 controlled entirely by the engagement between the lug 311 and notched wheel 291. It will be recalled that this selector shaft 238 is advanced step by step as the signal impulses are transferred from the hundreds wheel to the tens wheel, then to the units wheel and then to the condition wheel, and after a predetermined number of advancing steps have been imparted to this selector shaft one of the notches 292 in the wheel 291 moves under the riding lug 311 thereby allowing both tubes 305, 306 to drop to closed circuit position. Referring to Figure 2, the tube 305 in dropping to this position conducts positive polarity to the positive end of the printing coils 321, such being through the wire 312—312' extending from the positive battery feeder 34 to the tube and thence to the coils. Hence, when the next negative impulse is transmitted down from oscillator 37 it passes through wire 207 to the other side of said printing coils and energizes them. The other tube 306 in also dropping to closed position closes a circuit through wire 313—313' which extends from wire 207 to said tube and thence to the selecting coils 204. Therefore, the same next succeeding negative impulse which energizes the printing coils is transmitted from wire 207 through tube 306 for also energizing the selector coils 204, independently of the position of the selecting switch or relay 185. The deenergization of these selector or sequence coils restores the selector shaft and advancing pawls 217—220 to their original positions, ready for the next cycle. The return movement of the printing platen, away from its printing position, restores the tube 294 to its open circuit position and the restoring movement of the latter's supporting plate 295 operates through the shoulders 309, 308 to restore the upper tubes 305, 306 to open circuit positions, all of which will be hereinafter described in more detail in a description of the cycle of the complete system.

Referring now to the mechanism within the base casting 208, it will be seen from Figure 12 that the front of this casting is formed with a relatively wide opening 314 in the approximate center thereof, down through which travels the paper tape 315 upon which the records are printed. Vertical partition walls 316 and 317 define the sides of this central opening and also define left and right hand compartments 318—319 in the ends of the base casting. Vertically disposed in the left hand compartment 318 are the two printing coils 321 which attract an armature 322 extending across the tops of the coils. This armature is secured to a pivot shaft 323, having its ends mounted in trunnion bearings 324 carried by the side walls of the compartment. An arm 325 extends forwardly from the pivot axis of the armature and is connected to a tension spring 326 suitably anchored at its lower end to the base casting, this spring normally tending to swing the armature upwardly away from the printing coils. Projecting laterally from the swinging end of the armature is a pin 327 which projects into the central compartment 314 through a vertical slot 328 (Figure 22) in the upper portion of the partition wall 316. The end of this pin projects through a hole in a motion transmitting lever 329, the rear end of which is pivotally mounted on a stud 331 projecting inwardly from partition wall 316. The front end of said lever has a long slot 332 therein in which operates a pin 333 carried by one arm of a bell-crank lever 334. Said lever oscillates about a shaft 335 on which are mounted the paper feeding rolls 336 and 337. An arm 338, similar to the lower arm 334' of the bell-crank lever 334, is rotatably mounted on the shaft 335 at the other side of the opening 314, and extending between these two arms is an outer reinforcing bar 339 and a channel-shaped platen bar 341 in which the rubber platen block 342 is mounted. From the description thus far, it will be seen that the energized downstroke of the armature 322 will oscillate the motion transmitting lever 329 downwardly which in turn will swing the two arms 334' and 338 in an upward direction, carrying the platen 342 up into printing position. This printing position is defined by an inked ribbon 343 which extends transversely across the upper portion of the base casting directly below the printing faces of the type wheels. The paper tape 315 extends from the supply roll 315' across the tops of the feeding rolls 336, 337 and across the top of the platen 342 so that in the upward movement of the platen this paper tape is swung up against the bottom of the inked ribbon 343 through which it receives its printed impressions from the type wheels. The upward movement of the arms 334', 338 does not rotate the shaft 335 but the downward movement, after a printing operation, is arranged to advance this shaft for turning the feeding rolls the required distance for advancing the paper tape. Referring to Figure 23, the arm 338 carries a spring pressed pawl 345 which engages and rotates a ratchet wheel 346 when the arm swings down-

wardly, this ratchet wheel being secured to the shaft 335. A spring pressed detent pawl 347 prevents reverse rotation of the ratchet wheel when the platen swings upwardly. The forward rotation of said shaft rotates the feeding rolls 336, 337 and advances the paper tape the required distance for its next printing impression, the central roll 337 comprising a rubber surface which presses firmly against the paper tape, reacting against a small roller 349 rotatably supported on a shaft 351 which is secured to the hinged cover 209.

The mechanism for releasing the type wheels and restoring the mercury tubes 294, 305, and 306 to normal position comprises an arm 354 (Figure 22) which is secured to one end of a shaft 355 journaled in bearings 356 in the end wall and adjacent partition wall 316 of the base. The arm 354 is mounted on this shaft within the central opening 314 of the casting, and also mounted on this shaft within the compartment 318 is a lever 357 to the lower end of which a tension spring 361 is connected, the lower end of said spring being suitably connected to the base structure. The spring 361 exerts a constant biasing action on the shaft, tending to hold the upper arm of the lever 357 upright and to hold the other lever 354 in a substantially horizontal position, see Figure 22. The lower tripping arm 303 of the rocking sector 299 extends down into the base casting to a position immediately in front of the upper lever arm 357, whereby when this lever arm is rocked forwardly it engages and forces the tripping arm 303 forwardly for releasing the holding pawls and performing the other restoring operations previously described. The lever arm 354 has a beveled end 354' with which a stud 363 on the bell-crank lever arm 334' cooperates. On the upward movement of the platen the stud 363 engages the lower edge of the arm 354 and starts to swing the latter upwardly but because of the eccentricity between the centers 335 and 355 this stud soon slips past the beveled end 354' and continues its upward movement above the lever arm 354. On the down swing of the platen the pin 363 engages the upper side of the lever 354 and swings the latter downwardly to approximately the dotted line position illustrated in Figure 22, at which point the arc of the beveled tip 354' swings inside of the arc of the stud 363 so that the stud is allowed to continue its movement past the end of the arm 354. Instantly the lever 354 is restored to its normal position under the biasing action of the spring 361. In such downward swinging movement, however, the lever 354 also rocks the lever 357 in a forward direction and this movement operates to thrust the tripping finger 303 from the full line position to the dotted line position in Figure 22, thereby releasing the type wheels and restoring the mercury tubes, all at the completion of the printing operation when the platen is swinging downwardly to its normal position.

The paper supply roll 315' is supported between a stationary head member 365 and a rotating head member 366 both of which have forwardly protruding central boss portions 367 which extend into the center opening of the supply roll. The head member 366 is rotatably mounted on a shaft 368 which is supported in the walls of the casting, and mounted on this shaft is a compression spring 369 bearing against a collar 371 on the shaft. The spring pressure thus effective through the rotating head 366 yieldingly forces the supply roll against the stationary head 365 to impose the desired amount of friction to prevent overrunning of the roll. A knob 372 on the projecting outer end of the shaft 368 enables the head member 366 to be pulled outwardly when a new supply roll is being placed in position.

The inked ribbon 343 is adapted to travel first in one direction and then in the other between two reels 373 and 374 which are mounted in similar recesses 375 at opposite ends of the base casting. The intervening span of ribbon extends up through vertical slots in the end walls of the casting and then across the top of the partition walls 316, 317 directly below the printing line of the type wheels. Two spring retracted guide clips 377 are pivotally mounted on these partition walls, these clips having forked-shaped portions pressing down on the ribbon and engaging the side edges thereof for accurately guiding the ribbon. Such clips can be swung upwardly against the tension of their retracting springs to free the ribbon when the latter is to be changed. Each reel has detachable mounting on a shaft 381 which extends through bearing bosses in the side walls of the recess 375. These shafts have knobs 382 on their outer ends which enable these shafts to be pulled out of the reels when a new supply of ribbon is to be substituted, and in reinserting the shafts certain keyways therein are made to align with keys projecting from the reels so that rotative movement imparted to the shaft will be transmitted to the reel. The inner end of each shaft slides into keyed engagement with a bevel gear 384, the hub of which is rotatably mounted in the rear wall of the recess 375. A drive shaft 385 extends from end to end of the housing and carries bevel gears 386 and 387. Shifting of the shaft in one direction places the gear 386 in mesh with the left hand gear 384 for transmitting winding rotation to the left hand reel 373, and shifting of the shaft in the other direction interrupts this driving relation and places the other bevel gear 387 in mesh with the right hand bevel gear 384 for transmitting driving rotation to the other reel 374. Rotation is transmitted to said shaft through a sprocket wheel 388 over which travels a chain 389. This chain passes over a sprocket pinion 391 which is operatively connected through a pair of reducing gears 392 and 393 with a spur pinion 394 mounted on the shaft 335. Thus as intermittent motion is transmitted to this shaft for advancing the paper feeding rolls 336, 337 motion is also transmitted at a relatively slow speed to the lower drive shaft 385 for causing the ribbon 343 to be fed from one reel to the other. A knob 395 on the projecting outer end of the shaft 335 enables the feeding rolls to be advanced independently of swinging motion of the printing platen, so that the paper tape can be run forward manually if desired.

When one reel is almost unwound the direction of drive is reversed to cause the ribbon to travel in the other direction, such being effected through the instrumentality of a shifting rod 396 having sliding support in openings in the partition walls 316, 317. One end of said rod is bent forwardly and slotted as indicated at 397, the ribbon passing through this slotted portion. At the other end of the rod the ribbon similarly passes through a slotted pin 398 which projects from a block 399 secured to the rod 396. Metallic eyelets or other like projections 401 are secured to the ribbon adjacent to each end thereof, and when one of these eyelets engages either of the slotted members 397 or 398 the rod 396 is caused to move in the same direction with the ribbon travel. Pivot-

ally mounted on the lower portion of the block 399 is a pair of spaced links 402 between the swinging ends of which a roller 403 is supported. Cooperating with this roller is a vertical lever 404 having a wedge-shaped upper end 405 against which the roller is caused to bear under the pressure of a tension spring 406 pulling downwardly on the links 402. The lower end of the lever 404 has a slotted portion 407 embracing a shifting collar 408 which is rigidly pinned to the drive shaft 385. When the rod 396 is caused to shift in the other direction the roller 403 is carried over the crest of the tapered end 405 where the downward pressure of the roller acts on the reverse slope and causes the lever 404 to swing, for interrupting the drive to one reel and reestablishing the drive to the other reel for causing the ribbon to travel in the opposite direction.

Means is provided for indicating when the supply of paper on the roll 315' has become low, said means preferably comprising an arm 409 which is pivotally mounted at 410 in the base casting and which has its swinging end arranged to bear against the paper supply roll under the action of a spring 411, to follow inwardly with the decreasing diameter of this roll. A mercury tube 412 is arranged to be tilted by the movement of the arm 409 so that when the supply roll has diminished to a predetermined diameter the spring swings the arm 409 rearwardly past the roll so that the mercury tube will be tilted to a degree causing the mercury therein to close a circuit through its contacts 412'. This lights a low paper indicating bulb on the control panel, as I shall presently describe.

In substituting a new supply roll the hinged cover 209 is swung back to afford access to the open top of the base casting, and obviously such swings the type wheels up to a position where they would be ineffective to perform a printing operation. Accordingly, at this time, it is desirable that the system be rendered inoperative until after the new supply roll has been substituted and the hinged lid swung down to its normal position. To this end I have mounted a mercury tube 414 on the hinged cover 209 in such relation thereto that when the cover is in its normal position the circuit through the tube contacts is closed, but when the cover is tilted upwardly this circuit is opened. Said tube is connected in one of the leads extending from the battery to the control panel, as shown in Figure 2, where the tube is illustrated as being interposed in the negative battery feeder 35 at a point short of the connections of the various devices on the control panel with this feeder.

Mounted at any suitable point on the base casting adjacent to the paper discharge opening 314 is a lamp 415 (Figure 21) which is energized during the operation of the system for illuminating the paper tape.

