

1,320,291.

Patented Oct. 28, 1919.

4 SHEETS—SHEET 1.

Fig. 1.

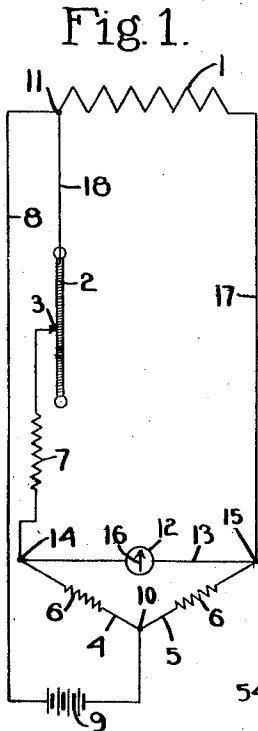
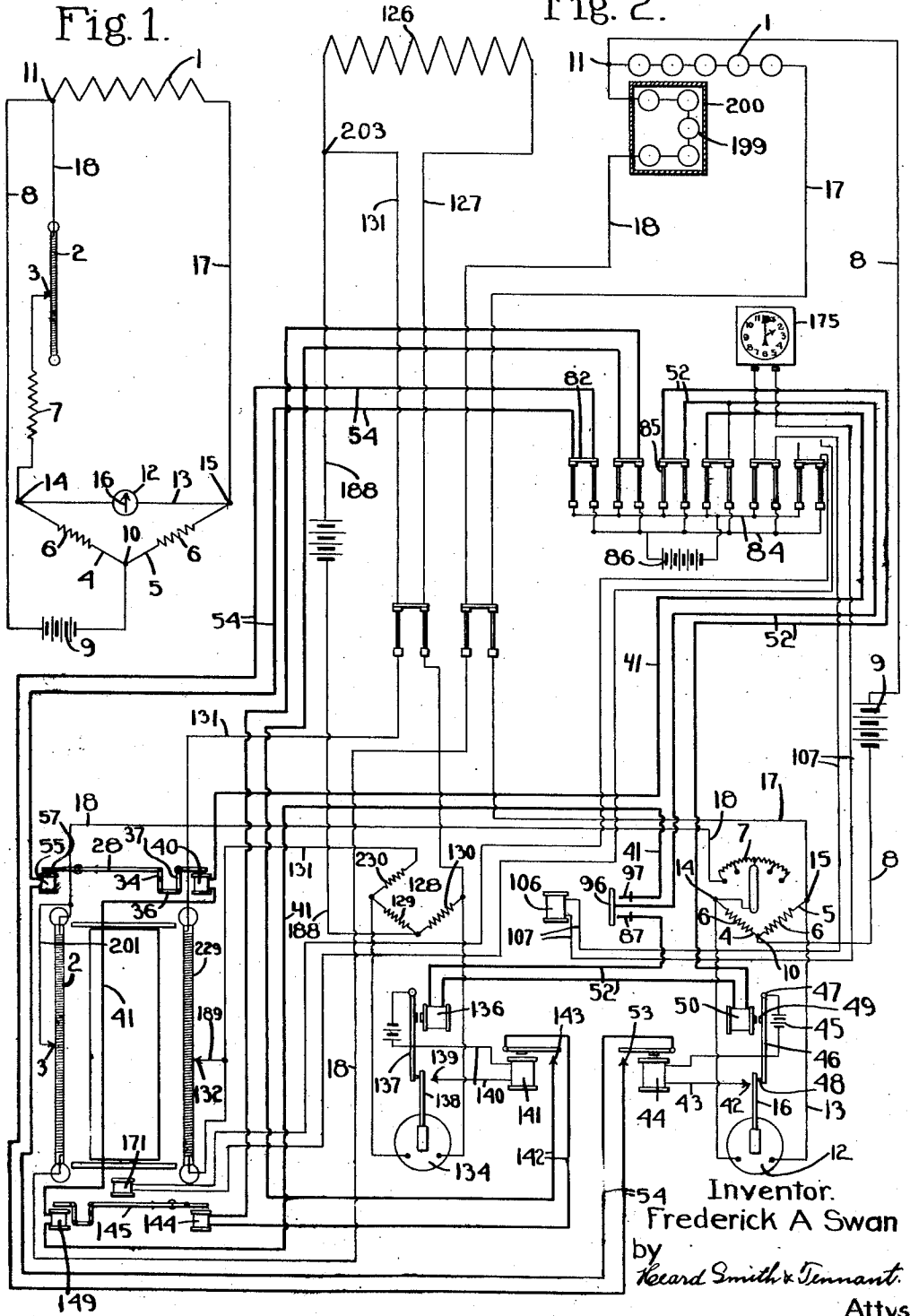


Fig. 2.



Inventor.  
 Frederick A Swan  
 by  
*Reed Smith & Tennant.*  
 Attys



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Fig. 6.

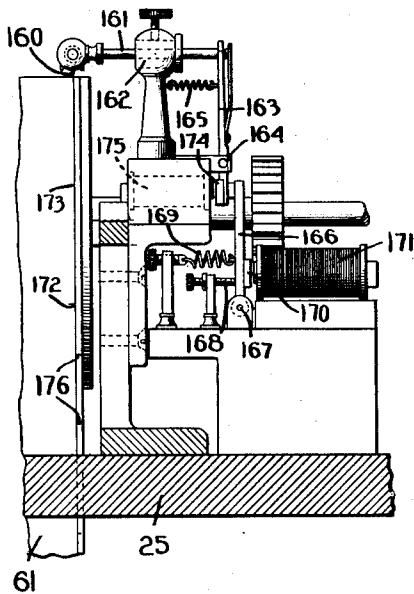


Fig. 7.

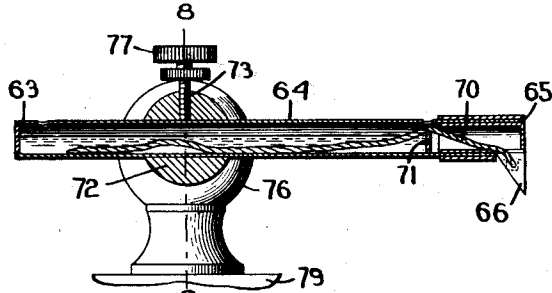


Fig. 8.

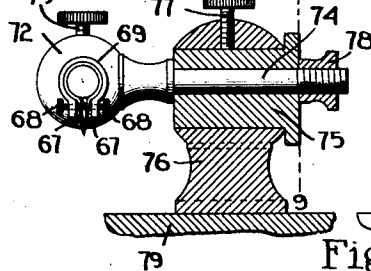


Fig. 9.

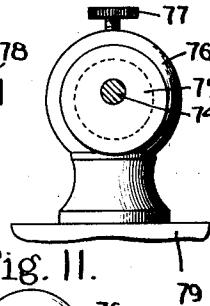


Fig. 11.

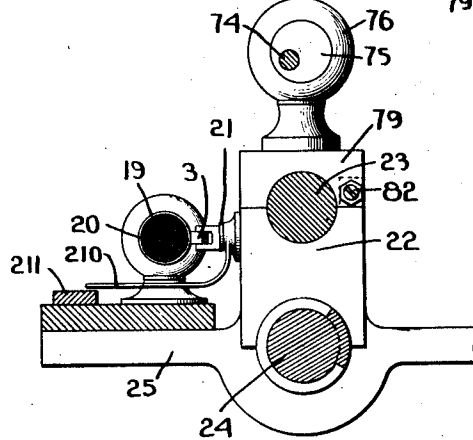


Fig. 10.

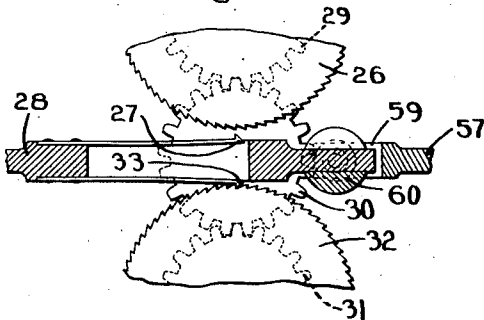
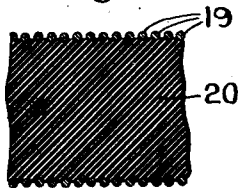


Fig. 12.



