

April 22, 1947.

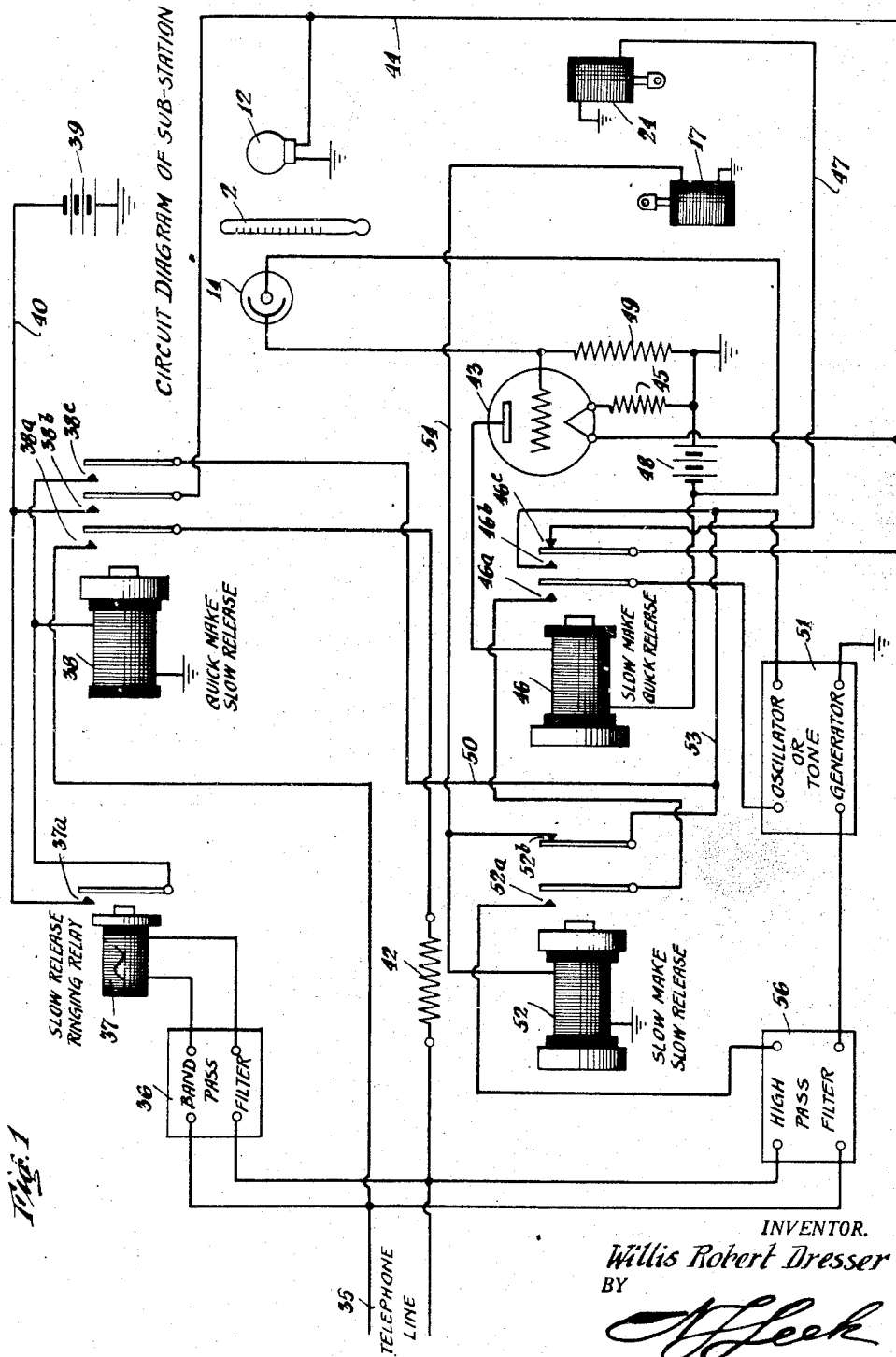
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2,419,487