All of the circuits leading to the recorder are extended to the stationary base portion of a multiple jack connector block indicated at 416 in Figure 12. This stationary base portion 417 is fixedly mounted on the support on which the recorder rests, and has a plurality of upwardly projecting jack connectors 418 to which all circuit wires leading to the recorder are individually connected. The base casting 208 of the recorder carries the upper portion 419 of the multiple connector block, and in this portion contact sockets 420 are provided to fit down over and establish electrical contact with the jack connectors 418. Leading from these sockets are wires running in the recorder assembly to the step-up and selector coils, the printing coils, the mercury tube switches, the low paper tube 412, the illuminating lamp 415, the time stamp, etc. In removing the recorder assembly it is only necessary to lift the recorder off the stationary base portion 417 of the connector block, there being no need of manually connecting or disconnecting any of the circuit wires. A multiple connector block 423 is also provided between the base casting 208 and the hinged cover 209 of the recorder. All circuits leading to devices mounted on the hinged cover are extended to a terminal block 424 (Figure 21) in the top of the base casting where they have connection with spring pressed contacts 425. The hinged cover 209 has a like terminal block provided with cooperating contacts, which, when the cover is closed, complete the circuits through these contacts to the electrical devices on the cover.

The electrically operated time stamp 212 is of any conventional type comprising printing time wheels which are advanced periodically, such as each minute, from electrical impulses transmitted from a master clock or other time controlled electrical circuit. These time wheels print on the paper tape, alongside the numeral and condition wheels, the day, month and year and time of day when the signal operation was received and recorded. The housing 211 enclosing the numeral and condition wheels preferably has removable top and inclined front windows 211' through which the type wheels and their actuating mechanism can be inspected.

The control panel X also comprises other relays for maintaining other circuits and apparatus under continuous test and for performing other functions to be later described. Included in this group is an oscillator test relay 427 which is normally energized and which is provided with two pairs of normally open contacts; a signaling circuit trouble relay 428 which is normally deenergized and which has two pairs of normally open contacts; a bell circuit test relay 429 which is normally energized and has two pairs of contacts normally open; a set-up relay 431 which is normally energized and has one pair of normally closed contacts and two pairs of normally open contacts; and a ground test relay 432 which is normally deenergized and has two pairs of normally open contacts. A heavy duty alarm relay 433 is also operatively responsive to certain movements of the directing switch or relay 185, this alarm relay having contacts for closing alarm bell circuits. An overload circuit breaker 434 is also connected in series in the box-operating circuit to protect the system against any accidental overload, and a voltmeter 435 may be mounted on the panel for indicating the voltage of the battery 35. The normal operation of the system is audibly indicated at the control panel by the sounding of a single stroke bell 436, and any abnormal condition arising on the system is audibly indicated by a trouble bell 437 having a distinctive pitch. Cooperating with this trouble bell is a trouble lamp 438 which can be switched on to the trouble indicating circuit, in lieu of the bell 437, through the medium of a three point switch 439. A 110 volt lighting circuit 441—442 is extended to the control panel for energizing the trouble bell 437 and lamp 438, and for also energizing the various pilot lamps which are associated with the various test relays, etc. These pilot lamps will be described in the description

of the circuit connections of their respective relays.

All of the relays illustrated in Figure 2, with the exception of the signaling relay 41, have testing or trouble indicating functions associated with different parts of the system maintained under continuous test. Each of said relays comprises a pair of cooperating contacts *b* and a pair of cooperating contacts *l*, the contacts *b* controlling a common circuit for the trouble bell 437 and the contacts *l* controlling individual circuits leading to individual pilot lamps on the control panel which designate the particular relay at which the contacts *l* are closed. The wire 441 of the lighting circuit is extended along the bank of relays and is connected to one of the contacts *b* and to one of the contacts *l* of each relay. The connections with the contacts of the oscillator test relay 427 will serve to illustrate the connections of the other trouble indicating relays. Referring to this oscillator test relay, a wire 444 leads from the lighting circuit conductor 441 and connects with two of the contacts *b* and *l* which, in the illustrated arrangement, happen to be the two adjacent or "inner" contacts. In the same manner, the lighting circuit conductor 441 is connected to the two adjacent or inner contacts *b* and *l* of each of the other trouble indicating relays 38, 36, 428, 429, 431 and 432. Referring again to the oscillator test relay 427, a wire 445 leads from the cooperating or "outer" contact *b* to a common return conductor 446 which extends back to one side of the trouble bell 437. In the same manner, each of the other testing relays has a wire leading from the cooperating or outer contact *b* to this common return 446. The cooperating or outer contact *l* has leading therefrom a wire 447 which extends up to the lamp 448 in the group of pilot lamps. In the same manner the corresponding outer contact *l* of the negative line test relay 38 connects through wire 449 with a lamp 450; the positive line test relay 36 connects through wire 451 with lamp 452; the signal circuit trouble relay 428 connects through wire 453 with lamp 454; the bell circuit test relay 429 connects through this same wire 453 with the same lamp 454; and the ground test relay 432 connects through wire 455 with lamp 456. (The connections of the set-up relay 431 will be later described). The other terminal of each of the aforesaid pilot lamps connects with the other side 442 of the lighting circuit. Also, the other terminal of the trouble bell 437 is connected with this other side 442 of the lighting circuit through the three point switch 439, which is normally in the position illustrated to complete the circuit through the trouble bell. Under the continuous test conditions under which these relays operate, they are normally energized (with the exception of the signal circuit trouble relay 428 and the ground test relay 432 which are normally deenergized) by continuously flowing testing currents, and in such normal condition the contacts *b* and *l* of each relay are held separated. As soon as one of said relays is deenergized, or the relays 428 or 432 are energized, both pairs of contacts close, with the result that the contacts *b* of the operating relay complete a circuit from the wire 441 of the lighting circuit to the common return 446 leading back to the trouble bell 447, thereby causing said trouble bell to sound continuously, and the other contacts *l* of the operating relay complete a circuit from the wire 441 up to an individual one of the pilot lamps, the lighting of which designates the particular relay which is then operating to indicate trouble. The use of illuminating pilot lamps is preferable, but target annunciators or other visual indicators might be substituted therefor.

If it is desired to interrupt the sounding of the trouble bell 437 until the system is again restored to normal condition, the switch 439 is actuated to interrupt the connection of the wire 442 with the trouble bell, but such actuation of the switch automatically places the trouble lamp 438 in shunt across the lighting circuit 441, 442, which remains lighted as long as the switch is in this position, irrespective of whether the relays are energized or deenergized, for indicating that the trouble bell is not in circuit.

The cooperating or outer contact *l* of the set-up relay 431 is not connected to a lamp in the group of pilot lamps but is connected through a wire 458 with one terminal of the lamp 415 which is mounted in the base portion of the recorder for illuminating the paper tape. A wire 459 leads from the other terminal of this lamp up to the conductor 442 of the lighting circuit. The set-up relay is deenergized whenever the system starts to transmit signals, and thereafter during the entire signaling operation, and until this relay is manually reset, the contacts *l* maintain a closed circuit from the wire 441 through the lamp 415 and back to the wire 442 for illuminating the data recorded on the paper tape, such lamp at this time also serving as a pilot lamp for indicating that the set-up relay is deenergized. As soon as one of the boxes starts to operate the set-up relay is deenergized and remains deenergized after the signaling cycle is completed, continuing to sound the trouble bell and to keep the lamp 415 burning so that if the attendant is absent he is immediately apprised upon his return of the fact that the system has been operating.

Another lamp 461 in the pilot group is connected through a wire 462 with one terminal of the low paper mercury tube 412, the other terminal of this tube being connected through wire 463 with the conductor 441 of the lighting circuit. Hence, whenever the supply of paper diminishes to a predetermined low point, the tilting of the tube 412 completes a circuit through the lamp 461 for indicating the low supply of paper.

Referring now to the functions of the relays, the positive line test relay 36 and the negative line test relay 38 have certain normal signaling functions which occur when any one of the boxes A, B, C, etc. is energized, as I shall hereinafter point out in the description of the general operation of the system, but in addition to these normal functions said relays also have trouble indicating functions. For example, if the positive conductor P should be accidentally broken at any point in its length, aside from the operation of a box, the positive line test relay 36 will be immediately deenergized, resulting in the ringing of the trouble bell 437 and the lighting of the pilot lamp 452. Likewise, if the negative conductor N should be accidentally broken at any point in its length, aside from the operation of a box, the negative line test relay 38 will be immediately deenergized, resulting in the ringing of the trouble bell 437 and the lighting of the pilot lamp 450.

Referring now to the function of the oscillator test relay 427, the actuating coils 161 of the oscillator 37 are normally maintained under continuous test during the normal non-signaling condition of the system by the oscillator test relay 427. The wire 179, which is adapted to conduct

positive polarity to the oscillator coils, is also extended to one end of the winding of said testing relay 427, and the other end of said relay winding is connected to the positive battery feeder 34. With the pulsator in the normal position shown in Figure 2, a continuous testing current is passed from the positive feeder 34 through the winding of the test relay 427, through wire 179 and through the coils 161 back to negative feeder 35. The resistance of the testing relay winding is sufficiently high so that this normal testing current is insufficient to actuate the armature 163 of the pulsator, but this testing current normally keeps the relay 427 energized, with its two pairs of trouble contacts *b* and *l* open. If any break should accidentally occur in the pulsator coils or in the circuit thereof, the relay 427 is instantly deenergized, resulting in the closing of the aforesaid contacts, thereby sounding the trouble bell 437, and designating the particular trouble by illuminating the lamp 348 which indicates a break in the pulsator energizing circuit.

With reference to the signaling relay 41, as previously described one end of the winding of this relay is connected with the positive branch feeder 34' and the other end of the winding is connected with the signal circuit terminal S^1 on the control panel. This signal circuit is completed through the series of boxes A, B, C, etc., and back to the signal circuit terminal S^2 on the panel, thence extending through the resistance element 39 back to the negative feeder 35. It will be apparent that any time one of the signaling boxes places positive battery potential on the signal loop S, the winding of the signaling relay 41 is shunted, with the result that the relay armature falls away so that the contacts 41' are closed and the coil 188 of the directing switch or relay 185 is energized. As previously described, the energization of the coil 188 actuates the movable switching element of the device 185 to establish a circuit from the wire 184 through the wire 201 to the step-up coils 202, the circuit of which is completed through the wire 205 leading to the positive feeder 34. The transmission of current impulses through wire 201 to the step-up coils 202 also energizes the relay 433 and sounds the alarm bell 436 in code impulses corresponding to the box designation, as I shall hereinafter describe. When the winding 188 of the directing switch is deenergized the switching element assumes the position shown, at which time current impulses are transmitted from the wire 184 through the wire 203 to the selecting or sequence coils 204.

The signal circuit trouble relay 428 differs from previously described relays 36, 38, 427 and 41 in that its winding is normally deenergized but the trouble contacts *b* and *l* are nevertheless normally open, these contacts being closed when the relay winding is energized. This winding is connected directly in shunt across the two ends of the signal circuit loop S. Hence, when this loop is complete, which is its normal condition, it short circuits the winding of this relay 428, maintaining the latter deenergized with the trouble contacts open. In the event of a break accidentally occurring at any point in the signal loop S, the short circuit across the relay winding is opened and the relay is immediately energized, thereby sounding the trouble bell 437 and illuminating the lamp 454 for indicating signal circuit trouble. It will be evident that the winding of said relay is energized by receiving positive polarity from the branch feeder 34' through the winding of signaling relay 41 and through wire 481 to one end of the winding of relay 428, the other end of said latter winding receiving negative polarity through resistance 39 and wire 482.

The bell circuit test relay 429 has the same two pairs of trouble signaling contacts *b* and *l*, and one end of the normally energized winding of this relay receives positive potential from the branch feeder 34'. The other end of the relay winding is connected through a wire 483 with one terminal of the single stroke signal bell 436. The other terminal of said bell connects through wire 484 with the negative feeder 35. Hence it will be seen that a testing current normally continuously flows from the positive branch feeder 34' through the winding of relay 429, through wire 483, through the windings of the bell 436 and through wire 484 back to negative feeder 35. The resistance of the winding of relay 429 is made sufficiently high so that this testing current will not hold the armature of the bell in an attracted position, but if a break should occur in the coils or circuit of the bell the relay 429 is immediately deenergized, thereby sounding the trouble bell 437 and illuminating the lamp 454 for indicating trouble in the bell circuit. If desired the bell circuit test relay 429 may be provided with an individual pilot lamp, separate from the signal circuit trouble relay 428, but since both relays test signal or bell circuits I have found it practicable to have only one pilot lamp responsive to the two relays.