Inventor.  
 Frederick A. Swan  
 by *Harold Smith & Tennant.*  
 Attys

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4 SHEETS—SHEET 4.

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Fig. 13.

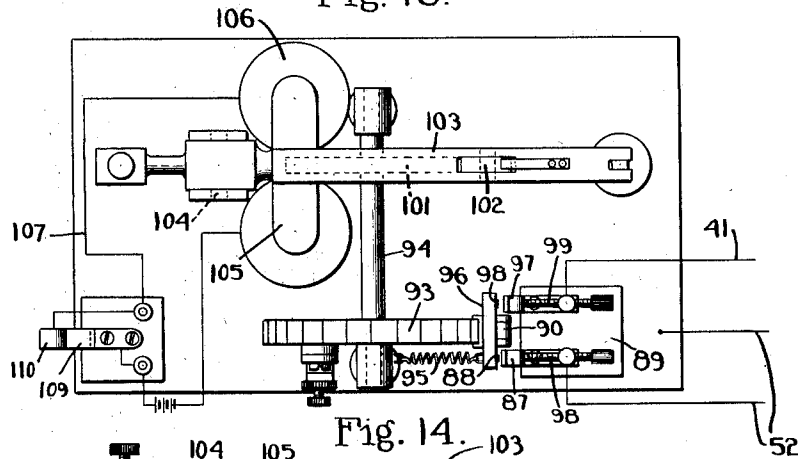


Fig. 14.

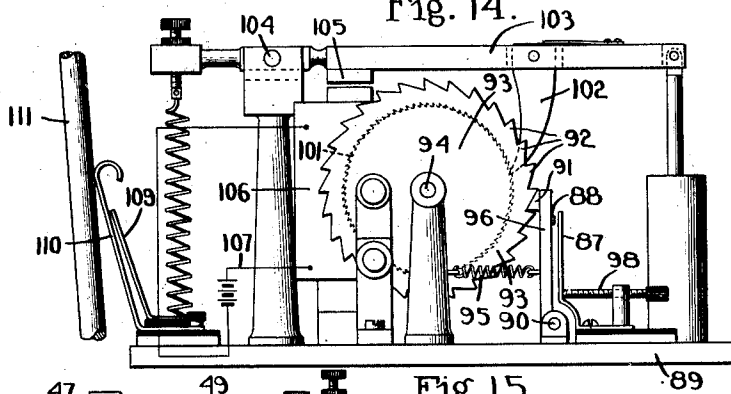


Fig. 15.

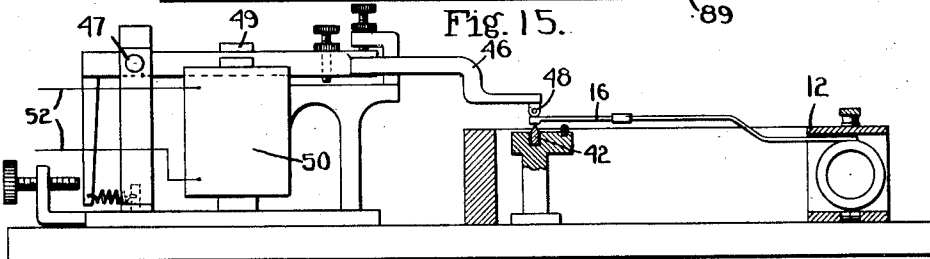
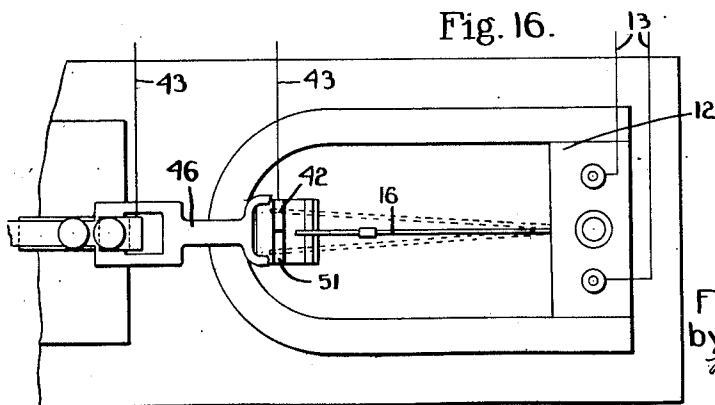


Fig. 16.



Inventor.  
 Frederick A. Swan  
 by *Heard Smith & Tennant.*  
 Attys.

# UNITED STATES PATENT OFFICE.

FREDERICK A. SWAN, OF CLIFTONDALE, MASSACHUSETTS.

## METEOROLOGICAL APPARATUS.

1,320,291.

Specification of Letters Patent.

Patented Oct. 28, 1919.

Application filed January 2, 1917. Serial No. 140,198.

*To all whom it may concern:*

Be it known that I, FREDERICK A. SWAN, a citizen of the United States, residing at Cliftondale, county of Essex, State of Massachusetts, have invented an Improvement in Meteorological Apparatus, of which the following description, in connection with the accompanying drawing, is a specification, like characters on the drawing representing like parts.

This invention relates to a meteorological apparatus which is constructed to make a record of variations in meteorological conditions, such, for instance, as temperature, light intensity, precipitation, etc.

The object of the invention is to provide a novel apparatus of this character which is relatively simple in construction, which is extremely sensitive and accurate in operation, and which will automatically and continuously register variations in meteorological conditions.

In order to produce a sensitive instrument or apparatus, I propose to make use of the principle of the familiar Wheatstone bridge, and for two of the arms of the bridge, I use fixed resistance of known amount, for another arm of the bridge I use a receiver element which is sensitive to changes in some meteorological conditions, such, for instance, as temperature, light intensity, radiant energy, luminous rays, etc., and which has the characteristic that its electrical resistance varies in accordance with variations in such meteorological conditions, and for the fourth arm of the bridge, I use a variable resistance having the same temperature coefficient as the receiver element.

Means are provided for varying the resistance of the variable resistance in accordance with variations of the resistance of the receiver element due to changing meteorological conditions thereby to keep the bridge substantially in balance, and such means are rendered operative by any change in resistance of the receiver element. Means are also provided for making a record corresponding to the variations thus made in the resistance of the variable resistance, and this record thus furnishes an accurate record of the changes in the meteorological conditions.

When the device is used for measuring light intensity, I propose to use a receiver in the nature of a photo-electric element which, for convenience, I will refer to as

a photo-electric cell or coil, or a photo-receptive element, and where the device is used for measuring temperature changes, I propose to use a receiver in the nature of a thermo-electric element which, for convenience, I will refer to as a thermo-electric cell or coil, or a thermo-receptive element. I wish it understood, however, that the terms cell and coil are not used for the idea of defining any particular cell or coil structure, but merely as a convenient term for indicating the receiver element of whatever nature that is responsive to changes of light intensity or changes of temperature.

In order to give an understanding of my invention, I have illustrated in the drawings a selected embodiment thereof which will now be described, after which the novel features will be pointed out in the appended claims.

In the drawings, Figure 1 is a diagrammatic view showing the principle on which my invention operates;

Fig. 2 is a diagrammatic view of the circuits involved in the apparatus;

Fig. 3 is a plan view of the recorder;

Fig. 4 is a side view thereof;

Fig. 5 is a detail view of the carriage of the recording device;

Fig. 6 is a view of an auxiliary device used in connection with the recorder to make on the record paper marks indicating certain predetermined time;

Fig. 7 is a sectional view of the pen used in making the record;

Fig. 8 is a section on the line 8—8, Fig. 7;

Fig. 9 is a section on the line 9—9, Fig. 8;

Fig. 10 is a detail of the mechanism for operating the contact of the variable resistance element;

Fig. 11 is a section on the line 11—11, Fig. 3.