REMOTE CONTROL METERING SYSTEM

Filed Feb. 2, 1944

3 Sheets-Sheet 1



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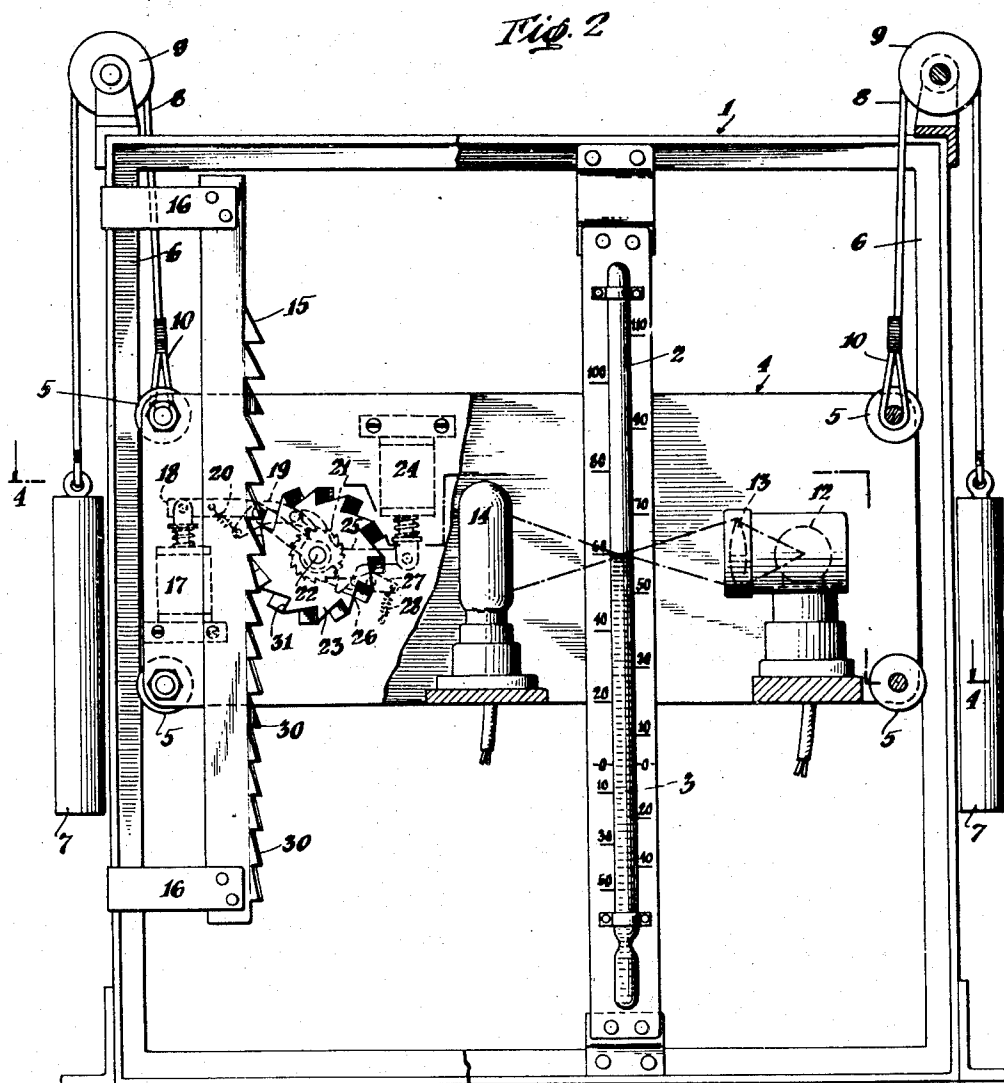
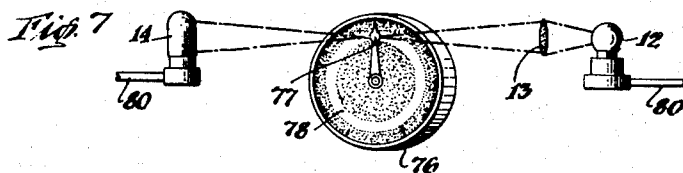
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3 Sheets-Sheet 2