The set-up relay 431 comprises the two pairs of normally open trouble contacts *b* and *l* and also comprises a pair of normally closed contacts 485. One of the latter contacts always has positive polarity from the branch feeder 34' and the other of said contacts is connected through wire 486 with one end of the relay winding. The other end of said winding is connected through wire 487 with the negative conductor N extending out over the box operating circuit from the negative line terminal NL. This relay will remain energized with the contacts 485 closed as long as the system is in its normal condition with a continuous testing current flowing out over the negative line conductor N. However, as soon as the transmission of negative polarity over this conductor is interrupted, as by the tilting of the pulsator 37 to its circuit opening position, the supply of negative polarity through wire 487 to the relay winding is interrupted and consequently the relay is deenergized and the contacts 485 are separated. The relay will remain deenergized during the entire signaling operation because the opening of the contacts 485 has broken the supply of positive polarity to the other end of the relay winding. The trouble bell signaling contacts *b* have the same above described connection with the wires 441 and 446 so that the closing of these contacts provides a current path for energizing the trouble bell 437. As previously described, the closing of the other pair of contacts *l* completes the circuit through wires 458 and 459 for the lamp 423 which is mounted in the base portion of the recorder for illuminating the paper tape, this lamp, therefore, continuing to burn during the entire signaling operation and until this set-up relay is reset to normal condition. The resetting is performed by the closing of a suitable momentary switch 488, mounted on the control panel. One contact of this switch is connected with the positive branch feeder 34' and the other contact is connected through wire 489 with the wire 486, whereby the momentary

closing of this resetting switch at the completion of the signaling operation establishes a shunt across the relay contacts 485 and supplies positive polarity to the relay winding for locking up the relay in an energized condition.

The ground test relay 432 has a normally deenergized winding and has its trouble bell contacts *b* connected to the wires 441 and 446 of the trouble bell circuit, the same as the other relays, and has its trouble lamp contacts *l* connected respectively with the wire 441 and the wire 455, so that the energization of this relay energizes the trouble bell 437 and lights the trouble lamp 456. One end of the relay winding is grounded and the other end is connected through wire 491 with a suitable mid-point of the battery group 33, such as to the conductor 492 which connects one group of cells with the other.

By virtue of having this relay connection established at an intermediate point in the group of battery cells, the relay is energized in the event that a ground should occur on any conductor in any part of the system, since a ground effective on either the negative or positive side of the battery supply will still energize the relay winding, with the consequent energization of the trouble bell 437 and the illumination of the lamp 456.

The heavy duty alarm relay 433 has positive polarity constantly applied through wire 494 to one end of this winding, and the other end of said winding is connected through wire 495 with the wire 201 that leads to the step-up coils 202 of the recorder. Thus, each time that a current impulse flows through these coils for advancing one of the type wheels of the recorder the relay 433 is also energized. The attraction of the relay armature is arranged to close two or more pairs of contacts 496 and 497. One pair of contacts 496 completes a circuit through wires 494 and 498 for the single stroke signaling bell 436. The other contacts 497 may likewise be arranged to close an audible signaling circuit (not shown) extending out to a plurality of single stroke signaling bells located at different parts of the building, or these latter contacts may control a circuit leading to a district fire alarm station or the like. It will be evident that each time the step-up coils 202 receive a negative impulse through wire 201 for advancing the type wheels the signal bell 436 (and such other bells as may be responsive to the contacts 497) also receive one signal impulse. Thus, if a box designated by the numerals "3—1—4" is transmitting its signals over the system the alarm bells receive in succession first three impulses, then one impulse, and then four impulses, for audibly designating in code the location of the box which is then signaling. If condition signaling impulses are transmitted from the energized box these bells will also sound in code this condition being signaled from the box.

Operation

Assume now, with all of the devices in their normal positions as shown in Figures 1 and 2, that through the opening of a sprinkler head, the flow responsive switch 49 associated with box B is caused to close. This immediately transmits positive polarity from conductor P to one end of the electromagnet 54 through frame *f*, contact 114, one or the other of the spring pressed contacts 115 or 115', wire 122'; flow responsive switch 49, wire 121' and wire 124 to the electromagnet. Since the other end of the electromagnet normally has negative polarity impressed thereon from conductor N through wire N6, the electromagnet is energized immediately with the closing of the flow responsive switch. The first action occurring within the box is the instantaneous movement of the secondary armature 85, with the immediate opening of the contacts 87 and 88. This immediately opens the conductor P at a point beyond the box, i. e., at a point beyond the connection between the positive conductor and the electromagnet 54. Hence, the transmission of positive polarity is interrupted to box C and to all other boxes in this direction in the series and hence no one of these boxes can take the line at this time. Substantially simultaneously with the operation of the secondary armature 85, the primary armature 55 of box B moves upwardly and engages its advancing pawl 56 with the next successive tooth on the ratchet wheel 58. The act of interrupting the continuity of conductor P back to the control panel, through the opening of contacts 87, 88 has interrupted the flow of current through the winding of the positive line test relay 36. The deenergization of this relay sounds the trouble bell 437 and illuminates the trouble lamp 452, as previously described; and the closing of the relay contacts 36' transmits positive polarity from the branch feeder 34' through the wire 179 to the positive end of the oscillator coils 161. The oscillator is immediately energized, thereby rocking the two contactor tubes 169 and 171 into their circuit opening positions. This opens the negative feeder 35, through the tube 169, thereby interrupting the transmission of negative polarity out over conductor N to the boxes. The transmission of negative polarity down through wire 184 and selecting switch 185 is also interrupted, but such has no effect at this time because the switch is connected through wire 203 with the selector coils 204, the circuit of which is open at the mercury tube 294. The act of interrupting the transmission of negative polarity out over conductor N deenergizes the electromagnet 54 of the box B, resulting in the armature 55 thereof dropping downwardly and advancing the ratchet wheel 58 one step. Such performs two switching operations with respect to the box operating circuit P—N. With respect to conductor P, it moves one of the arcuate segments 112 or 112' under the spring pressed contact 113 for placing a closed shunt across the flow responsive switch 49, whereby positive polarity is conducted through frame *f*, the aforesaid contact segments, and the contact 113 to the electromagnet. Thus, even if the flow responsive switch 49 should return to its normal open position after this first step advancement of the rotor, the energized box is nevertheless compelled to complete the signaling cycle which has been started, that is the rotor is compelled to rotate through a half revolution until the diametrically opposite gap between the arcuate segments 112, 112' moves under the contact 113. With respect to the negative conductor N, this first step advancement of the rotor moves either the bridging contact 103 or 103' out from its shunting relation between the spring pressed contacts 104, 105, whereby the transmission of negative polarity through conductor N is interrupted at a point beyond box B (at a point beyond the connection of electromagnet 54 of box B with the conductor N) so that box A and all of the other boxes toward this end of the series do not now have negative polarity transmitted thereto, nor is this negative polarity transmitted on back to negative return terminal NR on the control

panel. With reference to the signal loop S, the first or leading signal contact 101 of the lower group of contacts on the rotor is preferably spaced two steps away from the spring pressed contact 102 so that the first step advancement of the rotor has no effect on the signal conductor S. The interrupting of the negative return back through terminal NR on the control panel deenergizes the winding of negative line test relay 38, with the result that the contacts 38' thereof close and transmit positive polarity from positive branch feeder 34' through wire 179 to the coils 161 of the oscillator. At the same time that the oscillator interrupted the transmission of negative polarity out over conductor N to the energized box B it also interrupted its own circuit through its coils 161, and at about the same instant that the box armature 55 is rocking downwardly in its first advancement of the ratchet wheel 58 the tubes 169 and 171 of the oscillator are also rocking downwardly toward their closed circuit positions. Hence, when the interruption of the negative conductor N at the contacts 104, 105 of said box deenergizes the negative line test relay 38, as above described, the transmission of positive polarity from the relay contact 38' over the wire 179 to the oscillator 37 finds the oscillator coils 161 supplied with negative polarity through the lower mercury tube 171. Substantially at the same instant that the oscillator 37 completed its own coil circuit through said tube 171 it also transmitted a current pulsation through tube 169 out over the negative conductor N to the energized box B for rocking the armature 55 upwardly. The above described transmission of positive polarity from the relay contacts 38' through wire 179 to the oscillator 37 energizes said oscillator for rocking its tubes and interrupting the current pulsation out over conductor N and for interrupting its own coil circuit. Thereupon the box armature 55 rocks downwardly for advancing the ratchet wheel one more tooth, and substantially at the same time the oscillator armature rocks downwardly in the act of again completing the circuits through the tubes 169 and 171. This completes the second one-step advancement of the box rotor. At this time, attention is directed to the manner in which positive polarity is transmitted over wire 179 to the oscillator coils. The first time positive polarity was transmitted over this wire such was effected solely by the positive line test relay 36 through its contacts 36'. At the first energization of the box electromagnet 54 the opening of the secondary armature contacts 87, 88 deenergize this relay and thereby transmit positive polarity to the oscillator coils. At the completion of the first step advancement of the rotor the negative return to negative line test relay 38 was interrupted and the consequent deenergization of this relay and closing of its contacts 38' thereupon transmits positive polarity to the wire 179. The latter relay 38 remains deenergized throughout the remainder of the signaling cycle of box B and hence this relay continuously supplies positive polarity to the wire 179 until the completion of the signaling cycle. With each subsequent energization of the box electromagnet 54 the opening of the secondary armature contacts 87, 88 also deenergizes the positive line test relay 36 and the contacts 36' thereof also transmit positive polarity to the wire 179, but reliance need not be placed upon this relay for connecting positive polarity to said wire during the remainder of the signaling cycle. The continued deenergization of the negative line test relay 38 during the remainder of the cycle operates through contacts *b* to establish another circuit for maintaining continued sounding of the trouble bell 437, and the contacts *l* illuminate the pilot lamp 450. The placing of positive polarity on the wire 179 also deenergizes the oscillator test relay 427, thereby completing another circuit for energizing the trouble bell and also illuminating the pilot lamp 448. Moreover, with the first rocking movement of the oscillator tube 169, interrupting the transmission of negative polarity out over the conductor N, the set-up relay 431 was deenergized by reason of the interruption of negative polarity thereto, and, consequently, this relay becomes unlocked for the remainder of the signaling cycle—by reason of the separation of the contacts 485—and in such condition said relay maintains the tape illuminating lamp 415 burning throughout the signaling cycle.

Now referring back to the conditions which arise when the rotor of box B is advanced to the completion of its second step of movement, it will be seen from Figures 1 and 7 that the first signaling contact 101 has moved under the spring pressed contact 102. Engagement between these contacts occurs upon the downstroke of the armature 55, when the mercury in the oscillator tube 169 has rolled away from the tube contacts. Before the tube is rocked in the other direction and the mercury has rolled back into engagement with these contacts 169', 169'' for transmitting another negative pulsation out over conductor N, the engagement between signaling contacts 101, 102 has brought about an operation through the signal circuit S which results in this next negative pulsation being effective at the recorder. More specifically, the engagement between said signaling contacts transfers positive polarity through frame *f*, contacts 101, and 102 and signal loop S back to one end of the winding of signaling relay 41, and since the other end of the winding also has positive polarity this relay is deenergized. The consequent closing of the contacts 41' transmits positive polarity through wire 187 to the winding 188 of the relay or switch 185, thereby energizing the same and shifting the movable member 186 to complete a circuit from wire 184 down to wire 201 and hence through the step-up coils 202 and wire 205 back to positive battery feeder 34. Hence, when the oscillator tubes rock downwardly to transmit the succeeding negative pulsation out over conductor N this same negative pulsation is also transmitted down through the switch 185 to the step-up coils 202 and energize the same. With the energization of these coils, the advancing pawls are actuated and the hundreds wheel 222 is advanced one step. The downward movement of the armature 216 (Figures 13 and 15) in advancing said wheel trips the pawl 258, thereby enabling the shaft 246 to rock, which enables all of the holding pawls to move into cooperative engagement with the ratchets on the type wheels for holding each of said wheels in their successively advanced positions. The rocking of said shaft also operates through the sector members 299 and 295 to oscillate the mercury tube 294 to closed position. It will hence be seen that the first energization of the step-up coils 202 for imparting the first advancing movement to one of the type wheels also trips the tube 294 to closed position so that, as will be seen from Figure 2, positive potential is thereafter transmitted to the selector coils 204 whereby said latter coils are thereafter in readi-

ness to be energized by the transmission of a negative impulse down through wire 203. The two upper tubes 305 and 306 are maintained in their elevated, open circuit positions by virtue of the lug 311 riding on the outer surface of the notched wheel 291 at this time. At the same time that a negative impulse was transmitted down through wire 201 to the step-up coils 202 this same negative impulse also energized the bell circuit relay 433 which caused one stroke to be sounded on the signal bell 436, and on any other indicators responsive to the relay contacts 497.