Fig. 12 is a fragmentary sectional view of the variable resistance;

Fig. 13 is a plan view, and Fig. 14 is a side view of the time mechanism for intermittently closing some of the operative circuits of the device;

Fig. 15 is a side view of the galvanometer and the mechanism by which the galvanometer controls the auxiliary circuit;

Fig. 16 is a plan view of Fig. 15.

As stated above, I make use of the principle of the Wheatstone bridge in my invention, and I construct a bridge, two of the arms of which have the same fixed resist-

ance, and one of the other arms of which is constituted by a receiver which may be a photo-receptive element, a thermo-receptive element, or some other receiver element sensitive to changes in some meteorological condition and the electrical resistance of which changes as changes occur in such meteorological condition, while the fourth arm includes the variable resistance unit. The galvanometer of the bridge is connected to indicate any variations or differences in resistance between the receiver element and the arm including the variable resistance. Means are associated with the galvanometer and rendered operative thereby to increase or decrease the resistance of the variable resistance as the resistance of the receiver increases or decreases, thereby maintaining the Wheatstone bridge in balance. The device is constructed to indicate the amount which the variable resistance is thus increased or diminished, and this indication is recorded. Inasmuch as the variations of the resistance of the receiver correspond exactly with variations in the meteorological condition to which the receiver is sensitive, the resulting record which is produced as above will give a true record of such variations in the meteorological condition.

Before entering into a detailed description of the apparatus in its entirety, I will refer briefly to the diagrammatic view shown in Fig. 1 which illustrates in a simplified form the principle on which my invention operates. An understanding of the simplified diagram of Fig. 1 will assist in giving understanding of the more complicated mechanism of the complete device.

In Fig. 1, 1 indicates a receiver, such as a photo-electric cell or coil, or a thermo-electric cell or coil, and 2 a variable resistance. This variable resistance may be in the form of a resistance wire and a contact 3 is provided which may be moved longitudinally of the resistance wire to include a greater or less amount thereof in the circuit. The Wheatstone bridge illustrated in Fig. 1 is provided with the two arms 4 and 5, each having the same permanent resistance 6 therein. The receiver 1 constitutes a third arm of the bridge, and the variable resistance 2 together with a fixed resistance 7 constitute a fourth arm of the bridge. 8 indicates the energizer or battery circuit of the Wheatstone bridge which is provided with a source of electrical energy 9 therein. This circuit 8 is connected to the bridge at the point 10 between the resistances 6 and also at the point 11 between the receiver 1 and the variable resistance 2. 12 indicates the galvanometer, the circuit 13 of which is connected to the bridge at the points 14 and 15. According to the well-known principle of operation of the Wheatstone bridge, so long as the resistance of the receiver 1 is

the same as that of the variable resistance 2 plus the fixed resistance 7, the needle 16 of the galvanometer 12 will remain in zero position, but if the resistance of the receiver 1 increases or decreases relative to that of the bridge arm including the variable resistance 2, then the galvanometer needle 16 will be deflected one way or the other. The proper operation of my apparatus depends upon maintaining the resistance of the two arms, including the receiver and variable resistance, substantially equal, and this is accomplished by providing means associated with and controlled by the movements of the galvanometer needle 16 to move the contact 3 one way or the other thereby to increase or decrease the resistance of the variable resistance 2 as the resistance of the receiver varies. If, for instance, the receiver 1 is in the nature of a photo-electric cell or coil, and the light intensity or luminosity is continually increasing, as would occur when night changes into day, then the resistance of the photo-electric cell 1 will be constantly increasing, and the mechanism above referred to will operate to correspondingly increase the resistance of the variable resistance 2. This movement of the contact 3 is recorded and thus makes a record of the gradual increase of light intensity. Similarly, when the light intensity decreases, the decrease in the resistance of the photo-electric cell 1 will produce a corresponding decrease in the resistance of the variable resistance 2 and the movement of the contact 3 by which this decrease is secured provides the record of the decrease in light intensity.

In Fig. 2 I have shown the wiring connections of my apparatus in more complete form, said figure illustrating diagrammatically the mechanism for registering or recording both the variations in light intensity and variations in temperature. I will first describe that portion of the apparatus shown in Fig. 2, wherein variations in light intensity or luminosity are recorded. The photo-electric cell or coil is indicated at 1 and the variable resistance is indicated at 2. This resistance has a movable contact 3 as above described. The Wheatstone bridge comprises the two arms 4 and 5 having the fixed resistances 6 therein, said arms being connected together at 10, the third arm comprising the photo-electric cell 1 and the circuit connection 17, said arm being connected to the arm 5 at 15, and the fourth arm including a fixed resistance 7 and the variable resistance 2, together with the circuit connection 18. This fourth arm is connected to the arm 4 at 14 and is also connected to the arm including the photo-electric cell at the point 11. 8 is the energizing circuit for the bridge having the battery or other source electrical energy 9

therein, said circuit being connected to the bridge at the points 10 and 11. The galvanometer of the Wheatstone bridge is shown at 12 and the circuit 13 thereof is connected to the bridge at the points 14 and 15.

The photo-electric cell 1 may have any suitable construction and be made in any suitable way, the essential thing being that the electrical resistance thereof should vary with variations in the radiant energy or light intensity. I have found as a result of various experiments that a photo-electric cell made of material known as tungsten and which is used as the filament of the ordinary well-known incandescent lamps works very satisfactorily because the electrical resistance of tungsten varies as the light intensity or radiant energy varies. I have also found that it is not necessary to make up a specially-constructed cell having a tungsten filament, as the ordinary tungsten incandescent lamp such as can be purchased on the market will answer all the requirements demanded of the photo-electric cell. I will preferably, however, use as the photo-electric cell a plurality or bank of tungsten lamps rather than an individual lamp and find that good results can be obtained by using a relatively small current in the circuit 8. With a photo-electric cell of this construction and a relatively small current in the circuit 8, the variations in the resistance of the filaments of the lamps due to variations in light intensity can readily be made use of to cause the desired indication of such variations to be made. I do not wish to be limited, however, to the use of a photo-electric cell composed of tungsten incandescent lamps as the invention comprehends any suitable photo-electric cell or coil operating on the above principle. The photo-electric cell will be placed in the locality where it is desired to record the variations in light intensity. This may be in a room or in the open air. I will preferably inclose said photo-electric cell in a housing open on its under side so that the cell will not be subjected to the direct rays of the sun but will only receive reflected light.

The recording mechanism by which the variations in light intensity are recorded may be placed in any desired spot either adjacent to or remote from the photo-electric cell, it being simply necessary to connect the cell with the recording apparatus by suitable wiring.

Where the photo-electric cell 1 is situated at a point remote from the variable resistance and recording apparatus, I propose to place the point 11 of connection between the arms of the Wheatstone bridge including the photo-electric cell and variable resistance at a point closely adjacent the photo-

to-electric cell, as seen in Fig. 2. The reason for this is to avoid any errors in making the record which would result from change of resistance in the connection 18 leading to the photo-electric cell due to variations in temperature. By placing the point of connection 11 between the arms of the Wheatstone bridge having the photo-electric cell and variable resistance therein closely adjacent to the variable resistance, the circuit connections 17 and 18 are of substantially the same length and the resistance of both will be equally affected by any change in temperature. Since these two circuit connections 17, 18 are in different arms of the Wheatstone bridge, any similar change in resistance in the two circuit connections will not have any effect upon the galvanometer.

I also preferably place in the arm 18 of the Wheatstone bridge a bank of lamps having the same resistance as the bank of lamps 1, but these lamps 199 are inclosed in a dark chamber 200 so that they are not affected by variations in light intensity. The arrangement is such, however, that these lamps are subjected to the same temperature conditions as the lamps of the photo-electric cell or photo-receptive element 1. The purpose of these lamps is to eliminate any errors which might arise from a change of resistance of the photo-electric cell due to changes of temperature to which the filaments of the lamps may be subjected. Since the two banks of lamps 1 and 199 are subjected to the same temperature conditions, both banks of lamps will be equally affected by any temperature changes, and thus the resistance of the two arms 17 and 18 of the Wheatstone bridge will vary similarly and simultaneously as the temperature varies. The galvanometer 12, therefore, will not be affected by temperature changes.