SCANNING APPARATUS
AT SUB-STATION

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3 Sheets-Sheet 3

Fig. 3

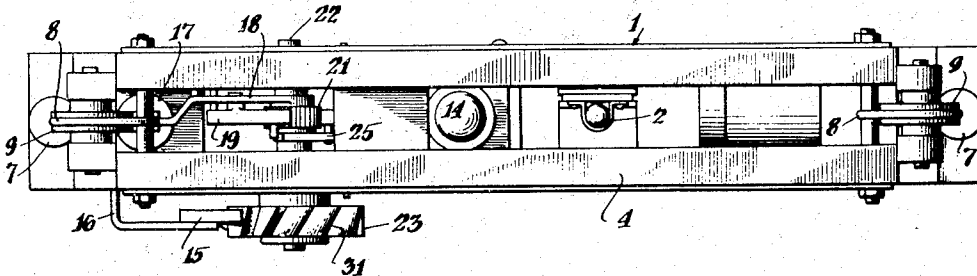


Fig. 4

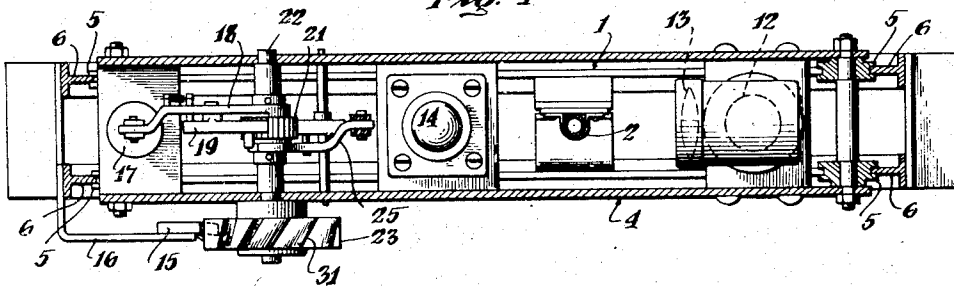
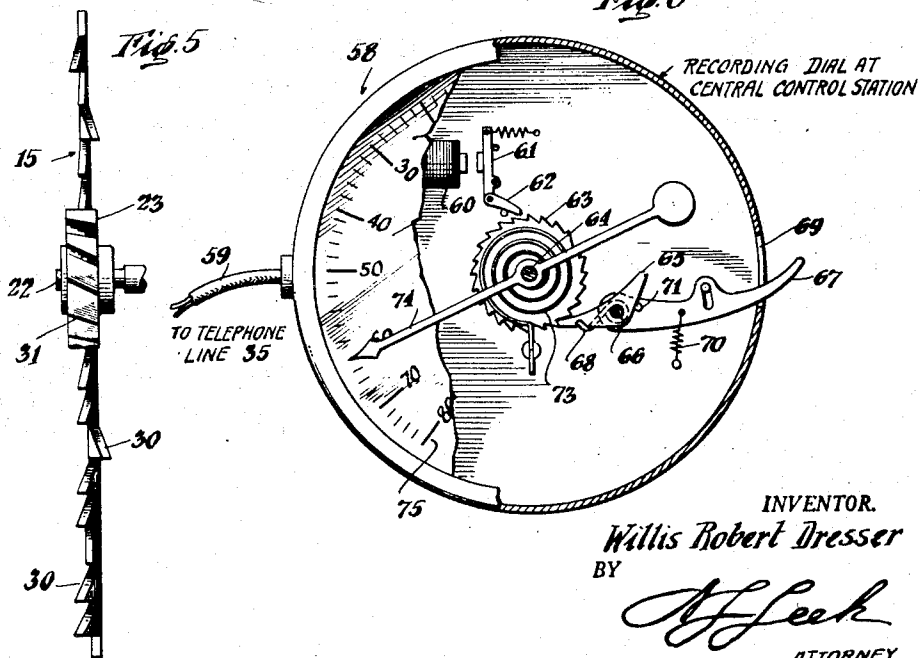


Fig. 6



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2,419,487

REMOTE-CONTROL METERING SYSTEM

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Application February 2, 1944, Serial No. 520,815

12 Claims. (Cl. 177—351)

1

This invention relates to remote control systems and has for its object to provide a novel and improved electrical system for controlling the operation of apparatus at a distant point and for automatically transmitting an answering signal to indicate the condition of such apparatus to the attendant at the control station.

Another object of the invention is to provide a remote control system for scanning an instrument such as a thermometer, barometer, pressure gauge or the like, located at a remote point such as an unattended weather station, and for promptly reproducing an accurate reading of such instrument at the distant control station.

Another object is to provide a system of the above type which is operated by alternating current impulses and in which all of the connections between the stations may be effected by means of a conventional telephone line or radio link, with no more supervision or effort than is required to initiate an ordinary telephone call.

Still another object is to provide a system of the above type with a new and improved scanning apparatus including a simple and accurate means to compensate for non-uniform calibrations of the thermometer, barometer, water-level gauge or other instrument which is to be scanned.

Various other objects and advantages will be apparent as the nature of the invention is more fully disclosed.

For the sake of simplicity I shall describe the invention in its application to a system for transmitting and recording temperature readings at a distant point, although it will be evident as the description progresses that the invention is equally applicable to the transmission of information regarding humidity, pressure, water level, etc., as well as a variety of other purposes.

It will be assumed that the attendant at a central weather bureau desires to take the reading of a thermometer located at an unattended distant sub-station, for example, on the top of a mountain, which is equipped with ordinary telephone toll service for occasional use by forest rangers, hunters or the like. According to my invention the attendant at the central control station, by merely dialing or otherwise ringing the unattended station, will automatically operate apparatus which will scan the thermometer and immediately transmit the correct reading back to the control station where it is recorded on a dial or other suitable instrument.

Important novel features of the invention include the provision of means at the remote sub-station for insuring the proper initial setting of

2

the scanning apparatus at the start of each call in case it was not properly set at the conclusion of the preceding call; a novel electric circuit at the sub-station including a special arrangement of relays for effecting the proper sequence of operations and insuring the faithful transmission of signalling impulses for operating the recording instrument at the control station in step with the scanning apparatus after it has once been set at the starting position; and various features in the construction and operation of the scanning apparatus itself, particularly the provision of means for compensating for the non-linear calibrations of the thermometer or other instrument to be scanned, whereby the impulses transmitted back to the control station will be of proper duration and will insure the faithful and accurate transmission and reproduction of the desired readings.

Although the novel features which are characteristic of this invention are set forth more in detail in the claims appended hereto, the nature and scope of the invention may be better understood by referring to the following description, taken in connection with the accompanying drawings forming a part thereof, in which certain specific embodiments have been set forth for purposes of illustration.

In the drawings:

Fig. 1 is a diagrammatic view of the electrical circuits and apparatus located at the sub-station containing the thermometer or other instrument to be scanned;

Fig. 2 is a side view of the instrument panel at the sub-station, including the thermometer and a vertically movable carriage containing the scanning and associated apparatus;

Fig. 3 is a top plan view of the apparatus shown in Fig. 2;

Fig. 4 is a transverse section taken on the line 4—4 of Fig. 2;

Fig. 5 is a fragmentary view of the toothed rack forming a part of the carriage-moving apparatus of Fig. 2;

Fig. 6 is a plan view of the recording dial located at the central control station, same being partly broken away to illustrate the operating mechanisms; and

Fig. 7 is a perspective view illustrating a modification of the invention employing a dial-type meter, such as a barometer, in place of the linear thermometer of Fig. 2.