This same negative impulse which caused the first step advancement of one of the type wheels and the first sounding of the signal bell has energized concurrently therewith the electromagnet 54 of box B for the third upward movement of its armature 55. The interruption of this impulse, by the pulsator 37 oscillating its tubes to open circuit positions, allows the armature 55 to drop back, thereby causing the rotor to be advanced to the end of its third one-step movement. This brings the second signaling contact 101 under the spring pressed contact 102, such occurring before the oscillator tubes rock back to closed circuit positions. The engagement between the second contact 101 and the contact 102 maintains the signaling relay 41 deenergized so that the selecting switch 185 is maintained energized for holding its movable member 186 in engagement with contact 187' connecting through wire 201 with the step-up coils 202. Hence, when the oscillator tubes rock back to their closed circuit positions the negative impulse transmitted out over conductor N and down through wire 184 again energizes substantially simultaneously the electromagnet 54 of the operating box and the aforesaid step-up coils of the recorder, whereby the hundreds type wheel is advanced a second step. Upon the cessation of this impulse the box rotor is advanced to the third signaling contact 101, and when the next negative impulse is transmitted from the oscillator it finds the movable member 186 of the selecting switch 185 still in its previous position so that this impulse is also transmitted down to the step-up coils for advancing the hundreds wheel to the third position. I have arbitrarily given box B the code designation "3—1—4", and hence this is as far as the hundreds wheel should be advanced.

Upon the cessation of this last negative impulse which steps the hundreds wheel to numeral 3 the armature 55 of the operating box drops back and advances the rotor one more step. Such movement carries the third signaling contact 101 past the spring contact 102 and moves an insulated blank portion of the rotor under the contact 102. This immediately takes positive polarity off of the signaling loop and consequently the signaling relay 41 is immediately energized. The opening of the contacts 41' deenergizes the winding of the selecting switch 185, which results in the movable member 186 thereof swinging back into engagement with contact 187'' for completing a current path down through wire 203 to the selector coils 204. Accordingly, when the oscillator transmits its next negative pulsation the current flow is conducted through the selector coils, which previously had positive polarity established thereto through the closing of the mercury tube 294. The deenergization of said coils advances the cam shaft 238 one step for throwing the advancing pawl 217 out of coaction with the hundreds wheel and for throwing the advancing pawl 218 into coaction with the tens wheel 223. The one step advancement of the cam shaft 238 also brings the next notch 292 of the notched wheel 291 one step closer to the supporting lug 311 which holds the mercury tubes 305, 306 elevated. The cessation of that same negative impulse which energized the selector coils for their first actuation allows the box armature 55 to drop back and to advance the rotor to the end of its next step. This brings another signaling contact 101 under the contact 102, thereby immediately deenergizing the signaling relay 41 and energizing the selecting switch 185 for shifting the movable element 186 back to a position for completing a current path down through wire 201 to the step-up coils 202. Consequently, when the oscillator tubes rock back and transmit their next negative impulse this impulse is transmitted to said step-up coils, whereby a one-step advancement is imparted to the tens wheel. The cessation of this impulse advances the rotor one more step, which brings an insulated blank portion under the contact 102, thereby allowing energization of the signaling relay 41, and deenergizing the directing switch 185, whereupon the next negative pulsation is transmitted to the selector coils 204 for advancing the cam shaft 238. Such movement of the shaft throws the pawl 218 out of operative association with the tens wheel 223 and throws the advancing pawl 219 into operative association with the units wheel 224. The cessation of this impulse brings the next signaling contact 101 under the spring pressed contact 102, and inasmuch as this third group of contacts has four contacts therein, four negative impulses are successively transmitted to the step-up coils in repetition of the operation above described for advancing the units wheel 224 to the numeral 4. Thus, at this time the three numeral wheels have the set-up of 3—1—4.

Upon the cessation of the last negative impulse which advances the units wheel to numeral 4, the box armature 55 drops back and advances the rotor another step to bring an insulated blank portion of the rotor under the contact 101. This causes the selecting switch to be deenergized so that the next negative pulsation is transmitted to the selector coils 204 for throwing the advancing pawl 219 out of operative coaction with the units wheel 224 and for throwing the advancing pawl 220 into operative coaction with the condition wheel 225. In the preferred embodiment of my system I arrange the operation so that any box intended to signal a "Fire" condition (such as boxes A and B energized by the flow responsive switches 49) does not need to transmit any further signal operation to the signaling relay 41, after the code number of the box has been transmitted. This is preferably effected by having that printing face of the condition wheel which bears the word "Fire" in a normal printing position above the paper tape, whereby this condition wheel will always print "Fire" unless it has been advanced from its normal position.

Since the operation of the box B, which is now being described, is intended to give a "Fire" indication, it is desirable that no advancing impulses be transmitted to the condition wheel 225. This is arranged by having a continuous insulated blank portion on the signal rotor follow the last group of four contacts 101 which had set up the numeral 4 on the units type wheel. The first step advancement on this blank portion throws the advancing pawl 219 out of coaction

with the units wheel 224 and throws the advancing pawl 220 into coaction with the condition wheel 225, as I have described above. However, this condition wheel is not advanced because the next step advancement on the blank portion leaves the selecting switch 185 deenergized so that the following negative impulse down through said switch energizes the selector coils 204. This second successive energization of said coils results in the cam shaft 238 being again advanced one step when the armature 271 is retracted upon deenergization of the coils, and this second advancement of the cam shaft 238 throws the advancing pawl 220 out of operative coaction with the condition wheel 225. Such advancement of the cam shaft, which is the fourth from the start of the cycle, brings one of the notches 292 of the notched wheel 291 under the rider lug 311, permitting the plate 307 to drop down and thereby swinging the mercury tubes 305 and 306 to closed circuit positions. The tube 305 conducts positive polarity through wires 312 and 312' to one end of the printing coils 321, and the tube 306 establishes a shunt around the selecting switch 185 to the selector coils 204—from wire 184 through wires 207, 313 and 313' to the coils. Neither the printing coils nor the selecting coils are energized by the movement of said tubes to closed circuit positions because the cam shaft 238 is not advanced to drop these tubes until the cessation of the negative impulse transmitted down through the wire 184. However, the next negative impulse transmitted out to box B and down through wire 184 energizes both the printing coils and the selecting coils.

The provision of the mercury tube 306 is merely a precautionary measure to insure that the selector coils 204 will be energized without fail when the printing coils 321 are energized. This tube establishes a shunt around directing switch 185 so that even if by some accidental abnormal condition the directing switch were in position to transmit this impulse to the step-up coils it would nevertheless be transmitted to the selector coils. This mercury tube 306 is only operative to establish this shunt when the printing coils are to be energized.

The energization of the printing coils swings the printing platen 342 up against the bottom of the paper tape and forces the latter and the inking ribbon up against the bottoms of the type wheels, thereby making the printed record. Upon deenergization of said coils by the tilting of the oscillator 37 in the other direction, the downstroke of the platen oscillates the sector arm 303 outwardly, thereby transmitting motion through the sector gears 298 and 297 to swing the tubes 294, 305 and 306 up to open circuit positions. The two latter tubes are swung up by the lug 309 pressing against the shoulder 308 on the plate 307, the resulting upward movement of said plate also swinging the rider lug 311 up out of the notch 292 on the notched wheel 291.

The energization of the selector coils 204 at the same time that the printing coils are energized results in the selector coil armature 271 being attracted rearwardly, and when the selector coils are deenergized simultaneously with the deenergization of the printing coils 321 the return movement of the armature 271 rotates the notched wheel 291 substantially simultaneously with the lifting of the rider lug 311 out of the notch 292 in said wheel. Consequently, the cessation of this last negative impulse transmitted from the oscillator down through wire 184 finds the lug 311 back upon the periphery of the wheel 291, beyond the notch 292 in which it had just been reposing; and finds all three tubes 294, 305 and 306 tilted up to their open circuit positions. The movement of the sector 299 in restoring the tubes to their open circuit positions results in all of the holding pawls for the type wheels being released, so that the type wheels are now restored to their initial positions.

Succeeding negative impulses from the oscillator 37 continue to advance the rotor of box B but these impulses do not energize any part of the recorder because at this time a blank portion of the code wheel is continuing to advance under the signal contact 102, resulting in the selecting switch 185 remaining in the position to direct said negative impulses to the sequence coils 204—which, however, cannot be energized at this time because the movement of the mercury tube 294 to open circuit position has disconnected positive polarity from the other end of said coils.

The rotor of box B continues to advance through the aforesaid blank portion of the code wheel (which blank portion in a supervisory box would be occupied by contacts serving to advance the condition wheel 225 to a particular position) until the approaching one of the two pin contacts 108 or 108' moves under the spring pressed contact 109. Such occurs on the down-stroke of the box armature at the end of a negative impulse and establishes a shunt around the secondary armature contacts 87—88, thereby reestablishing the continuity of conductor P for transmitting positive polarity down to boxes C, D, E, etc. This takes place one step in advance of the completion of the cycle of box B, and before the approaching one of the two bridging contacts 103 or 103' has shunted the cooperating spring pressed contacts 104—105 in the negative conductor N. Hence, a testing flow of positive polarity is transmitted down to boxes C, D, E, etc. through contacts 108—109 but no negative polarity can be transmitted up to box A at this step in the cycle. Accordingly, if either of the boxes C, D, E, etc. has become "energized" through the closing of the flow responsive switches or supervisory contacts associated therewith while the box B has been going through its signaling cycle, such energized box will be advanced one step along with box B by the next negative impulse following the engagement of contacts 108—109, but if box A, or any other box in this other direction in the series, has also become energized, such box will not be advanced by that pulsation because the pulsation will not be able to reach it, owing to the negative conductor N being open at contacts 104—105 of box B. If it should happen that boxes C, D, and E have all become energized during the operating interval of box B, only the armature of box C will have a full actuated movement imparted thereto by the negative impulse following the engagement of contacts 108—109, because the secondary armature contacts 87—88 of box C (or whatever box is first in the series of energized boxes below box B) will have a lead of operation over the other boxes below it and will interrupt the transmission of positive polarity to these other boxes before any effective movement can be given to their armatures.