The variable resistance unit is constructed not only to increase or decrease the resistance of the bridge arm 18 in which said unit is connected, but also to afford means for graphically indicating any variation in the resistance. The variable resistance herein shown is in the form of a resistance wire 19 wound in a helical coil upon a core 20 of insulating material with the individual turns of the coil spaced from each other, as seen in Fig. 12. Coöperating with this resistance coil 19 is a movable contact 3 in the form of a roll journaled in a bracket 21 mounted on a carriage 22 that is adapted to move longitudinally of the core 20. This carriage is guided in its reciprocation or movement by a guide rod 23, and as it moves, the roll contact 3 is moved back and forth longitudinally of the spiral coil 19. This contact 3 is connected in a shunt circuit 201 so that the amount of the resistance wire 19 which is in the circuit 18 depends

upon the position of the carriage 22 and the contact 3 which it carries. In Fig. 2 the contact 3 is illustrated diagrammatically and it will be seen that when this contact is moved toward the lower end of the resistance wire 19 in Fig. 2, the amount of resistance in the circuit will be decreased, while as the contact 3 moves toward the opposite end of the coil, the amount of resistance in the circuit is increased.

Means are provided for moving the carriage 22 in one direction or the other thereby to increase or decrease the amount of the variable resistance in the circuit as the resistance of the photo-electric cell varies so as to maintain a balance in resistance between the two arms of the Wheatstone bridge including the variable resistance and photo-electric cell. While any suitable means for thus moving the carriage 22 may be employed, I have chosen for this purpose an actuating screw 24 with which the carriage 22 has screw-threaded engagement. The core 20 for the resistance coil 19, the guide 23 and the actuating screw 24 are all illustrated as being mounted on a suitable base 25. The actuating means for the screw 24 is controlled as to its operation by variations in the resistance of the photo-electric cell 1, and the construction is such that when the resistance of said cell decreases, the screw will be turned in a direction to reduce the amount of the variable resistance in the circuit, while when the resistance of the photo-electric cell increases, the screw will be turned in the opposite direction thereby to increase the amount of the variable resistance which is in the circuit 18. The screw 24 has rigid therewith a ratchet wheel 26 and also a gear 29. The gear 29 meshes with an intermediate gear 30 which in turn meshes with a gear 31 rigid with a second ratchet wheel 32, the teeth of which are oppositely disposed to those of the ratchet wheel 26.

Situated between the ratchet wheels 26 and 32 is an oscillatory actuator 28 carrying two resiliently-sustained pawls 27 and 33, one adapted to cooperate with each ratchet wheel. The actuator 28 is capable of a slight lateral movement so as to bring either of the pawls into cooperative engagement with the corresponding ratchet wheel. In Fig. 10 the pawl 33 is shown as in position to actuate the ratchet wheel 32, and the pawl 27 is out of engagement with the ratchet wheel 26. When the actuator 28 is moved upwardly, the pawl 27 will be brought into engagement with the ratchet wheel 26 and the pawl 33 disengaged from the ratchet wheel 32. When the actuator is in the position shown in Fig. 10 and is reciprocated, the reciprocation thereof will operate through the ratchet 32 and gears 31, 30 and 29 to rotate the screw 24 in one

direction, while when the actuator is shifted to disengage the pawl 33 from the ratchet 32 and to bring the pawl 27 into engagement with the ratchet 26, the reciprocation of said actuator will operate to rotate the screw 24 in the opposite direction. Means are employed for shifting the actuator 28 into operative engagement with one or the other ratchet wheel, depending on whether the resistance of the photo-electric cell increases or decreases, the means being so constructed that an increase in the resistance will cause the actuator 28 to be shifted into operative position relative to the ratchet wheel 26, while a decrease in resistance of the photo-electric cell will cause the actuator to be brought into the position shown in Fig. 10.

Any suitable means for reciprocating the actuator may be employed. I have herein, however, provided an electrically-controlled time mechanism for this purpose which gives to the actuator a reciprocation at stated time intervals, say every three seconds. This actuator is pivotally connected at one end to a lever 34 that in turn is pivoted at 35 to the frame 25. This lever is connected by a link 36 with a bell crank 37 pivoted at 38, the arm 39 of said elbow-lever being in the form of an armature for an actuating magnet 40. The circuit 41 of this magnet is connected to a suitable clock mechanism by which the circuit is closed at regular time intervals. This time-actuated circuit-closing device will be presently described.

I will now describe the means by which the actuator 28 is shifted into operative engagement with one or the other ratchet wheel, depending on the variations in resistance of the photo-electric cell 1. This is accomplished through a selective mechanism which is associated with the galvanometer 12 connected with the Wheatstone bridge. Situated adjacent the pointer 16 of the galvanometer 12 is an insulated contact 42 connected in a circuit 43 having a relay 44 therein, said circuit being energized by a battery 45. The contact 42 is so located that when the galvanometer needle 16 is moved to one side of its center it will be carried out of line with the contact, while when it is moved to the other side of its central position, it is in position to engage the contact 42. Inasmuch as the current by which the galvanometer is operated is exceedingly small and the galvanometer 12 is very delicate, the force tending to move the needle or pointer 16 is insufficient to produce a good electrical contact with the contact 42. I have, therefore, so arranged the contact 42 that the needle or pointer 16 merely moves over it when it is carried to one side of its neutral position and have provided an auxiliary device for positively bringing the needle

into engagement with the contact 42. This mechanism is best seen in Figs. 15 and 16. Situated above the needle 16 is an arm 46 pivoted at 47 and carrying at its end a shoe or foot 48 overlying the end of the galvanometer needle 16. This arm 46 is connected in the circuit 43 and carries the armature 49 for a magnet 50. Whenever the magnet 50 is energized, the arm 46 is depressed, thus forcing the needle 16 into engagement either with the contact 42 or with a rest or support 51 which is insulated from the contact, depending on the position of the needle. The circuit 52 for the magnet 50 is connected to the bus-bars 84 which are energized from a source of electrical supply 86. Said circuit 52 is closed periodically by a circuit-closing mechanism presently to be described, and each time that said circuit 52 is closed, the magnet 50 becomes energized and the arm 46 serves to depress the galvanometer needle into contact with either the contact 42 or the rest 51, depending on the position of the needle. If in any period of time between successive movements of the lever 46, the resistance of the photo-electric cell 1 has increased, then the galvanometer needle will be moved over above the contact 42 so that at the next actuation of the arm 46, said needle will be depressed into engagement with the contact 42, thus closing the circuit 43 and energizing the relay 44. On the other hand, if during the interval between successive movements of the arm 46, the resistance of the photo-electric cell 1 has decreased, then the galvanometer needle will be carried over the rest 51, and when the arm 46 makes its movement, said needle will be carried against the rest 51. Since the rest 51 is insulated, this operation does not close any circuit.

The relay 44 is provided with a circuit-closing contact 53 for closing a circuit 54 including a selective magnet 55. The circuit 54 is shown as connected to the bus-bars 84 and provided with a switch 82 by which it may be opened or closed. The armature 56 of this magnet 55 is carried by a lever 57 pivoted at 58 to the frame 25. The end of the lever 57 is forked, as at 59, and pivotally mounted in the fork is a block 60 having an aperture through which the end of the actuator 28 is loosely received. Whenever the selective magnet 55 is energized, the lever 57 is rocked thereby lifting the actuator 28 into position to bring the pawl 27 into operative engagement with the ratchet wheel 26. When the magnet 55 is deenergized, however, the action of gravity carries the actuator into the position shown in Fig. 10 with the pawl 33 in engagement with the ratchet wheel 32. It will thus be seen that whenever the galvanometer needle 16 is moved

over the contact 42, the operation of the arm 46 will close the circuit 43, thus energizing the relay 44 and in turn closing the circuit 54 and energizing the magnet 55. This results in shifting the actuator 28 into coöperative relation with the ratchet 26 so that the reciprocation or actuation of the actuator 28 will turn the screw 24 clockwise. When, however, the galvanometer needle is over the rest 51, the relay 44 remains deenergized so that the actuator is in coöperative relation with the ratchet 32 so that the screw 24 will be turned anti-clockwise by the actuator 28.