In the following description certain specific terms are used for convenience in referring to the various details of the invention. These

terms, however, are to be interpreted as broadly as the state of the art will permit.

Scanning apparatus

I shall first describe the scanning apparatus shown in Figs. 2 to 5, which is assumed to be located at an isolated unattended sub-station of a weather bureau or the like.

At this sub-station there is an instrument box or panel 1 containing an upright thermometer 2 of standard construction having the usual mercury or other fluid column 3.

The apparatus for scanning thermometer 2 is mounted on a vertically movable carriage 4 having rollers 5 which run on vertical tracks 6 secured to opposite sides of the instrument panel 1, as shown in Figs. 2 and 4.

Suitable counterweights 7 are secured to cords 8 which pass over pulleys 9 on the top of panel 1 and are tied to the vertically movable carriage 4 by loops 10, as shown in Fig. 2. Hence when the carriage 4 is released by a locking device hereinafter described, and permitted to ride freely on its tracks 6, the counterweights 7 will descend and thereby raise the carriage to the top of the panel 1.

The scanning apparatus mounted on carriage 4 includes an exciter lamp 12 and lens 13 on one side of thermometer 2, and a photoelectric cell 14 mounted on the opposite side of said thermometer. The lens 13 focuses the rays from lamp 12 at a point on the mercury column 3 of thermometer 2, and when the mercury is in the path of said rays the photoelectric cell 14 is inoperative. However, when the rays from lamp 12 are focused at a point on the thermometer above the column of mercury, the light will strike the photoelectric cell and render it conductive.

As will be hereinafter more fully explained, the scanning operation always starts with the carriage 4 at the top of panel 1, and the thermometer employed at the sub-station is always such that the mercury will never rise high enough to obstruct the rays from lamp 12 when the carriage is at its uppermost starting position.

The mechanism for actuating the carriage 4 includes a vertical toothed rack 15 secured by brackets 16 to the panel 1; a stepping solenoid or magnet 17 mounted on carriage 4 and having an armature lever 18 carrying a pivoted stepping pawl 19 which is normally held by spring 20 in engagement with the teeth of a pinion 21 on shaft 22 journaled in carriage 4; a star wheel or sprocket 23 keyed to shaft 22 and engaging the teeth of stationary rack 15; a release solenoid or magnet 24 having an armature lever 25 adapted to disengage pawl 19 from pinion 21, and an extension 26 of said lever 25 adapted to trip a locking pawl 27 which is normally held by spring 28 in engagement with the teeth of pinion 21.

Accordingly, each time the stepping magnet 17 is energized, in a manner hereinafter described, it actuates its armature lever 18, causing the pawl 19 to rotate the pinion 21 one step and thereby rotating the sprocket 23 and lowering the carriage 4 a distance of one measured increment. This increment may be equal to one degree on the scale of thermometer 2. And when the release magnet 24 is energized, as hereinafter described, it actuates its armature lever 25, thereby disengaging stepping pawl 19 and locking pawl 27 from pinion 21 and permitting the counterweights 7 to descend and thus raise the carriage 4 to the top of panel 1.

In the embodiment illustrated in Figs. 2 to 5

the teeth of rack 15 are equidistant, as are also the teeth of sprocket 23. However, the calibrations of thermometer 2 are not all uniformly spaced, and this same condition may also prevail in other types of meters or gauges employed in a system of this kind. In the preferred form of the invention this non-uniformity in the calibrations of thermometer 2 is compensated or corrected by cutting or forming the teeth of sprocket 23 at a slant or diagonally on the edge instead of straight across the edge of the sprocket, and by bending the teeth of rack 15 when necessary to make them engage the slanting teeth of the sprocket at certain points which will be determined by the spacing of the calibrations on the thermometer.

Thus in Figs. 2 and 5 certain teeth 30 of the rack 15 are bent sideways out of the flat vertical plane of the rack, in a manner somewhat analogous to the teeth of a rip-saw, while all of the teeth 31 of the sprocket 23 are arranged on a slant or diagonal with respect to the sides of said sprocket. The slanting teeth 31 of the sprocket are equally spaced and are parallel to one another; hence if all the teeth of rack 15 were unbent and in the flat vertical plane of said rack they would all engage the slanting teeth 31 of the sprocket at precisely the same points. However, the bent teeth 30 of rack 15, being out of vertical alignment with the plane of said rack, will necessarily engage a different portion of the slanting teeth of the sprocket. The extent of bending of the teeth 30 is made to coincide with the increment between the corresponding calibrations of the thermometer. Such adjustments may easily be made to fit any thermometer or other instrument, as required.