The foregoing has to do with the non-interfering, successive repeating characteristics of the system, which will be described more in detail later. In order to complete a full description of

the operation of box B it will suffice to say here that: (1) if one or more of the succeeding boxes C, D, E, etc. has become energized during the operation of box B the negative impulse following the closing of contacts 108—109 will attract the armature of box B and will simultaneously attract the armature of the first energized box in the succeeding group C, D, E, etc., moving both of said armatures through a full stroke, and upon the cessation of this negative impulse the rotor of box B will move through the final step to the completion of its cycle, bringing the contact 108 out of engagement with contact 109, bringing the aproaching gap between segments 112—112' under contact 113, and bringing the approaching bridging contact 103 under both contacts 104—105, and concurrently therewith the rotor of the succeeding energized box will move through its first step, bringing its bridging contact 103 out of shunting engagement between contacts 104—105, thereby causing the continuity of negative conductor N up to box B to be broken so that box B gives up the line to the succeeding energized box until a later time in the cycle of the system; (2) if no succeeding box C, D, E, etc. has become energized during the operation of box B, the negative impulse following the engagement of contacts 108 and 109 will result in the rotor of box B moving through the final step of its cycle, exactly as described above, except that in this case box B can stop at the completion of this cycle or will be caused immediately to start operating through another cycle, depending upon the position of the flow responsive switch 49. In the latter case, if the flow responsive switch has moved back to open circuit position, indicating a cessation of water flow through its branch main 46 and that the fire hazard has ceased, box B will cease operating when its rotor completes its cycle, at which time the gap between contact segments 112—112' will move under spring pressed contact 113, thereby interrupting the transmission of positive polarity to the electromagnet coil 54; but, if the flow responsive switch 49 is still closed at the completion of the cycle the movement of the aforesaid gap under the contact 113 will make no difference because positive polarity will continue to be transmitted to the coil 54 through contacts 114 and 115 or 115' and consequently the rotor will be caused to revolve through another signaling cycle, which, in the construction illustrated, is a half revolution. Assuming that the box B is caused to continue its operation through this next signaling cycle, the numeral wheels at the recorder will be successively advanced to the same code designation 3—1—4 and the printing coils will then be energized for again printing the record "Fire 3—1—4" on the next succeeding line of the tape, in a repetition of the same cycle described above. Assuming that no other boxes on the circuit become energized, the box B will continue to repeat successively its signaling cycle as long as its flow responsive switch 49 remains closed, corresponding to a continuance of fire conditions at the box. The successive signaling cycles result in the printing of successive printed records on successive lines of the paper tape, one for each cycle, as illustrated in Figure 24. Hence, the system affords a definite printed record showing how long the fire condition existed at a particular location, as indicated by the number of printed records on the tape and the time of each printing as indicated in hours and minutes alongside each record. Concurrently with the transmission of code impulses to the recorder, the alarm bell 436 (and such other alarm bells as may be responsive to the contacts 497) is sounding in code to designate the box B by the gong impulses 3—1—4.

Assume now that the fire condition at box B has ceased, as represented by the opening of the flow responsive switch 49, (and that no other boxes on the circuit have become energized in the meantime) the rotor of box B will move through to the completion of its last cycle and will then stop, with the box contacts in their normal positions as illustrated in Figure 1. The final step of the box rotor brings the shunt contact 103 in bridging engagement under both spring contacts 104, 105, thereby transmitting negative polarity up through conductor N beyond the box and back to the negative line test relay 38, which is immediately energized. Since the final advancing step of the box rotor occurred when the electromagnet of the box was deenergized the secondary armature contacts 87, 88 are at this instant engaging, and hence positive polarity is being transmitted down through conductor P away from the box and back to the positive line test relay 36 which is also energized. Consequently, when both line test relays 38 and 36 become energized at the completion of the last step of the rotor (and with the flow responsive switch 49 of box B open) these two test relays open their contacts 38' and 36' and thereby interrupt the transmission of positive polarity over wire 179 to the oscillator coils 161. Thereupon the oscillator 37 ceases operating. At this time all parts of the system are in a normal condition with the exception of the set-up relay 431 and the parts or devices controlled thereby. Owing to the fact that the contacts 485 of said relay separated with the first interruption of negative polarity through conductor N, this relay remains deenergized throughout the entire signaling operation, and continues to remain deenergized until the relay is manually reset. While remaining deenergized after the signaling operation has been completed, its contacts *l* keep the illuminating lamp 423 over the paper tape burning, and its contacts *b* keep the trouble bell 437 sounding continuously. Thus, if the attendant was absent during the signaling operation, and also failed to hear the alarm gongs 436, upon his return to the supervisory location at which the recorder is situated he would be apprised of the previous signaling operation of the system by the continued sounding of the trouble bell 437 and the illumination of the lamp 415. After the alarm or trouble condition has been corrected the entire system can be restored to normal condition by closing the manually operated switch 488 which energizes the set-up relay 431, thereby opening its contacts *b* and *l* and closing its contacts 485, whereby this relay is reset to normal condition. This leaves the entire system in its normal condition.

I shall now describe the operation of a supervisory box, and for simplicity of explanation it will be assumed that the energization of such box occurs after the entire system has been restored to normal, non-signaling condition. Taking the box C as an example of a supervisory box, it will be assumed that the valve 51 which controls the associated floor branch main 46 is manually closed, as for the purpose of making repairs or for any other reason. From the preceding description of Figure 8, it will be evident that the closing of valve 51 will result in positive polarity being transmitted through the box energizing switch associated with this valve and through wire

121' to the coil 54 of box C. Instantly upon this energization the secondary armature contacts 87, 88 interrupt the continuity of conductor P beyond the box, and the resulting deenergization of the positive line test relay 36 causes the oscillator 37 to be set into motion, in the same manner as described of the operation of box B. I have illustrated box C as having a code designation of 3—1—2. The continued step-by-step advancement of the rotor of this box proceeds to set up the numeral designation 3—1—2 on the type wheels of the recorder in the same manner described before. After the numeral 2 has been set up on the units type wheel the insulating gap 100^3 on the box rotor is advanced under the spring pressed contact 102. This results in the selector coils 204 being energized upon the next negative pulsation and causing the advancing pawl 219 to be thrown out of operative coaction with the units wheel 224 and causing the advancing pawl 220 to be thrown into operative coaction with the condition wheel 225. Following the insulating gap 100^3 on the box rotor are three signaling contacts which I have arbitrarily chosen to indicate the condition "Valve closed". As these contacts are successively brought under the spring pressed contact 102 they result in three advancing steps being imparted to the condition wheel 225, the type face on said wheel arriving in printing position at the end of these three steps of advancement carrying the indicia "Valve closed". When the insulating gap portion 100^4 on the box rotor, following these condition contacts, moves under the spring pressed contact 102 the selector coils 204 are caused to receive the next negative pulsation. This is the fourth energization of the selector coil in this signaling cycle, as represented by the gap portions 100^1, 100^2, 100^3 and 100^4 in Figure 8, and the deenergization of said coils results in the cam shaft 238 being advanced through its fourth step. As described in the operation of box B, it is this fourth step advancement of said shaft that results in the mercury tubes 305 and 306 dropping to closed circuit positions, owing to one of the notches 292 moving under the rider lug 311. Consequently, the next negative pulsation energizes the printing coils 321, whereupon the printing impression is made and the mercury tubes 294, 305 and 306 are then returned to their normal open circuit positions. The box rotor continues to be advanced through the remainder of this cycle or half revolution but no further operation occurs at the recorder owing to the fact that the last insulating gap portion on the rotor continues to the end of the cycle and owing to the fact that the transmission of positive polarity to the selector coils 204 has been interrupted by the movement of the mercury tube 294 to open circuit position.

Figure 24 illustrates the printed record which is made on the paper tape by this signaling operation. During the signaling cycle the alarm gongs 436 sound in code the designation of the operating box, and the last three impulses indicate a valve closed condition. The set-up relay 431 was deenergized with the first opening of negative line conductor N, and this relay remains deenergized with continued sounding of the trouble bell 437 and illumination of the lamp 415 of the relay is manually reset by closing of the contacts 486.

Assuming that the valve 51 is still closed when the box rotor completes its half revolution signaling cycle, the rotor will stop at this point because the cooperating contact segment 112' has moved out from under the spring pressed contact 113, thereby interrupting the transmission of positive polarity to the box electromagnet through contact 113. Since the control or energizing switch is still in the same position with contact 121 engaging contact 122, positive polarity cannot be transmitted through this switch to the electromagnet 54 because at the end of this cycle rotating contact 114 has moved out from under spring pressed contact 115 and is now engaging under the opposite spring pressed contact 115', which latter contact is connected through wire 123' with the open circuit contact 123 of the control switch. Hence, box C will remain inert until valve 51 is operated in the reverse direction, i. e., to open the same. Such will cause the control switch contact 121 to be moved into engagement with cooperating contact 123. This will cause instant energization of the box electromagnet by the transmission of positive polarity from pin 114 through contact 115', wire 123', contacts 123 and 121, and thence through wires 121' and 124 to the end of the electromagnet coil. Thereupon the box is again set into operation, and the rotor is progressively stepped around by the successive negative impulses transmitted from the oscillator 37. This cycle of the box proceeds to set up the same code designation of 3—1—2 on the type wheels of the recorder. The side of the code wheel which is now advancing under the spring pressed signaling contact 102 differs from the other side of the wheel which moved under said contact in the previous cycle in that there are a different number of contacts in the end group of "condition" contacts. In the illustrated arrangement I have shown four of these condition contacts on this side of the wheel, as distinguished from three contacts on the other side thereof, these four condition contacts representing the condition "Valve open". Hence, in this cycle or half revolution of the box rotor four impulses are transmitted to the condition wheel 225, the fourth position of this wheel bearing type indicating "Valve open". After the condition wheel has been set up to this position by the fourth condition contact the movement of the fourth insulating gap 100^4 under the signal contact 102 results in the subsequent energization of the printing coils, the completion of the printing operation, and the restoration of the mercury tubes 293, etc. to normal positions, in the same manner as described in the case of the preceding cycle. The box continues to operate until the rotor reaches the end of this cycle, at which point it will stop if the valve 51 still remains in its open condition.

It will be seen from the foregoing that each supervisory box is thus enabled to signal two distinct conditions existing at the point where the box is located. Thus, one box suffices to indicate the two conditions of any apparatus or factor to be supervised in the installation, such as power off and power on, low water and high water, etc., as I have typically indicated on the paper tape in Figure 24.

I shall now describe the operations or conditions which occur when two or more boxes are concurrently energized, whereby the possibility of interference between the boxes is positively prevented. In my reference to a box which has been "energized" concurrently with another box I mean the establishment of a condition at the former box where a circuit connection capable of transmitting positive polarity to the electro-

magnet of that box has been completed through any of the control switch contacts 121, 122 or 123. By "concurrently" I mean that simultaneously with the "energization" of one box another box is "energized", or that during the cyclical "operation" of one box another box is "energized".

I shall assume as a first condition, with the entire system in its normal non-operating condition, that boxes A and B were simultaneously energized by the closing of the control switch contacts 121, 122 of both boxes at the same instant of time. The simultaneous energization of both electromagnets would result in the two secondary armatures 85 of both boxes starting to move toward their attracted positions in advance of movement of the main armatures 55 of both boxes because of the lead of operation which the secondary armatures have over the main armatures. In this initial movement of the secondary armatures 85 the secondary armature of box A instantly separates the contacts 87 and 88 of that box, thereby instantly interrupting the transmission of positive polarity down to box B. Hence, before the main armature of box B can move upwardly through any appreciable movement, such as would be effective to advance its rotor upon retraction of said armature, the transmission of positive polarity to that box is interrupted and no advancing movement is given to the rotor or armature of box B. On the other hand, the main armature 55 of box A moves upwardly through its full stroke, and in the subsequent deenergization of the electromagnet of box A when the oscillator 37 rocks to open circuit position, this main armature of box A drops back to normal position and imparts the first one step advancement to its rotor. Thereafter, the transmission of successive negative impulses to operating box A will result in successive repetitions of this same non-interfering function, i. e., on each impulse the secondary armatures 85 of box A will open the contacts 87, 88 and interrupt the transmission of positive polarity to box B before the main armature of that box can be actuated through any appreciable movement.

Assume as another condition that while box B is operating through a signaling cycle box C should be energized. While box B continues to operate through its cycle the same non-interfering operation occurs with respect to box C as has been described above. That is to say, the lead of operation of the secondary armature 85 of box B will interrupt the transmission of positive polarity to box C on each current impulse before the main armature of box C can have any appreciable movement. As box B continues to operate and nears the end of its cycle one of the two pin contacts 108 or 108' will move under the spring pressed contact 109 at an interval one step short of the completion of the cycle of box B. This establishes a shunt around the secondary armature contacts 87, 88. On the next negative impulse energized box C will therefore be advanced one step along with box B. This means that box C will operate through its first step advancement while box B is operating through its last step advancement and completing its cycle. This first step advancement of box C moves bridging contact 103 or 103' out of shunting relation between spring contacts 104 and 105 and consequently the transmission of negative polarity up to box B is interrupted in this simultaneous advancement of both box rotors. Thereby, box C has taken the line away from box B and even if box B is still in an energized condition with its control switch contacts 121 and 122 closed nevertheless this box cannot start operating through a second cycle at this time because box C has now taken the line.