The mechanism for closing the circuits of the magnets 40 and 50 is such that during each time interval, the magnet 50 is first energized, after which the actuating magnet 40 is energized thereby to give the actuator 28 its operative movement. The magnet 50 is maintained energized while the actuator 28 is operating, and thus said actuator will be held either in position to act on the ratchet wheel 26 or in position to act on the ratchet wheel 32, while it is making its forward operative movement. As soon as the actuator has made its operative movement, then both magnets are deenergized and at the end of another time interval, these operations are repeated.

The position of the carriage 22 and its contact 3 depends upon the amount of resistance which it is necessary to add to or take from the circuit 18 to maintain the bridge in balance, and the position of the carriage at any given time thus indicates the degree of the light intensity or radiant energy at such time.

In the device herein illustrated, I have provided a recording apparatus for making a record of variations of light intensity, and I find it convenient to associate such apparatus with the carriage 22. I have herein illustrated a recording device comprising a pen or other marking implement mounted on the carriage 22 and movable therewith, and a record paper situated to receive the record from the pen or other marking implement. The record paper is shown at 61 and is illustrated as being carried over a drum 62 rotatably mounted in the frame 26 and situated adjacent the carriage 22, suitable means being provided for drawing the paper over the drum at a uniform rate of speed. The marking implement or pen is shown at 63 and it is constructed to mark on the paper as it is drawn over the drum. The pen I prefer to use is best seen in Figs. 6 and 7. It comprises a hollow shank 64 adapted to contain a quantity of ink and a head 65 having the marking point 66 in the form of two wings or leaves 67 separated from each other. The amount of separation and consequently the width of the mark which is made is controlled by set-screws 68

carried in a collar 69 mounted on the head 65. The ink is fed to the pen point by means of a wick 70, and in order to avoid a surplussage of ink at the pen point, I propose to form the pen with the dam or partition 71 near the head 65 and over which the wick 70 is carried. This partition 71 not only retains the ink in the shank of the pen but it also causes the portion of the wick, which passes thereover to be elevated above the level of the ink. As a result, the ink will be carried over this partition by capillary attraction, and as this will result in a relatively-slow feed of the ink to the pen point, there is no danger that the pen will become flooded.

The shank of the pen is adjustably mounted in a holder 72 and is held in adjusted position therein by means of a set-screw 73. This holder is also adjustably sustained on the carriage 22. The holder is provided with a shank 74 which extends through a sleeve or bushing 75 that is adjustably mounted in a stand 76 carried by the carriage 22. The shank 74 is mounted eccentrically in the bushing 75 and the latter is adapted for turning movement in the stand 76. The bushing 75 is held in adjusted position by the set-screw 77. Owing to the eccentric mounting of the shaft 74 in the bushing 75, the turning movement of the latter in the stand 76 will operate to raise and lower the pen. The holder 74 can be turned in the sleeve 75 and is held in its adjusted position by the set nut 78. This turning of the holder will vary the inclined position of the pen.

I propose to so mount the pen on the carriage 22 as to provide for a slight play or lost motion between the pen and carriage. For this purpose the stand 76 is secured directly to a cap piece 79 which rests on the carriage 22. This cap piece is provided with the two flanges 80 (see Fig. 5) which overlie the sides of the projection 81 on the carriage. The flanges carry set-screws 82 which will be so adjusted as to allow a slight play or lost motion between the cap piece 79 and the carriage 22. The amount of this lost motion is designed to be just equal to the amount which the carriage 22 would be advanced at one reciprocation of the actuator 28. The purpose of this lost motion is to provide for making a straight line on the record sheet 61 when the radiant energy or light intensity remains constant. It will be seen that the actuator 28 will at each actuation thereof operate to advance one step either the ratchet wheel 32 or the ratchet wheel 26, and, therefore, at each time interval, the screw 24 will be turned in one direction or the other and the carriage 22 will thus be moved slightly in one direction or the other. Thus the amount of the variable resistance in the circuit 18 will either be added to or

subtracted from at each movement of the actuator 28.

When the light intensity is uniform and the resistance of the photo-electric cell 1 is consequently constant, the screw 24 will be actuated by the ratchets 26 and 32 alternately on successive movements of the actuator 28. The reason for this is because when the light intensity remains constant, the carriage 22 will be brought into such a position that one step thereof in one direction will place in the circuit 18 a slightly greater resistance than that of the photoelectric cell 1, while a step of the carriage in the opposite direction will place in the circuit 18 a slightly less resistance than that of the photo-electric cell 1. Consequently when the light intensity is constant and the resistance of the photo-electric cell 1 is constant, the carriage 22 will be brought into a position to place a slight excess of resistance in the circuit 18 and the galvanometer needle will consequently swing over the rest 51. At the next actuation of the actuator 28, the parts will be in the position shown in Fig. 10 and the screw 24 will be turned backward one step which will reduce the resistance in the circuit 18 slightly below that of the photo-electric cell. As a result, the galvanometer needle 16 will swing over the contact 42 so that at the next actuation of the actuator 28, the pawl 27 will be brought into engagement with the ratchet wheel 26, and the screw 24 will be rotated forwardly one step. This will place a slight excess of resistance in the circuit 18 and the next movement of the actuator 28 will, therefore, move the screw 24 back one step. There will thus be this alternate forward and backward movement of the screw so long as the light intensity remains constant. Owing to the lost motion between the cap 79 and the carriage 22, this alternate forward and backward movement of the carriage will not produce any movement in the cap 79 and the pen will, therefore, produce a straight line upon the paper 61.

The mechanism for opening and closing the circuits of the magnets 50 and 40 will now be described. It will be remembered that during each time interval the magnet 50 is first energized so as to bring the galvanometer needle 16 against either the rest 51 or contact 42, and so as to insure the placing of the actuator 28 in proper position, and then the magnet 40 is energized, thereby giving the actuator its operative movement. The mechanism by which these two magnets are energized in proper sequence is illustrated in Figs. 13 and 14. The magnet 50 is in a circuit 52 connected to the bus-bars 84 through a suitable switch 85, said bus-bars being suitably connected to a source of electrical energy 86. The circuit 52 has therein a pair of circuit-closing

contacts indicated at 87 and 88, respectively. The contact 87 is a spring contact which is insulated from a base or support 89, and the contact 88 is carried on an arm 96 pivoted to the base at 90. This arm 96 is provided with a nose 91 adapted to be engaged by teeth 92 on a wheel 93 which is fast on a shaft 94 that is suitably journaled in stands on the base 89. The arm 96 is yieldingly held in engagement with the wheel 93 by means of a spring 95. As the wheel 93 is rotated, the arm 96 is forced backwardly by each tooth 92, and then will be moved forwardly by the spring 95 as the tooth passes out from under the nose 91. This backward movement of the arm 96 brings the contact 88 against the contact 87 thereby closing the circuit 52.

When the contact 88 is in the position shown in Fig. 14, it is then separated from the contact 87 and the circuit 52 is opened. The circuit 52 will, therefore, be closed and then opened again each time that a tooth 92 passes the nose 91. The circuit for the magnet 40 is closed by means of this same wheel 93. The magnet 40 is in a circuit 41 which includes a spring contact 97 carried by but insulated from the base 89 and also a contact 98 carried by the pivoted arm 96. The normal position of the contacts 87 and 97 is controlled by stop screws 98, 99, and these stop screws are so adjusted that when the arm 88 is moved backwardly by any tooth 92, the contacts 88 and 87 in the circuit 52 will first be closed, thereby energizing the magnet 50, and subsequently the contacts 98 and 97 in the circuit 41 will be closed, thereby energizing the magnet 40. When the tooth 92 passes out from under the nose 91, the resultant forward movement of the arm 96 will open both circuits. The two magnets 50 and 40 are thus energized in proper sequence.