Electrical circuit at sub-station

Fig. 1 is a circuit diagram of the sub-station where the thermometer 2 is located. In the embodiment illustrated, this sub-station may be connected to a central control station by a transmission medium such as a conventional telephone toll line 35.

When the attendant at the control station desires to read the thermometer at the sub-station, he merely dials or otherwise signals the sub-station in the same way that an ordinary telephone call is initiated.

When a call is initiated in this manner, the low frequency ringing current impressed upon the transmission line 35 passes through band-pass filter 36 at the sub-station and operates the slow release alternating current relay 37. This relay 37 establishes an energizing circuit for the quick make-slow release relay 38, extending from grounded battery 39, through conductor 40, contact 37a of relay 37, winding of relay 38, to ground.

Contact 38a of relay 38, in closing, connects the line terminating resistor 42 across the incoming transmission line 35, thereby discontinuing the ringing signal. Contact 38b of relay 38 connects battery 39 to the exciter lamp 12; it also completes an energizing circuit for the filament of vacuum tube amplifier 43, extending from grounded battery 39, through conductor 40, contact 38b of relay 38, conductor 44, the filament of amplifier 43, resistor 45, to ground. Although the ringing signal was discontinued when resistor 42 was connected across the line 35, the relay 38 is designed to have a sufficiently slow release to allow the filament of amplifier 43 to be warmed up and a holding circuit established for relay 38

as hereinafter described before the relay releases.

In the meantime, the closing of contact 38b of relay 38 establishes an energizing circuit for the release magnet 24 of the scanning apparatus, extending from grounded battery 39, through conductor 40, contact 38b of relay 38, conductor 44, the normally closed back contact 46c of slow make-quick release relay 46, conductor 47, winding of release magnet 24, to ground. Operation of the release magnet 24 releases the carriage 4 of the scanning apparatus of Fig. 2, permitting the counterweights 7 to descend and thereby raise the carriage to its "starting" position at the top of the instrument panel 1, as previously described. This makes certain that the scanner carriage is released and returned to its initial scanning position before each transmission.

Now, as soon as the filament of the vacuum tube 43 has warmed up, light from the exciter lamp 12, striking the photoelectric cell 14, renders it conductive and causes a positive biasing potential to be impressed upon the control grid of tube 43 by battery 48 through resistor 49. This permits the passage of plate current from battery 48 through the winding of the slow make-quick release relay 46, thereby closing relay contacts 46a and 46b, and opening relay contact 46c. The opening of contact 46c breaks the energizing circuit of the scanner release magnet 24.

The closing of contact 46b of relay 46 establishes a holding circuit for relay 38, extending from grounded battery 39, through conductor 40, contact 38b of relay 38, conductor 44, contact 46b of relay 46, conductor 50, contact 38c of relay 38, winding of relay 38, to ground. Thus relay 38 remains energized and its contacts closed even after the discontinuance of the incoming ringing signal.

The contact 46b of relay 46, in closing, also operates the oscillator or tone generator 51 over a circuit extending from grounded battery 39, through contact 38b of relay 38, conductor 44, contact 46b of relay 46, the energizing element of oscillator 51, to ground. It also operates a slow make-slow release relay 52 over a circuit extending from grounded battery 39, through conductor 40, contact 38b of relay 38, conductor 44, contact 46b of relay 46, conductor 53, the normally closed back contact 52b of relay 52, winding of relay 52, to ground.

At the same time, the scanner stepping magnet 17 is energized over a circuit extending from grounded battery 39, through conductor 40, contact 38b of relay 38, conductor 44, contact 46b of relay 46, conductor 53, contact 52b of relay 52, conductor 54, winding of magnet 17, to ground. The scanner magnet 17 thereupon moves its stepping pawl 19 and pinion 21 to permit a displacement of one measured increment, holding until the current to magnet 17 is cut off by the opening of contact 52b of relay 52 as a result of the delayed operation of said relay 52.

The relay 52, in operating, closes its front contact 52a, thus completing the circuit from oscillator 51 through said contact 46a of relay 46 and the contact 52a of relay 52 to the high pass filter 56 and thence to the telephone line 35. As a result, an outgoing signal or tone is impressed upon the telephone line 35 by the oscillator 51 before each actuation of the scanner stepping magnet 17, provided there is no interruption of the light from the exciter lamp 12 to the photoelectric cell 14.

The opening of the normally-closed back contact 52b of relay 52 breaks the energizing cir-

cuit of the scanner stepping magnet 17, causing said magnet to be reset thereby causing a displacement at one increment of the scanner current conditioning the magnet 17 to receive the next current impulse. The opening of relay contact 52b also breaks the energizing circuit of relay 52, causing a delayed release of its armatures and the restoration of the current flow to stepping magnet 17 through said relay contact 52b when again closed, thus repeating the tone transmission by oscillator 51 and the stepping of the scanning mechanism as described above.

The foregoing cycle is repeated as long as the light from the exciter lamp 12 is not interrupted in its passage to the photoelectric cell 14. When the scanning cycle is continued to the point where the light from exciter lamp 12 is interrupted by the column of mercury in thermometer 2, preventing light from reaching the photoelectric cell 14, the following cycle of operations is initiated.