Assume now that this same condition is repeated further down in the series beyond box C, namely, that one of the other boxes D, E, F or G, etc. should become energized while box C is moving through its signaling cycle. Identically the same operation will occur when box C reaches the end of its signaling cycle as was described above, i. e., on the next to the last advancement of box C the contacts 108 or 108' and 109 will transmit positive polarity down to the next energized box, which will be assumed as being box F, and in the last step advancement of box C and the first step advancement of box F this latter box will take the line away from box C even though box C is still energized and ready to start through the performance of a second signaling operation.

When box F completes one signaling cycle the movement of its bridging contact 103 back into shunting relation to its contacts 104 and 105 reestablishes the continuity of negative conductor N up through the entire line of boxes towards the A end of the series. If box B still remains energized, preparatory to transmitting a second signaling cycle, it will take the line in precedence over any other box C or F which may be energized, owing to the secondary armature contacts 87, 88 of box B preventing the transmission of positive polarity to these lower boxes such as would result in the actuation thereof. (Correspondingly, if box A had become energized in the meantime it would take precedence over box B). Box B will then operate through its second signaling cycle and at the point one step short of the completion of this second cycle it will transmit a testing flow of positive polarity down through contact 109 to box C, and if this latter box is still energized, preparatory to transmitting a second signaling cycle, this box will take the line on the next impulse and will thereafter operate through its second signaling cycle. In the same manner, if box F still remains energized it will take the line from box C when the latter completes its second cycle. It will thus be seen that as long as a group of boxes remain energized these boxes will continue to repeat their signaling operations in the same sequence as their position in the series. Any other box becoming energized in the meantime will take its place on the line or in the order of operation corresponding to the sequence of its position.

If, while box B, or any of the other boxes toward the C end of the series, is operating, box A should become energized this latter box would be incapable of operating because the transmission of negative polarity up to box A has been interrupted at the contacts 104—105 of the box then in operation. However, as soon as the last box, in any concurrently energized group of boxes toward the C end of the series, has completed its cycle the transmission of negative polarity up along conductor N will result in box A immediately taking the line in precedence over the other boxes.

In regard to the non-interfering characteristics of the system, attention is directed to the fact that at no time is there a series of boxes all standing in the condition with their rotors one step short of the completion of their cycles. That is to say, there is no time element involved in getting previously operated boxes back to their original rotor positions. In the case of successively operating boxes, the same impulse which initiates the first

step advancement of a succeeding box also completes the last step advancement of a preceding box. For example, in the case of boxes A, B and C all being concurrently energized or placed in condition to operate during the first operating cycle of box A, as soon as box A comes to its position one step short of the completion of its cycle and transmits positive polarity through contacts 109 and 108 or 108' to box B, the next impulse which initiates the operation of box B completes the cycle of box A, and likewise, the impulse which initiates the operation of box C completes the cycle of box B. Thus, all previously operated boxes stand in their normal condition so that after the last energized box in the series has completed its cycle there is no time delay in transmitting negative polarity up to the first energized box in the series for successive repeating of the boxes.

In the preceding description of the relays and of the testing functions I have disclosed how the entire system is maintained under continuous test to safeguard against the possibility of accidental breaks in the positive conductor P, in the negative conductor N and in the signal conductor S, also how the system is safeguarded against the possibility of a signal disturbing ground being established on any one of these conductors. In this regard, attention is directed to the fact that in the event of a break or disconnection in the signal conductor S, any box in the system can still transmit its code signals over this conductor, and this regardless of where the break occurs in the signal loop. For example, if the break should occur beyond the box (i. e. toward the C end of the series with respect to the box which is then operating or which later operates) then positive polarity is transmitted on each code signaling impulse through the upper portion of the signal loop and down through signal circuit terminal S^1 on the control panel down to the outer end of the winding of signaling relay 41, whereby this relay 41 is deenergized by such impulse because it then has positive polarity at both ends of its winding. On the other hand, if the break should occur in advance of the box (i. e. towards the A end of the series with respect to the box then operating or which later operates) then positive polarity is transmitted on each signaling impulse down through the lower part of the signal loop and up through signal circuit terminal S^2 on the control panel to the wire 482 of the signal circuit trouble relay 428, from whence this positive polarity impulse is transmitted through the winding of said relay 428 and through wire 481 to the outer end of the winding of signaling relay 41, thereby deenergizing said relay because it then has positive polarity at both ends of its winding. It will therefore be seen that a double safeguard is afforded, in that if any break develops in the signal conductor S this break is instantly indicated through the signal circuit trouble relay 428, and, notwithstanding this break, signals can still be transmitted from any operating box over the signal conductor.

In the preceding disclosure I have shown the system as having the dual capacity of (1) an alarm system for signaling water flow or other fire conditions; and (2) a supervisory system for signaling conditions associated with apparatus which is generally related to the fire prevention apparatus of the building or plant, although this apparatus may constitute no part of the fire prevention installation. However, in many large installations it may be desirable to have all of the alarm signaling performed on one system and all of the supervisory signaling performed on a separate system. The two systems would be exact duplicates of the one herein described, with the possible exception that in the case of the supervisory system the large alarm bells 436 might be dispensed with.

In Figures 25 and 26 I have diagrammatically illustrated a modified arrangement differing from the preceding embodiment only in that the advancement of the box rotor occurs simultaneously with the current pulsation transmitted to the box, and in that the pulsations transmitted over the box operating circuit and the pulsations transmitted to the recorder occur in alternating sequence. The signaling box diagrammatically illustrated in Figure 25 is the same as the previously described box except that main armature 55 and advancing pawl 56 are reversed or rearranged so that it is the upstroke of the armature that advances the rotor, instead of the downstroke thereof as previously described. In this instance I have designated the main armature and advancing pawl as 55*a* and 56*a*, respectively. In Figure 26 I have illustrated the oscillator 37 rearranged to transmit the box operating impulses and the recorder operating impulses in alternating sequence. The mercury tube 169*a* has the same pair of terminals 169' and 169'' which transmit the impulses out over the box operating circuit in the same manner as described of the mercury tube 169 of Figure 2. However, in this modified arrangement, the other end of this tube carries a pair of terminals 170' and 170'', one of which is connected to negative battery feeder 35 and the other of which is connected to wire 184*a* which extends down to the directing switch 185. When the tube 169*a* is in the position illustrated current is being transmitted out over the box operating circuit, and when the tube tilts in the other direction the mercury flowing down into the opposite end of the tube will cause a negative impulse to be transmitted down through wire 184*a* to the selecting switch 185, in the same manner that a negative impulse was transmitted through wire 184 of Figure 2, except that in the modified arrangement the impulse transmitted to the recorder occurs during the time when no impulse is being transmitted over the box operating circuit. The automatic making and breaking of the circuit through the oscillator winding 161 may be performed through the terminals 169', 169'', or a separate mercury tube 171 may be provided for making and breaking the coil circuit, as shown in Figure 2. Likewise, a separate mercury tube might be provided for the terminals 170', 170''. In every other respect the system is the same, and the operation of this modified arrangement can be readily understood by substituting the box of Figure 25 for box B of Figure 7, and by interposing the modified oscillator of Figure 26 in the circuit diagram of Figure 2 in lieu of the one there illustrated.

In the operation thereof, when the tube 169*a* tilts down to the position illustrated and transmits a box operating impulse out over the line the rotor of the operating box is advanced instantly with the upstroke of the main armature 55*a*. This instantly performs the operation of either moving one of the signal contacts 101 on the rotor under the stationary spring contact 102, or moving one of the insulated gap portions of the rotor under this spring contact 102. This functions instantly either to apply positive polarity to the signal conductor S or to remove positive polarity therefrom, as the case may be, and concurrently therewith the directing switch 185 responds

through the signaling relay 41 to position the switch for directing the next recorder impulse either down to the step-up coils 202 or to the selector coils 204. All of this occurs in a very short space of time, substantially while the mercury tube 169a is tilted down in the position illustrated. The tube then tilts back in the other direction, thereupon interrupting the impulse transmitted out over the box operating circuit and creating an impulse which is transmitted down through wire 184a to the directing switch 185. Since the position of this switch has been previously determined by the above described advancement of the box rotor this impulse will be properly directed either to the step-up coils or to the selector coils. When the mercury tube rocks in the other direction the impulse down to the recorder is interrupted and the next succeeding impulse is transmitted out over the box operating circuit, and from this point on the cycle is a repetition of that described.

The three numeral type wheels illustrated are capable of designating several hundred signal boxes, such as might be installed in a large system. It will be understood that the number of numeral wheels may be increased to four or more if desired, and more than one condition wheel 225 may be employed. With more than one condition wheel, these condition wheels could be selected in the same way that the numeral wheels are selected, or they could be arranged so that they would both or all be advanced in a signaling cycle to have a printing impression made from both or all of said condition wheels. For a larger number of type wheels the arrangement and ratio of advance of the notched wheel 291 would be changed so that the printing coil switch 305 would not be closed until the cam shaft 238 had been advanced five, six or more steps depending on the total number of type wheels employed.

In the case of an alarm box for signaling a fire condition, the entire rotor may be utilized for one signaling cycle, such as would be desirable if the number of signaling contacts 101 occupied more space than half the circumferenee of the rotor. In such arrangement the two contact segments 112 and 112' would be in effect one segment with only one gap therein so positioned as to come under the spring contact 113 at the end of the cycle; and only one pin contact 115 and one bridging contact 103 would be provided, with the contact 115 coming under the spring contact 114 and the contact 103 coming under the spring contacts 104, 105 at the end of the cycle. Such a box having only one cycle per revolution could be employed in the same system with other boxes having two cycles per revolution without interfering with the operation of the system.

I also contemplate combining the signaling relay 41 and the directing switch 185 in one device.

It will be understood that, if desired, the timed relation of the advancing pawls 217—220 may be such that the condition wheel 225 will be advanced before any of the numeral wheels 222—224 are advanced. In this regard I also contemplate having the position or movement of the condition wheel 225 operate through control devices to determine whether or not the signal stroke alarm bells 436 will be energized. In such arrangement the condition wheel is first actuated, and if it is left in a position designating "Fire" all of the other impulses transmitted to the numeral type wheels 222—224 will be sounded on the alarm bells 436, whereas if the condition wheel is left in some other position designating a supervisory condition the other impulses transmitted to the numeral wheels are not effective to cause energization of said alarm bells.

Claims directed to certain features of the invention, particularly involving the details of the recorder, are contained in my copending application, Serial No. 62,913, filed February 8, 1936.

While I have illustrated an embodiment of my invention which I consider to be the preferred embodiment, it will be understood that such is merely exemplary of the essence of my invention and that various modifications and rearrangements may be made therein without departing from the broad scope of the invention. In several of the appended claims I have used the term "notification" apparatus in the broad sense of embracing apparatus which conveys desired information either by the sounding of the signaling bell 436 or by the actuation of the character bearing elements 222, 223, 224 and 225. Also, in several of the claims I have defined the "notification" apparatus as comprising "movable character elements" or the like, without regard to a printing operation, such terminology embracing apparatus which conveys the desired information either by a printed record or by the direct reading of the movable character elements.

I claim:

1. In a system of the class described, the combination of a pulsator for transmitting electrical impulses, a series of signal boxes each comprising a signal wheel and a step-by-step electric motor elcment including an oscillating armature operative to advance said signal wheel in its retractive movements, a box operating circuit for conducting said electrical impulses from said pulsator to said motor elements for energizing the latter, signal receiving apparatus comprising a selector coil and a step-up coil also adapted to be energized by the impulses from said pulsator, a directing switch adapted in one position to direct said impulses to said selector coil and in the other position to direct said impulses to said step-up coil, signal contacts in each box brought into and out of engagement by the rotation of said signal wheel, and means controlled by said signal contacts for shifting said directive switch from one position to the other, said latter means functioning to shift said switch between attractive movements of said armature, whereby the switch is positioned during the time interval between successive impulses transmitted to the signaling box and to said signal receiving means.