The wheel 93 may be given its forward rotation by any suitable means. I have for this purpose illustrated a ratchet wheel 101 fast on the shaft 94 and a pawl 102 carried by an arm 103 pivoted at 104 for actuating said ratchet wheel. This arm carries the armature 105 of a magnet 106 so that each time the magnet 106 is energized, the arm 103 will be moved downwardly thereby to advance the wheel 93 one step. The parts are so constructed that it takes three forward steps of the wheel 93 to carry one tooth 92 past the nose 91, and, therefore, at the first forward step, the circuit 52 of the magnet 50 will be closed, thus setting in motion the selective mechanism for positioning the actuator 28 and then at the second forward step, the circuit 41 for the magnet 40 will also be closed, thus causing the movement of the actuator 28. At the third forward step, the tooth 92 will pass out from under the nose 91, thus opening both circuits and caus-

ing the deenergization of the magnets 50 and 40.

The magnet 106 may be energized periodically by any suitable means. I have herein shown said magnet as connected in a circuit 107 connected to the bus-bars 84 and containing the two normally-open contacts 109, 110. 111 indicates a portion of the pendulum of a clock mechanism 175 which is so constructed that at each oscillatory movement thereof, it will engage the contact 110 and close it against the contact 109, thus closing the circuit 107 and energizing the magnet 106. If this pendulum is of the proper length to make one vibration per second, then it will follow that at each interval of a second the magnet 106 will be energized and the actuator 28 will be given its operative movement every three seconds. This particular interval of time, however, may be of any desired duration.

The record paper 61 can conveniently be in the form of a long web or strip and any suitable means may be employed for carrying it over the drum 62 with a uniform motion. In Fig. 4 I have illustrated a simple device for this purpose. The web of paper 61 is taken from a roll 112 and is carried up through suitable openings in the base 25, around the drum 62 and then down through another opening in said frame. The web of paper is fed forward by means of feed rolls 113 and 114, the feed roll 113 being positively driven and the feed roll 114 being a spring-pressed roll. The feed roll 113 has a gear 115 rigid therewith which meshes with a gear 116, and the gear 116 has rigid therewith a ratchet wheel 117. This ratchet wheel is actuated by a pawl 118 mounted on a pivoted lever 119. Said lever is connected by a link 120 to an armature lever 121 pivoted at 122 and actuated by a magnet 123. The pawl-carrying lever 119 is acted upon by a spring 124 which tends to move it in a direction to turn the ratchet wheel 117 forwardly. When the magnet 123 is energized, the pawl-carrying lever is moved against the action of the spring 124 and is caused to click over a tooth of the ratchet wheel. The magnet 123 can be operated at stated time intervals by any suitable circuit-closing mechanism.

125 indicates cutting knives by which the web 61 can be cut into lengths, each indicating the record for each day or any other stated period of time.

The operation of the device as thus far described for recording variations in light intensity may be briefly summarized as follows:

If the light intensity or luminosity increases or decreases, the result will be an increase or decrease of the resistance of the photo-electric cell 1, and such increase or decrease will cause the galvanometer needle

16 to move over the contact 42 or over the rest 51.

It will be remembered that the wheel 93 is constantly rotating and as each tooth 82 thereof engages the nose 91 of the arm 96, the contacts 87, 88 in the circuit 52 are first closed, thereby energizing the magnet 50, and then the contacts 97, 98 in the circuit 41 are closed, thus energizing the actuating magnet 40. The energizing of the magnet 50 causes the arm 46 to force the galvanometer needle 16 into engagement with either the contact 42 or the rest 51, depending on the position of the needle. If the galvanometer needle is over the contact 42, then this operation will close the circuit 43 and energize the relay 44, thus closing the circuit 34 and energizing the selective magnet 55 which will cause the actuator 28 to be raised into coöperative engagement with the ratchet wheel 26. On the other hand, if the needle is over the rest 51, the magnet 55 will remain deenergized and the actuator 28 will remain in coöperative engagement with the ratchet wheel 32. After the position of the actuator has thus been determined by the position of the galvanometer needle, the contacts 97, 98 are closed thereby closing the circuit 41 and energizing the actuating magnet 40 which operates to give the actuator its operative movement. This movement of the actuator operates to turn the screw 24 in one direction or the other, and thus shifts the carriage 22 carrying the contact 3 so as to add to or subtract from the resistance in the arm 18 of the Wheatstone bridge, depending on whether the resistance of the photo-electric cell has been increased or decreased. This change of position of the carriage 22 moves the recording pen 63 and thus produces the desired record on the record sheet 61.

The carriage 22 is shown as having a pointer 210 extending therefrom which moves over a scale 211 sustained on the base 25. This scale can be readily graduated so as to indicate different degrees of light intensity and by noting the position of the pointer 210, the observer may determine the degree of luminosity or light intensity at any moment.

As stated above, my apparatus also includes mechanism for registering and keeping a record of temperature changes. The mechanism for this purpose is similar in construction and operation to that already described. It comprises a thermo-electric cell or coil 126, the electrical resistance of which varies as the temperature varies, and which is connected in a circuit 127 forming one arm of a Wheatstone bridge indicated at 128. Two other arms 129 and 130 of this Wheatstone bridge have fixed resistance therein and the fourth arm 131 has therein

a variable resistance 229 similar to the variable resistance 2 and also an additional resistance 230 which can be fixed at any desired amount. The variable resistance 229 includes the coil of wire wound on a core and connected in the circuit 131 of the Wheatstone bridge and a movable contact 132 mounted on a carriage 133 similar to the carriage 22 and similarly operated, said contact being in a shunt circuit 189. The energizing circuit for the bridge 128 is indicated at 188, and the galvanometer therefor is shown at 134, it being constructed similarly to the galvanometer 12.

The deflection of the needle 138 of the galvanometer 134 carries it over either an insulated rest similar to the rest 51, or over a contact 139 in a relay circuit 140 which has a relay 141 therein. The galvanometer needle 138 is periodically depressed into engagement either with the rest or the contact 139 by means of an armature lever 137 which is actuated by a magnet 136 that is connected in the circuit 52 for the magnet 50. When, therefore, the circuit 52 is closed, as above described, the magnet 136, as well as the magnet 50, will be energized, and thus the galvanometer needle 138 will be brought into contact either with the rest or with the contact 39, depending on whether the resistance of the thermo-electric cell 126 has increased or decreased during the preceding time interval. The energizing of the relay 141 closes a circuit 142 at the contact 143. This circuit 142 connects to a selective magnet 144 which has a function similar to the selective magnet 55 in that it determines the position of an actuator 145 similar in all respects to the actuator 28, but which controls the operation of a screw 146. The actuator 145 carries two pawls adapted to coöperate with two ratchet wheels similar to the ratchet wheels 32 and 26 so that the direction of rotation of the screw 146 at each reciprocation of the actuator 145 is determined by the position of the actuator. If the actuator is moved upwardly into contact with the upper ratchet wheel corresponding to the ratchet wheel 26, then the movement of the actuator will turn the screw 146 in one direction, while if the actuator is in its lowered position in operative engagement with the lower ratchet wheel corresponding to the ratchet wheel 32, then the movement of the actuator will turn the screw in the opposite direction. The selected position of the actuator, it will be seen, is thus determined by the position of the galvanometer needle 138 at the end of each time interval.

The actuator 145 is given its reciprocating movements by a magnet 149 and connections similar to those between the actuator 48 and the magnet 40. The magnet 149 is in

the same circuit 41 as the magnet 40 so that closing of the circuit 41 actuates both magnets 40 and 149 and causes both actuators to operate simultaneously. The carriage 133 has a recording pen 151 thereon which is similar to the pen 63 and which makes on the record paper 61 a record line indicating temperature changes.