When the photoelectric cell 14 is no longer conductive, due to the cessation of light thereto, the positive bias is removed from the vacuum tube 43, thus interrupting the flow of current from battery 48 through the winding of relay 46 to the plate of the tube 43. This causes relay 46 to be deenergized, opening contact 46b and thus breaking the holding circuit of the quick make-slow release relay 38. However, because of the slow-release characteristics of relay 38 it will maintain its contact 38b in closed position for a short time after the interruption of said holding current; hence contact 38b can again supply current from battery 39 through the now closed back contact 46c of relay 46 to the scanner release magnet 24, thereby returning the carriage 4 of the scanning apparatus to its starting position at the top of the instrument panel 1 as previously described.

Also, because of the opening of contact 46a of relay 46 and contact 52a of relay 52, and the interruption of operating current to the oscillator 51, no further signals will be impressed upon the telephone line 35 by said oscillator.

Upon the delayed release of relay 38, the opening of its contact 38a disconnects the line terminating resistor 42 from the line 35. Likewise, the opening of relay contact 38b discontinues the flow of current to the exciter lamp 12, the vacuum tube 43 and the scanner release magnet 24, resetting the entire system at the sub-station in readiness for the receipt of a later call.

Recording signals at control station

The central control station or weather bureau is represented in the drawing by the recording instrument 58 shown in Fig. 6.

This instrument, which may be of any suitable type, is connected to the telephone line 35 by conductors 59 and includes a stepping magnet 60 responsive to the alternating current tone impulse impressed upon the line 35 at the sub-station as previously described.

The stepping magnet 60 has an armature 61 controlling the stepping pawl 62 which engages the teeth of a ratchet wheel 63 mounted on shaft 64. Also engaging the ratchet 63 is a holding pawl 65 pivoted on a stud 66 with a separate releasing lever 67 and normally urged into engagement with the ratchet by a spring 68.

The releasing lever 67 projects out through a slot 69 in the casing of instrument 58, and, when this lever is grasped and pivoted about the stud 66 against the tension of spring 70, a pin 71 carried by the lever forces the holding pawl out of engagement with ratchet 63. When ratchet

63 is thus released a helical spring 73 returns the shaft 64 and a pointer 74 carried thereby to an initial starting position corresponding with the highest possible reading of the thermometer 2 when the carriage 4 is at the top of the instrument panel 1 at the sub-station.

The recording instrument 58 has a calibrated dial face 75 corresponding with the calibrations on the thermometer 2 at the sub-station. Before calling the sub-station the attendant at the central control station trips the releasing lever 67 of the instrument 58 to set the pointer 74 at the starting position. He then signals the sub-station, and, as previously described, the first signal received at the sub-station causes the operation of the scanner release magnet 24 which sets the scanning apparatus at its proper starting position if not already in such position. Hence the instruments at the two stations will be ready to step in unison at the beginning of the scanning operation.

The signalling impulses impressed upon the line 35 by the oscillator 51 at the sub-station are received at the central control station, and the stepping magnet 60 of instrument 58, responding thereto, advances the pointer 74 one measured increment for each impulse received. The pointer 74 thus moves in step with the descending carriage 4 of the scanning apparatus, and, when the pointer finally comes to rest upon the cessation of the impulses transmitted by oscillator 51, it will coincide with the reading of the thermometer 2 at the sub-station.

Dial-type meter of Fig. 7

Fig. 7 illustrates a modification of the invention employing a cylindrical dial-type meter 76, such as a barometer, pressure gauge or the like, in place of the straight glass thermometer 2 of Fig. 2.

The meter 76 may be of any suitable type having a hand or pointer 77 which is rotated in an arc or circle in response to changes in air pressure, water level, temperature or any other condition for which the instrument is intended.

The casing of meter 76 is stationary and it has an arcuate or circular transparent area 78 encompassing the field of movement of the pointer 77, which field is usually considerably less than a full circle.

The exciter lamp 12 and lens 13 and the photoelectric cell 14 are mounted on a rotatable carriage shaft 80 in axial alignment with the shaft of pointer 77, and the parts are so positioned that the light from lamp 12 will pass through the transparent area 78 of the instrument and impinge upon the photoelectric cell 14 when said light rays are not obstructed by the pointer 77.

In operation, the shaft 80 carrying the scanning apparatus is rotated step-by-step in any suitable manner, usually by a pawl-and-ratchet mechanism of the type previously described. The movement of the carriage ceases when the light rays from exciter lamp 12 are intercepted by the pointer 27. The electrical circuit may be the same as that shown in Fig. 1, and the recording instrument at the central control station may be the same as that shown in Fig. 6.

It will be evident that a plurality of remotely controlled units such as that described above may be operated in parallel, or at the same time by employing different tones or different operating frequencies for the various answer-back oscillators for simultaneous transmission. Such a system may be employed, for example, for trans-

mitting and recording the readings of wet and dry bulb thermometers. Likewise a number of scanners may be employed in tandem, or operated one after another, by the addition of a following sequence relay selector.

It is to be understood that the above examples are only illustrative and that various changes may be made therein and that the invention is capable of various other uses which will be readily understood by a person skilled in the art.