2. In a signal system, the combination with a series of signal boxes, a circuit connecting said boxes, and a control element in each box cooperating with said circuit, of signal responsive apparatus comprising a plurality of movable character elements, selecting means for selecting the character elements for actuation, actuating means for actuating said character elements, means for transmitting current pulsations for effecting the operation of said selecting means, said actuating means and the energized box, and means responsive to the said control element in an operating box for directing said current pulsations in proper sequence to said selecting means and said actuating means.

3. In a signal system, the combination with a series of signal boxes, a control element in each box, and means for actuating said control elements, of signal responsive apparatus remote from said boxes and controlled thereby, said apparatus comprising a plurality of movable character elements, a signaling conductor extending

in series through said boxes, means actuated by the control element in an operating box for causing current variations to be produced in said conductor independently of any interruption of the continuity of said conductor, means for transmitting current impulses of the same periodicity to the operating box and to said signal responsive apparatus, and means responsive to the current variations in said signaling conductor for controlling said apparatus.

4. In a signal system, the combination with a series of signal boxes, a control element in each box, and means for actuating said control elements, of signal responsive apparatus remote from said boxes and controlled thereby, said apparatus comprising a plurality of movable character elements, a signaling conductor extending in series through said boxes, means actuated by the control element in an operating box for causing current variations to be produced in said conductor, means separate from said signal boxes for transmitting electrical impulses to said apparatus for actuating said movable character elements, and means responsive to the current variations in said conductor for controlling the actuation of said apparatus by said electrical impulses.

5. In a system of the class described, the combination of a series of three or more signal boxes, A, B, C, etc., a box operating circuit comprising two conductors P and N extending through said series of boxes with said boxes arranged in bridging relation between said conductors, a supply circuit connected to impress at any given instant one polarity on conductor P at the A end of the series of boxes and to impress at the same instant the opposite polarity on conductor N at the C end of the series of boxes, a step-by-step electric motor element in each box deriving its operating current from conductors P and N when the box is energized, said motor element comprising an oscillating armature, a control station comprising a circuit pulsator connected to one of said conductors and adapted in operation to transmit intermittent current impulses over said conductors imparting step-by-step advancement to the motor element of the energized box, means controlled by the current flow in one of said conductors for controlling said circuit pulsator, pawl means for advancing said signaling rotor on the retractive movement of said armature when no current impulse is being transmitted over said box operating circuit conductors P and N, non-interfering means cooperating therewith whereby, in the event of concurrently energized boxes, the signaling box will complete its cycle of movement prior to the completion of the cycle of movement of any other energized box, and notification means responsive to the operation of said boxes.

6. In a system of the class described, the combination of a series of three or more signal boxes, A, B, C, etc., a box operating circuit comprising two conductors P and N extending through said series of boxes with said boxes arranged in bridging relation between said conductors, a supply circuit connected to impress at any given instant one polarity on conductor P at the A end of the series of boxes and to impress at the same instant the opposite polarity on conductor N at the C end of the series of boxes, an electric motor element in each box deriving its operating current from conductors P and N when the box is energized, a single signaling conductor extending in series through said boxes, means actuated by the motor element in an operating box for transferring electrical energy between said box operating circuit and said signaling conductor for causing current variations to be produced in said signaling conductor while maintaining the continuity of such conductor, and signal means controlled by the current variations in said signaling conductor.

7. In a system of the class described, the combination of a series of three or more signal boxes, A, B, C, etc., a box operating circuit comprising two conductors P and N extending through said series of boxes with said boxes arranged in bridging relation between said conductors, a supply circuit connected to impress at any given instant one polarity on conductor P at the A end of the series of boxes and to impress at the same instant the opposite polarity on conductor N at the C end of the series of boxes, an electic motor element in each box deriving its operating current from conductors P and N when the box is energized, means for energizing each of said boxes, a third conductor extending in series through said boxes, contact mechanism in each box for connecting said third conductor to one of said box operating circuit conductors, signaling apparatus, and means electrically connected with said third conductor and responsive to the operation of said contact mechanism in an operating box for governing the operation of said signaling apparatus.

8. In a signal system, the combination with a series of signal boxes, an electric motor device in each box, electric circuit connections between said boxes, and means for energizing the motor devices in said boxes, of signal responsive apparatus comprising a plurality of movable character elements, selecting means for selecting the character elements for actuation, actuating means for actuating said character elements, means for simultaneously transmitting current impulses to the motor element of the energized box and to said signal responsive apparatus, and means responsive to the energized box and functioning between said current impulses for determining whether the next current impulse is to operate said selecting means or said actuating means.

9. In a signal system, the combination with a series of signal boxes, a circuit connecting said boxes, a control device in each box, and means for causing signaling operation of said boxes, of signal responsive apparatus remote from said boxes and controlled thereby, said signal responsive apparatus comprising a plurality of movable character elements, selecting means operative in the selection of the character elements to be actuated, advancing means operative in the actuation of the selected character element, means separate from said boxes creating current impulses for the energization of said selecting means or said advancing means, and directing means controlled by the operating box for directing said current impulses in proper sequence to said selecting means and said advancing means.

10. In a signal system, the combination with a series of signal boxes, a circuit connecting said boxes, and a control element in each box cooperating with said circuit, of signal responsive appparatus comprising a plurality of movable character elements, two operating mechanisms cooperating with said movable character elements, means for energizing one of said boxes for operation, means for transmitting current impulses in predetermined timed relation to the operating box in the series and to said signal responsive apparatus, the current impulses transmitted to

said signal responsive apparatus energizing one of said operating mechanisms during one part of the box operating cycle, and means operative between the current impulses transmitted to said signal responsive apparatus for causing said impulses to energize the other of said operating mechanisms.

11. In a signal system, the combination with a series of signal boxes, a circuit connecting said boxes, an electric motor device in each box, and a signaling element in each box actuated by said electric motor device, of notification apparatus comprising a plurality of character wheels, a step-up coil operatively connected to cause advancement of said character wheels, a selecting coil operatively connected to cause a selection of the character wheels to be advanced, synchronizing means for synchronizing the operation of said notification means with the operation of a signaling box comprising means for transmitting current impulses of substantially fixed frequency to said notification means and to the electric motor device of the signaling box, and means responsive to the signaling element of the signaling box for determining whether said fixed frequency impulses energize said step-up coil or said selecting coil.

12. In a system of the class described, the combination of a series of signal boxes, a box operating circuit connecting with said boxes, a step-by-step electric motor element in each box deriving its operating current from said box operating circuit, a code wheel in each box actuated by the motor element thereof, a signal conductor connecting with said boxes and cooperating with the code wheels therein, means for energizing said boxes to cause their operation, notification apparatus comprising a plurality of character wheels, a step-up coil operatively connected for causing advancement of said character wheels, a selecting coil operatively connected for causing selection of the character wheel to be advanced, means for transmitting intermittent current impulses over said box operating circuit to the step-by-step electric motor element of an energized box and for transmitting current impulses to said notification apparatus for causing energization of said coils, and means connected with said signal conductor and responsive to the code wheel of the operating box for selectively determining which of said coils is energized by said current impulses.

13. In a system of the class described, the combination of a series of signal boxes, a box operating circuit comprising two conductors connecting with said boxes, an electric motor element in each box deriving its operating current from said two conductors, means for energizing any one of said boxes for causing operation of the motor element therein, a third conductor extending in series through said boxes, a relay connected with said third conductor, contact mechanism in each box actuated by the motor element thereof and operative to intermittently connect said third conductor with one of said box operating circuit conductors independently of any interruption in the continuity of said third conductor whereby to control the energization and deenergization of said relay, electrically controlled apparatus comprising a plurality of movable character elements, selecting means for selecting the character element to be actuated, advancing means for actuating the selected character element, means responsive to said relay for controlling the operation of said selecting means and said advancing means, and means for electrically synchronizing the operation of said electrically controlled apparatus with the signaling operations of any one of said boxes comprising means for transmitting electrical impulses to said operating box and to said electrically controlled apparatus in timed relation.

14. In a signal system, the combination of a series of signal boxes, electric motor elements in said boxes, a box operating circuit comprising a supply conductor supplying current to said motor elements, a signal conductor connecting with said boxes, notification means responsive to current conditions in said signal conductor, and signal mechanism in said boxes comprising signaling rotors responding to the operation of said electric motor elements, said signal mechanism intermittently connecting said supply conductor with said signal conductor for causing the operation of said notification means, the signaling rotor in one of said boxes operating to transmit in a single revolution of said rotor different signals indicating different conditions and each of said signals designating the box from which the signals originated.

15. In a signal system, the combination of a series of signal boxes, electric motor elements in each of said boxes, a box operating circuit comprising two conductors supplying current to said motor devices, signal transmitting means in said boxes controlled by said motor elements, a signal conductor having loop connection with said boxes, said signal transmitting means operating to intermittently connect said signaling conductor with one of said box operating circuit conductors, and a device operatively connected to be responsive to signal impulses created by said signal transmitting means and transmitted from either end of said loop whereby signals can be transmitted to said device from one end or the other of said looped conductor independently of a break in the continuity of said conductor.

16. In a signal system, the combination of a series of signal boxes, electric motor elements in said boxes, a box operating circuit comprising two conductors supplying current to said motor elements, a signal conductor, a signal device responsive to current variations in said signal conductor, and means in each of said boxes responsive to the electric motor device therein for intermittently connecting said signaling conductor with one of said box operating circuit conductors for actuating said signal device.

17. In a signal system, the combination of a series of signal boxes, step-by-step electric motor devices in said boxes, a box operating circuit comprising two conductors connecting with said boxes, control means associated with each of said boxes for connecting the motor element thereof with both of said conductors, means for transmitting current impulses over said box operating circuits for advancing the motor element in an operating box, a signal conductor connecting with said boxes, a relay connected to be responsive to current changes in said signal conductor, and contact means in said boxes actuated by the motor elements therein for intermittently establishing a cross connection between one of said box operating circuit conductors and said signal conductor to thereby control said relay.

18. In a signal system, the combination of a series of signal boxes, electric motor elements in said boxes, a pair of conductors connecting with said boxes to supply current to the motor elements therein, a device for transmitting variable current over one of said conductors, and non-in-

terference means cooperating therewith whereby the signaling wheel of an operating box is caused to complete the final movement of its cycle concurrently with the initial movement of the signaling wheel of a concurrently energized box, and relays in each of said conductors operatively connected to initiate the operation of said device when one of the signal boxes is placed in condition to transmit a signal.

19. In a system of the class described, the combination of a series of three or more signal boxes A, B, C, etc., a box operating circuit comprising two conductors P and N extending through said series of boxes with said boxes arranged in bridging relation between said conductors, a supply circuit connected to impress at any given instant one polarity on conductor P at the A end of the series of boxes and to impress at the same instant the opposite polarity on conductor N at the C end of the series of boxes, a step-by-step electric motor element in each box deriving its operating current from conductors P and N when the box is energized, a control station comprising a circuit pulsator connected to one of said conductors and adapted in operation to transmit intermittent current impulses over said conductor imparting step-by-step advancement to the motor element of the energized box, means operative upon the energization of one of said boxes for interrupting the continuity of one of said conductors beyond said box in the normal operation of the system, a test relay having its winding interposed in conductor P, a test relay having its winding interposed in conductor N, means effective upon the initial energization of one of said boxes and responsive to the deenergization of one of said test relays for causing said circuit pulsator to operate, and means responsive to the deenergization of the other relay in the continued operation of the box for causing said circuit pulsator to operate.