The thermo-electric coil or cell 126 will be located in the particular place the variations in temperature of which it is desired to record. In order to eliminate any error due to temperature changes of the wire of the circuit 127 which may be of considerable length, depending upon the remoteness from the recording apparatus of the thermo-electric coil 126, I propose to connect the arm 131 of the Wheatstone bridge to the arm 127 at the point 203 closely adjacent the thermo-electric cell or coil so that both wires 127 and 131 will be equally affected by any temperature changes. The operation of the above-described device for recording temperatures will be readily understood, but may be briefly summarized as follows:

As the resistance of the coil 126 increases or decreases the galvanometer needle 138 will be deflected in one direction or the other. The periodical movement of the lever 137 will bring the galvanometer needle into contact either with the rest or the contact 139, depending on the position of the needle at stated time intervals, and the selective magnet 144 will either remain deenergized or become energized at each operation of the lever 137, depending on the position of the galvanometer needle. The condition of the selective magnet 144 determines the position of the actuator. Immediately after the actuator has been properly positioned by this selective mechanism, the circuit 41 is closed, thus causing the operation of the actuator 145 and this actuator turns the screw 146 in one direction or the other as determined by the position of the galvanometer needle. This movement of the screw operates the carriage 133 and thereby shifts the contact 132 to add resistance in or subtract resistance from the variable resistance, thus maintaining the bridge in balance. This movement of the carriage causes the movement of the recording pen 151 which makes the record of the temperature changes.

The mechanism I have herein shown is also provided with means for making additional record marks on the record paper 61 which may be indicative of various phenomena. I have shown for this purpose an additional marking pen 160 which is carried by a holder 161 slidably mounted in a supporting standard 162. This pen 161 is adapted for movement in a direction parallel to the axis of the drum 62, or, in other

words, in a direction transversely to the sheet 61. The pen 160 normally remains stationary so that it will make a straight line on the record sheet 61. I have provided herein means for giving the holder 161 a quick movement in the stand 162 thereby moving the pen transversely of the record sheet 61. The means herein shown for this purpose is adapted to move the pen in one direction or the other, depending on the phenomena it is desired to record. I have shown a device adapted to give the pen a movement at stated time intervals as, for instance, at the noon hour each day, and also another device to give the pen a movement in the opposite direction for recording other phenomena, such, for instance, as rain fall.

The holder 161 is slidably mounted in the standard 162, as above stated, and the end thereof rests against a positioning device 163 which is pivoted at 164 to the frame 25. A spring 165 holds the positioning device against the end of the holder 161. The lower end of the positioning device 163 normally rests against an arm 166 which is pivoted at 167. This arm is held against an adjustable stop 168 by means of a spring 169. The spring 169 is much stronger than the spring 165 so that the normal action of the spring 169 will not overcome the spring 165 and move the arm 166 away from the stop 168. The arm 166 carries the armature 170 for a magnet 171. When the magnet 171 is energized, the arm 166 is moved to the right, Fig. 6, which operation will allow the spring 165 to operate thereby to move the holder 161 to the left, Fig. 6. If the magnet 171 is energized merely for an instant and then deenergized again, the arm 166 will have a quick vibratory movement which will permit the holder 161 to have a quick vibratory movement. This will make a mark on the record sheet such as indicated at 172 which extends laterally from the straight mark 173 normally made by the pen.

If the magnet 171 is connected to some clock circuit by which it is energized at twelve noon each day, then this lateral jog 172 will indicate the time element on the record sheet. I propose to use a plain record sheet bearing no time-indicating lines and then to print the time-indicating lines thereon after the sheet has been removed from the apparatus.

By making the mark 172 on the record sheet which corresponds to the noon hour or to any other predetermined time, it is possible to print the time-indicating lines on the record sheet accurately and in proper position after the record sheet has been removed from the apparatus with the record of the light intensity and temperature changes thereon.

The positioning member 163 is provided at its lower end with an armature 174 for a magnet 175. When the magnet 175 is energized, the upper end of the positioning member 163 is moved to the right, Fig. 6, thus moving the pen 160 to the right and making a lateral jog or indication mark 176 which extends in the opposite direction from the indication mark 172. The magnet 175 may be connected to any apparatus which measures any phenomena of which it is desired to make a record. For instance, this magnet 175 might be connected to the rain buckets of a precipitation-measuring device, such as commonly used on weather bureau stations, so that whenever a predetermined amount of precipitation has fallen, the magnet would be momentarily energized, thus making the lateral mark 176.

While I have illustrated herein a selected embodiment of my invention I desire it to be understood that various changes in the structure of the device may be made without departing from the invention. I also wish to make it clear that the term cell or coil as applied to the receivers has been used merely as a convenient term and not for the purpose of limiting the invention to any particular structure. This term may be considered as synonymous with the term photo-receptive element or thermo-receptive element as indicating any element which will cause variations in the resistance of a circuit in response to variations in light intensity or in the temperature. The term cell or coil is, therefore, herein used in a generic sense.

I claim:

1. In a meteorological apparatus, the combination with a receiver element having the characteristic that its electrical resistance varies in accordance with variations of some meteorological conditions, a variable resistance, and a galvanometer, all connected as a Wheatstone bridge, of means actuated by the galvanometer to vary the resistance of the variable resistance as the resistance of the receiver varies.

2. In a meteorological apparatus, the combination with a receiver element having the characteristic that its electrical resistance varies in accordance with variations of some meteorological conditions, a variable resistance, and a galvanometer, all connected as a Wheatstone bridge, of means actuated by the galvanometer to vary the resistance of the variable resistance as the resistance of the receiver varies, and means to indicate such variations.

3. In a meteorological apparatus, the combination with a receiver having the characteristic that its electrical resistance varies in accordance with variations in some meteorological conditions, a variable resistance, and a galvanometer, all connected as

a Wheatstone bridge with the receiver element situated, remote from the variable resistance, the point of connection between the two arms of the bridge including the receiver and the variable resistance, respectively, being adjacent the receiver, and means actuated by deflections of the galvanometer as the resistance of the receiver varies to vary correspondingly the resistance of the variable resistance.

4. In a meteorological apparatus, the combination with a receiver having the characteristic that its electrical resistance varies in accordance with variations in some meteorological conditions, a variable resistance, and a galvanometer, all connected as a Wheatstone bridge with the receiver situated remote from the variable resistance, the point of connection between the two arms of the bridge including the receiver and the variable resistance, respectively, being adjacent the receiver, means actuated by deflections of the galvanometer as the resistance of the receiver varies to vary correspondingly the resistance of the variable resistance, and means to indicate such variations.

5. In a device of the class described, the combination with a photo-electric cell, variable resistance, and a galvanometer, all connected as a Wheatstone bridge, of means actuated by the galvanometer to vary the resistance of the variable resistance as the resistance of the photo-electric cell varies.

6. In a device of the class described, the combination with a tungsten lamp constituting a photo-electric cell, variable resistance, and a galvanometer connected as a Wheatstone bridge, of means actuated by the galvanometer to vary the resistance of the variable resistance as the resistance of the photo-electric cell varies, and means to indicate visually such variations.

7. In a device of the class described, the combination with a tungsten lamp constituting a photo-electric cell, variable resistance, and a galvanometer all connected as a Wheatstone bridge, of means actuated by the galvanometer to vary the resistance of the variable resistance as the resistance of the photo-electric cell varies, and a recording device to make a record of such variations.

8. In a device of the class described, the combination with a tungsten lamp constituting a photo-electric cell, fixed and variable resistances, and a galvanometer connected as a Wheatstone bridge, of means actuated by the galvanometer to vary the resistance of the variable resistance as the resistance of the photo-electric cell varies, a recording device, and means controlled by the movements of the galvanometer needle to cause a record to be made of va-

riations in the resistance of the photo-electric cell.

9. In a device of the class described, the combination with a bank of tungsten lamps constituting a photo-electric cell, a variable resistance and a galvanometer, all connected as a Wheatstone bridge, of means actuated by the galvanometer as the resistance of the photo-electric cell varies to vary correspondingly the resistance of the variable resistance, a recording device to make a record of such variation, and means whereby said lamps are protected from the direct rays of the sun but are subject to reflected light only.

10. In a photoscope, the combination with a photo-electric cell having the characteristic that its electrical resistance varies as the radiant energy to which it is subjected varies, of a variable resistance connected in parallel with said cell, means to vary the resistance in the variable resistance as the resistance of the photo-electric cell varies, a recording device actuated by variations in said variable resistance, and means to protect said photo-electric cell from the direct rays of the sun while permitting said cell to be subjected to reflected light only.