What is claimed is:

1. In a remote control scanning system including a transmission medium for the transmission of signals between a central control station and a remote sub-station, an instrument at said sub-station having a movable element, a carriage including an exciter lamp and a light-responsive cell adapted to move about the field of said movable element to direct the light rays from said lamp upon said cell when not interrupted by said movable element, means for advancing said carriage in successive measured increments from a predetermined starting position, means at said sub-station for setting said carriage at said starting position upon receipt of an incoming signal, and means at said sub-station responsive to such incoming signal and operative during the energization of said light-responsive cell for advancing said carriage and for impressing signals in step therewith upon said transmission medium for transmission to said central station.

2. In a remote control scanning system including a transmission medium for the transmission of signals between a central control station and a remote sub-station, an instrument at said sub-station having a movable element, a carriage including an exciter lamp and a light-responsive cell adapted to move about the field of said movable element to direct the light rays from said lamp upon said cell when not interrupted by said movable element, means including a stepping magnet for moving said carriage in successive measured increments from a predetermined starting position, means at said sub-station for setting said carriage at said starting position upon receipt of an incoming signal, and means at said sub-station responsive to such incoming signal during the energization of said light-responsive cell for actuating said stepping magnet and for impressing signals in step therewith upon said transmission medium for transmission to said central station.

3. In a remote control scanning system including a transmission medium for the transmission of signals between a central control station and a remote sub-station, a measuring instrument at said sub-station having a movable element adapted to fluctuate in response to changes in the conditions to be measured by said instrument, a light-transmitting area in said instrument in the field traversed by said movable element, a carriage including an exciter lamp and a light-responsive cell adapted to move about the field of said movable element to direct the light rays from said lamp upon said cell when not interrupted by said movable element, means including a stepping magnet for moving said carriage in successive measured increments from a predetermined starting position, means at said sub-station for setting said carriage at said starting position upon receipt of an incoming signal, and means at said sub-station responsive to such incoming signal during the energization of said light-responsive cell for actuating said stepping magnet and

for simultaneously impressing signals in step therewith upon said transmission medium for transmission to said central station.

4. In a remote control scanning system including a transmission medium for the transmission of signals between a central control station and a remote sub-station, a measuring instrument at said sub-station having a movable element adapted to fluctuate in response to changes in the conditions to be measured by said instrument, a light-transmitting area in said instrument in the field traversed by said movable element, a carriage adapted to move about the field of said movable element, an exciter lamp and a light-responsive cell on said carriage in position to direct the light rays from said lamp to said cell when not interrupted by said movable element, means including a stepping magnet for moving said carriage in successive measured increments from an initial starting position, means including a releasing magnet for returning said carriage to said starting position, means at said sub-station for operating said releasing magnet momentarily upon receipt of a signal, and means operated subsequently upon receipt of such signal and during the energization of said light-responsive cell for actuating said stepping magnet and for simultaneously impressing signals in step therewith upon said transmission medium for transmission to said central station.

5. In a remote control scanning system including a transmission medium for the transmission of signals between a central control station and a remote sub-station, a measuring instrument at said sub-station having a movable element adapted to fluctuate in response to changes in the conditions to be measured by said instrument, a light-transmitting area in said instrument in the field traversed by said movable element, a carriage adapted to move about the field of said movable element, an exciter lamp and a light-responsive cell on said carriage in position to direct the light rays from said lamp to said cell when not interrupted by said movable element, means including a stepping magnet for moving said carriage in successive measured increments from an initial starting position, means including a releasing magnet for returning said carriage to said starting position, a relay at said sub-station responsive to incoming signals, means actuated by said relay to operate said releasing magnet momentarily upon receipt of a signal, and means controlled by said relay upon the energization of said light-responsive cell for actuating said stepping magnet in measured increments and for simultaneously impressing corresponding signals upon said transmission medium for transmission to said central station.

6. In a remote control scanning system including a transmission medium for the transmission of signals between a central control station and a remote sub-station, a measuring instrument at said sub-station having a movable element adapted to fluctuate in response to changes in the conditions to be measured by said instrument, a light-transmitting area in said instrument in the field encompassed by said movable element, a carriage adapted to move about the field of said movable element, an exciter lamp and a light-responsive cell on said carriage in position to direct the light rays from said lamp to said cell when not interrupted by said movable element, means including a stepping magnet for moving said carriage in successive measured increments from an initial starting position, means

including a releasing magnet for returning said carriage to said starting position, a relay at said sub-station responsive to incoming signals, a second relay operated by said first relay and adapted to actuate said releasing magnet upon receipt of a signal, a vacuum tube having a filament circuit energized by said second relay and a control element in circuit with said light-responsive cell for activating said tube when said cell is rendered conductive by the reception of light, a third relay actuated by said vacuum tube, said third relay having a back contact in the energizing circuit of said releasing magnet and a front contact completing a holding circuit for said second relay whereby to break the former circuit and complete the latter upon the operation of said third relay, a signalling device operated by said third relay, a fourth relay operated by said third relay, said fourth relay having a back contact in its own energizing circuit and in the energizing circuit of said stepping magnet and having a front contact connecting said signalling device to said transmission medium whereby to alternately make and break said circuits under its control and thereby actuate said stepping magnet in measured increments while impressing corresponding signals from said signalling device upon said transmission medium for transmission to said central station.