20. In a signal system, the combination of a series of signal boxes, step-by-step motor elements in each of said boxes, indicating means responsive to the operation of said motor elements, a pair of conductors connecting with said boxes for supplying current to said motor elements, an oscillating circuit pulsator for causing the transmission of current pulsations over one of said conductors in the signaling operation of a box, said circuit pulsator comprising two pairs of contacts and a winding, one pair of contacts controlling the transmission of current pulsations over said box operating circuit, the other pair of contacts controlling the current flow through said winding, and means for causing said circuit breaker to operate when one of said boxes is placed in a signal transmitting condition.

21. In a signal system, the combination of a series of signal boxes, step-by-step motor elements in said boxes, signaling means responsive to the operation of said motor elements, a pair of conductors connecting with said boxes for supplying current to the motor elements therein, a circuit pulsator for transmitting current pulsations over one of said conductors to an operating box, said circuit pulsator comprising a mercury tube contactor, a winding, and means responsive to said winding for actuating said contactor, means for causing an operating current to pass through said winding when one of said boxes is placed in condition to transmit signals, means normally passing a continuous testing current through said winding during the non-signaling intervals of the system, a relay responsive to said testing current, and trouble indicating means controlled by said relay.

22. In a signal system, the combination of a series of signal boxes, electric motor elements in said boxes, a box operating circuit comprising two metallic conductors connecting with said boxes and supplying current to the motor elements therein, a metallic signal conductor connecting with said boxes, means in said boxes responsive to said motor elements for causing current changes in said signal conductor, signal means responsive to the current changes in said signal conductor, said three conductors being continuously ungrounded in the normal condition of the system during signaling and non-signaling intervals, and means for indicating the accidental establishment of a ground on any one of said three conductors.

23. In a signal system, the combination of a series of signal boxes, electrically operated devices in said boxes, circuit connections between said boxes for supplying current to said electrically operated devices, said circuit connections comprising a conductor extending in series through said boxes, means for transmitting current impulses over said circuit connections, and means in said boxes and functioning in an operating box in response to every current impulse for interrupting the transmission of current through said conductor in one direction from said box.

24. In a signal system, the combination of a series of signal boxes, each of said boxes including a step-by-step electric motor element comprising a coil, an armature responsive thereto and a movable device actuated by said armature, a box operating circuit comprising two conductors extending in series through said boxes, means for transmitting current impulses over said box operating circuit to an operating one of said boxes, and means in each of said boxes having a lead of operation over said armatures and functioning in an operating box in response to said current impulses for interrupting the continuity of one of said conductors in one direction from the operating box.

25. In a system of the class described, the combination of a series of three or more signal boxes A, B, C, etc., a box operating circuit comprising two conductors P and N extending through said series of boxes with said boxes arranged in bridging relation between said conductors, a supply circuit connected to impress at any given instant one polarity on conductor P at the A end of the series of boxes, and to impress at the same instant the opposite polarity on conductor N at the C end of the series of boxes, an electric motor device in each box deriving its operating current from conductors P and N when the box is energized, each of said motor devices comprising an electromagnet, two armatures responding to said electromagnet, a rotor actuated by one of said armatures, signal transmitting contacts controlled by said rotor, a pair of box controlling contacts responsive to said rotor and connected to control the continuity of one of said box operating circuit conductors, a second pair of box controlling contacts responsive to the other armature and having a lead of operation over said first mentioned box controlling contacts, said second mentioned box controlling contacts connected to control the continuity of the other of said box operating circuit conductors, and signal means responsive to said signal transmitting contacts.

26. In a signal system, the combination of a series of signal boxes, each of said boxes including a step-by-step electric motor element comprising a coil, a main armature responsive thereto and a movable device actuated by said main armature, means for transmitting current impulses over said box operating circuit to an operating one of said boxes, a secondary armature in each of said boxes having a lead of operation over said main armature and functioning in an operating box in response to said current impulses for interrupting the continuity of one of said conductors in one direction from the operating box, and signal means responsive to the operation of said movable device.

27. In a signal system, the combination of a series of signal boxes, a box operating circuit extending in series through said boxes, means for transmitting current impulses over said box operating circuit to an operating one of said boxes, each of said boxes including a step-by-step electric motor arranged to be actuated by said current impulses, each of said motors comprising a coil, an armature responsive thereto, a rotatable signaling wheel, pawl means actuated by said armature and arranged to advance said signaling wheel in the retractive movement of said armature, between current impulses transmitted to said motor, and non-interference means cooperating therewith whereby the signaling wheel of an operating box is caused to complete the final movement of its cycle concurrently with the initial movement of the signaling wheel of a concurrently energized box, signaling contacts controlled by said signaling wheel and signaling means responsive to said signaling contacts.

28. In a signal system, the combination of a series of signal boxes, a box operating circuit extending in series through said boxes, means for transmitting a variable current over said box operating circuit to an operating one of said boxes, each of said boxes including an electric motor element arranged to be driven by said variable current, signal transmitting means actuated by said electric motor comprising contacts arranged to have relative movement in a switching operation when said box operating circuit is substantially electrically dead, and non-interference means cooperating therewith whereby a signaling box is caused to complete its cycle of movement concurrently with the initial movement of a concurrently energized box, and signaling means responsive to the switching operations of said contacts.

29. In a system of the class described, the combination of a series of electrically energized signal boxes, notification apparatus comprising a plurality of character elements adapted to be selected and actuated at a rate corresponding to the speed of operation of any of said signal boxes, a common source of power supply directing electrical energy to any signaling box of the series and to said notification apparatus, said source of power supply including means maintaining the frequency of energization of the signaling box in a definite ratio to the frequency of energization of said notification apparatus, and means responsive to the signaling box for determining which of said character elements is to be actuated by the power transmitted from said source of power supply.

30. In combination, a plurality of transmitting stations, a receiving station comprising a plurality of electrically responsive devices adapted to be actuated at a rate corresponding to the speed of operation of said transmitting stations, a common source of power supply functioning during the operation of one of said transmitting stations to supply power impulses of the same frequency to said transmitting stations and to said receiving station, and apparatus in said transmitting stations transmitting directive impulses to said receiving station for determining which of said electrically responsive devices is to receive the power impulses from said source of power supply.

31. In a signal system, the combination of a plurality of signal boxes, notification apparatus comprising a plurality of electrically responsive devices adapted to be actuated in synchronism with the operation of any one of said signal boxes, a common source of power supply functioning during the operation of any one of said signal boxes to transmit power impulses of the same frequency to said signal box and to said notification apparatus, and signal means in said boxes functioning in the operating box to transmit directive impulses to said notification apparatus for determining which of said electrically responsive devices is to respond to the power impulses from said common source of power supply.

32. In combination, a common power supply device transmitting a synchronizing current, a plurality of control devices operable thereby at a rate of operation governed by said synchronizing current, a responsive device having responsive elements adapted to be operable by said common power supply device at a rate of energization governed by said synchronizing current, and a selector governable by said control devices for selecting the element to be driven by the power device, said control devices having a common means for selectively operating the selector each according to a predetermined individual program or code.

33. In combination, a common power supply device transmitting a synchronizing current, a plurality of control devices operable thereby at a timed rate determined by said current, a responsive device having responsive elements adapted to be actuated at a timed rate determined by said current, and a selector for selecting the element to be driven by the power device, said control devices having a common means for selectively operating the selector each according to a predetermined individual program or code.

34. In combination, a common power supply device transmitting a synchronizing current, a plurality of control devices operable thereby, a responsive device operable thereby, and a selector for controlling the actuation of the responsive device by said power supply device, said selector being operable by each of said control devices according to a predetermined individual code.

35. In a signal system, the combination of a series of three or more signal boxes, electric motor elements in each of said boxes, a box operating circuit connecting with said boxes for supplying current to the motor elements thereof, means responsive to the energization of one of said boxes for transmitting a periodically varying current over said circuit for operating the motor element of the energized box, non-interfering means associated with said boxes whereby, in the event of concurrently energized boxes the signaling box will complete its cycle of movement prior to the completion of the cycle of movement of any other energized box, signal transmitting means actuated by the electric motor elements

in said boxes, and notification means responsive to said signal transmitting means.

36. In a system of the class described, the combination of a pulsator for transmitting electrical impulses, a series of signal boxes each comprising a signal wheel and a step-by-step electric motor element operative to advance said signal wheel upon the deenergization of said motor element, a box operating circuit for conducting said electrical impulses from said pulsator to said motor elements for energizing the latter, signal receiving apparatus comprising a selector coil and a step-up coil also adapted to be energized by the impulses from said pulsator, a directing switch adapted in one position to direct said impulses to said selector coil and in the other position to direct said impulses to said step-up coil, signal contacts in each box actuated by the rotation of said signal wheel, and means controlled by said signal contacts for shifting said directing switch from one position to the other, said latter means functioning to shift said switch during the time interval between successive impulses transmitted to the signaling box and to said signal receiving means.

37. In a system of the class described, the combination of a synchronizing control element for transmitting a pulsating current, a series of signal boxes each comprising a signal wheel and an electric motor element operative to actuate said signal wheel, a box operating circuit for conducting said pulsating current from said synchronizing control element to said motor element for energizing the latter, signal receiving apparatus comprising two coils each adapted to be energized by the pulsating current from said synchronizing control element, a directing switch adapted in one position to direct said pulsating current to one of said coils and in the other position to direct said current to the other of said coils, and means controlled by said signal wheel for shifting said directing switch from one position to the other during the time interval between successive impulses of said current transmitted to the signaling box and to said signal receiving means.

38. In a signal system, the combination of a series of signal boxes, a box operating circuit connecting with said boxes, an electric motor element in each box deriving its operating current from said box operating circuit, a code wheel in each box actuated by the motor element thereof, a signal conductor connecting with said boxes and cooperating with the code wheels therein, means for energizing said boxes to cause their operation, receiving apparatus adapted to respond to the signals transmitted from said signal boxes, and mechanism for electrically synchronizing the operation of said receiving apparatus with the signaling operations of any one of said boxes comprising means for transmitting electrical impulses to said operating box and to said receiving apparatus in timed relation.

39. In combination, a plurality of signal boxes each comprising an electrically driven signal transmitter, receiving apparatus adapted to respond to the signals transmitted from said signal boxes, said receiving apparatus comprising a plurality of electromagnets adapted to be selectively energized in the operation of the receiving apparatus, means governed by the signal transmitter in an operating box for controlling the selective energization of said electromagnets, and mechanism for electrically synchronizing the operation of said receiving apparatus with the signaling operations of any one of said boxes comprising means for transmitting electrical impulses to said operating box and to said receiving apparatus in timed relation.

40. In a system of the class described, the combination of a series of three or more signal boxes A, B, C, etc., a box operating circuit comprising two conductors P and N extending through said series of boxes with said boxes arranged in bridging relation between said conductors, a supply circuit connected to impress at any given instant one polarity on conductor P at the A end of the series of boxes and to impress at the same instant the opposite polarity on conductor N at the C end of the series of boxes, an electric motor element in each box deriving its operating current from conductors P and N when the box is energized, a code wheel in each box actuated by the electric motor element thereof, a signal conductor connecting with said boxes and cooperating with the code wheel in each box, receiving apparatus comprising a movable character element adapted to respond to the signals transmitted from said signal boxes, and means for electrically synchronizing the operation of said receiving apparatus with the signaling operations of any one of said boxes comprising means for transmitting electrical impulses to said operating box and to said receiving apparatus in timed relation.

41. In combination, a first station having a control device therein, a second station having a responsive device adapted to be controlled by the control device of said first station, and mechanism for electrically synchronizing the operation of said two stations comprising means for transmitting electrical impulses to the control device of said first station and to the responsive device of said second station in timed relation.

JAMES R. HARRINGTON.

CERTIFICATE OF CORRECTION.

Patent No. 2,164,324. July 4, 1939.

JAMES R. HARRINGTON.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 30, second column, line 75, and page 31, first column, lines 1 to 5, claim 18, strike out the comma and words ", and non-interference means cooperating therewith whereby the signaling wheel of an operating box is caused to complete the final movement of its cycle concurrently with the initial movement of the signaling wheel of a concurrently energized box" and insert instead for causing the operation of the electric motor element in an operating box during a signaling operation; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 5th day of September, A. D. 1939.

Henry Van Arsdale,
Acting Commissioner of Patents.

(Seal)