7. In a remote control scanning system including a transmission medium for the transmission of signals between a central control station and a remote sub-station, a measuring instrument at said sub-station having a movable element adapted to fluctuate in response to changes in the conditions to be measured by said instrument, a light-transmitting area in said instrument in the field encompassed by said movable element, a carriage adapted to move about the field of said movable element, an exciter lamp and a light-responsive cell on said carriage in position to direct the light rays from said lamp to said cell when not interrupted by said movable element, means including a stepping magnet for moving said carriage in successive measured increments from an initial starting position, means including a releasing magnet for returning said carriage to said starting position, a relay at said sub-station responsive to incoming signals, a second relay of the quick make-slow release type operated by said first relay and adapted to actuate said releasing magnet momentarily upon receipt of a signal, a vacuum tube having a filament circuit energized by said second relay and a control element in circuit with said light-responsive cell for activating said tube when said cell is rendered conductive by the reception of light, a third relay of the slow make-quick release type actuated by said vacuum tube, said third relay having a back contact in the energizing circuit of said releasing magnet and a front contact completing a holding circuit for said second relay whereby to break the former circuit and complete the latter upon the operation of said third relay, a signalling device operated by said third relay, a fourth relay of the slow make-slow release type operated by said third relay, said fourth relay having a back contact in its own energizing circuit and in the energizing circuit of said stepping magnet and having a front contact connecting said signalling device to said transmission medium whereby to alternately make and break the said circuits under its control and thereby actuate said stepping magnet in measured increments and impress corre-

11

sponding signals from said signalling device upon said transmission medium, a recording instrument at said central control station responsive to signals received from said transmission medium, and means for setting said recording instrument at an initial starting position corresponding with that of the movable carriage at said sub-station.

8. A scanning apparatus comprising an instrument panel, a measuring instrument in said panel having a movable element adapted to fluctuate in response to changes in the conditions to be measured by said instrument, a light-transmitting area in said instrument in the field encompassed by said movable element, a carriage in said panel adapted to move about the field of said movable element, an exciter lamp and a photoelectric cell on said carriage in position to direct the light rays from said lamp to said cell when not interrupted by said movable element, means for moving said carriage in successive measured increments from a predetermined starting position, and means for returning said carriage to said starting position.

9. A scanning apparatus comprising an instrument panel, a stationary measuring instrument in said panel having a movable element adapted to fluctuate in response to changes in the conditions to be measured by said instrument, a transparent area in said instrument in the field encompassed by said movable element, a carriage in said panel adapted to move about the field of said movable element, an exciter lamp and a photoelectric cell on said carriage in position to direct the light rays from said lamp to said cell when not interrupted by said movable element, means including a stepping magnet for moving said carriage in successive measured increments from a predetermined starting position, and means including a releasing magnet for returning said carriage to said starting position.

10. A scanning apparatus comprising an instrument panel, a vertical transparent instrument in said panel having a fluid column of variable height, a vertically movable carriage in said panel, an exciter lamp and a photoelectric cell on said carriage on opposite sides of said instrument in position to direct the light rays from said lamp through said instrument to said cell when not obstructed by said fluid column, means on said panel and said carriage for actuating the latter including a toothed rack and a cooperating toothed wheel, means including a stepping magnet and a holding device for actuating said wheel in a direction to lower said carriage in measured increments, means including a releasing magnet for releasing said holding device, and means operative upon the release of said holding device to raise said carriage.

12

11. A scanning apparatus comprising an instrument panel, a vertical transparent instrument in said panel having a fluid column of variable height adapted to fluctuate in non-linear gradations, a vertically movable carriage in said panel, an exciter lamp and a photoelectric cell on said carriage on opposite sides of said instrument in position to direct the light rays from said lamp through said instrument to said cell when not obstructed by said fluid column, a vertical toothed rack on said panel, and a rotatable toothed wheel on said carriage cooperating with said rack for actuating said carriage, the teeth on said rack and wheel being spaced and shaped to make their points of mutual contact coincide with the corresponding gradations of said instrument.

12. A scanning apparatus comprising an instrument panel, a vertical transparent instrument in said panel having a fluid column of variable height adapted to fluctuate in non-linear gradations, a vertically movable carriage in said panel, an exciter lamp and a photoelectric cell on said carriage on opposite sides of said instrument in position to direct the light rays from said lamp through said instrument to said cell when not obstructed by said fluid column, a vertical toothed rack on said panel, and a rotatable toothed wheel on said carriage cooperating with said rack for actuating said carriage, the teeth on said wheel being slanting and uniformly spaced and certain of the teeth of said rack being distorted out of the normal plane of said rack to make their points of engagement with the slanting teeth of said wheel compensate for the non-linear gradations of said instrument.

WILLIS ROBERT DRESSER.

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FOREIGN PATENTS

Number	Country	Date
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