11. In a photoscope, the combination with a bank of tungsten lamps constituting a photo-electric cell, of means to protect said lamps from the direct rays of the sun while permitting said lamps to be subjected to reflected light, a variable resistance connected in parallel with said cell, means to vary the resistance of the variable resistance as the resistance of the cell varies, and a recording device actuated by variations in said variable resistance.

12. In a device of the class described, the combination with a recording pen, of a screw for moving said pen, two ratchet wheels operatively connected to said screw, one of which turns the screw in one direction and the other of which turns the screw in the opposite direction, an actuator movable to operatively engage either ratchet wheel, selective means rendered operative by variations in the light intensity at a given place to cause the actuator to move into operative engagement with one or the other ratchet wheel, depending on whether the light intensity is increasing or decreasing, and means to actuate said actuator periodically.

13. In a device of the class described, the combination with means to support a record sheet, of a pen for making a record thereon, a vibratory actuator for giving movement to the pen, said actuator being capable of vibrating in either one of two different paths and being operative to move the pen in one direction when vibrating in one path and in the other direction when

vibrating in the other path, and selective mechanism responsive to variations in light intensity to determine which path the actuator can vibrate in.

14. In a device of the class described, the combination with means for supporting a record sheet, of a pen for making a record thereon, a vibratory actuator for giving movement to the pen, said actuator being capable of vibrating in either one of two different paths and being operative to move the pen in one direction when vibrating in one path and in the other direction when vibrating in the other path, and a selective mechanism responsive to variations in light intensity for controlling the position of the actuator, said mechanism causing said actuator to vibrate in one path when the light intensity increases and in the other path when the light intensity decreases.

15. In a device of the class described, the combination with means for supporting a record sheet, of a pen for making a record thereon, a screw for moving the pen, an actuator for operating the screw and adapted in one position to turn the screw in one direction and in another position to turn the screw in the opposite direction, and selective mechanism responsive to variations in light intensity to determine the position which the actuator shall assume.

16. In a device of the class described, the combination with means for supporting a record sheet, of a pen for making a record thereon, a screw for moving the pen, an actuator for operating the screw and adapted in one position to turn the screw in one direction and in another position to turn the screw in the opposite direction, and selective mechanism responsive to variations in light intensity for controlling the position of the actuator for placing the actuator in one position when the light intensity increases and in the other position when the light intensity decreases.

17. In a device of the class described, the combination with a pen or its equivalent for recording a record, of an actuator for moving the pen and adapted in one position to move the pen in one direction and in another position to move the pen in another direction, and a selective mechanism responsive to variations in light intensity to determine the position of the actuator.

18. In a device of the class described, the combination with a pen or its equivalent for making a record, of a movable actuator adapted to move in either one of two paths, means operated by the actuator to move the pen in one direction or the other, depending on the path in which the actuator is moving, a selective mechanism responsive to variations in light intensity to determine the path in which the said actuator moves, and

means to render the selective mechanism operative periodically.

19. In a device of the class described, the combination with a pen or its equivalent for making a record, of an actuator adapted to move in either one of two paths, means operated by the actuator to move the pen in one direction or the other, depending on the path in which the actuator is moving, a selective mechanism responsive to variations in light intensity to determine the path in which said actuator moves, means to render the selective mechanism operative periodically, and means to operate the actuator periodically in timed relation to the operation of the selective mechanism.

20. In a device of the class described, the combination with a pen or its equivalent for recording a record, of a vibrating actuator for moving the pen and adapted to travel in two different paths, said actuator when vibrating in one path operating to move the pen in one direction and when vibrating in the other path operating to move the pen in another direction, a selective mechanism responsive to variations in light intensity to determine the path in which the actuator is to move, and means to render the selective mechanism operative periodically and immediately thereafter to operate the actuator.

21. In a device of the class described, the combination with a photo-electric cell, variable resistance, and a galvanometer connected as a Wheatstone bridge with the photo-electric cell and the variable resistance situated in different arms of the bridge, of means to prevent the bridge from becoming unbalanced by the effect on the photo-electric cell of changes of temperature, and means actuated by the deflections of the galvanometer needle to vary the resistance of the variable resistance in accordance with variations of the resistance of the photo-electric cell due to variations in light intensity.

22. In a device of the class described, the combination with a photo-electric cell, variable resistance, and a galvanometer connected as a Wheatstone bridge with the photo-electric cell and the variable resistance situated in different arms of the bridge, of means to prevent the bridge from becoming unbalanced by the effect on the photo-electric cell of changes of temperature, means actuated by deflections of the galvanometer needle to vary the resistance of the variable resistance in accordance with variations of the resistance of the photo-electric cell due to variations in light intensity, and means to cause a record to be made of such variations.

23. In a device of the class described, the combination with a tungsten photo-receptive element, of a record sheet, a recording in-

strument for making a record thereon, means actuated by variations in the resistance of the photo-receptive element for controlling the movements of said recording instrument, and means to nullify the effect on the recording instrument of any change of resistance in the photo-receptive element due to change of temperature.

24. In a device of the class described, the combination with a tungsten receiver element, which is sensitive to variations in light intensity and also to variations in temperature and the electrical resistance of which varies as the light intensity or the temperature varies, of a recording device, means to cause the recording device to be operated in accordance with variations of the resistance of the receiver due to variations in light intensity while preventing said recording instrument from being operated by variations in resistance of the receiver due to temperature changes.

25. In a photoscope, the combination with a tungsten receiver element having the characteristic that its electrical resistance varies in accordance with variations in the light intensity and the temperature to which it is subjected, of a variable resistance connected in parallel with said receiver element, a balancing member in the circuit of the variable resistance, said balancing element having the characteristic that its resistance varies in accordance with variations of temperature changes only, and means actuated by the difference between the variations in resistance of the receiver element and balancing element, respectively, to make a record of such variations.

26. The combination with a receiver element responsive to changes in some meteorological condition, of a galvanometer so connected to said element that any changes in said meteorological condition cause a deflection of the galvanometer needle, a rest over which the needle of the galvanometer moves as it is deflected, said rest presenting two sections insulated from each other, means operating periodically to press said needle against said rest, a recording device, an actuator for moving said recording device periodically, and means to cause the actuator to move said recording device in one direction or the other, depending on which of the two sections of the rest the galvanometer needle is pressed against.

27. In a device of the class described, the combination with a receiver element responsive to changes in some meteorological condition, of a galvanometer so connected thereto that any changes in said meteorological condition cause a deflection of the galvanometer needle, a rest over which said galvanometer needle moves as it is deflected, said rest presenting two sections insulated

from each other, means operating periodically to press said needle against said rest, a relay circuit connected to one section to be closed when the galvanometer needle is pressed thereagainst, a recording device, and means actuated by the closing of the relay to operate said recording device.

28. In a device of the class described, the combination with a receiver element responsive to changes in some meteorological condition, of a galvanometer so connected thereto that any changes in said meteorological condition cause a deflection of the galvanometer needle, a rest over which said galvanometer needles moves as it is deflected, said rest presenting two sections insulated from each other, means operating periodically to press said needle against said rest, a relay circuit connected to one section to be closed when the galvanometer needle is pressed thereagainst, a recording device, an actuator for moving the recording device periodically, and means to cause the actuator to move the recording device in one direction or the other, depending on whether the relay circuit is closed or not.

29. In a device of the class described, the combination with a receiver element responsive to changes in some meteorological condition, of a variable resistance, said variable resistance and receiver element being situated in parallel-connected circuits, a galvanometer so connected to said circuits as to indicate any change in the relative resistance of said circuits, a rest over which the galvanometer needle moves as it is deflected, said rest presenting two sections insulated from each other, means to press the galvanometer needle against said rest periodically, and means to increase or decrease the amount of variable resistance, depending on which section of the rest the galvanometer needle is pressed against.

30. In a device of the class described, the combination with a receiver element having the characteristic that its electrical resistance varies in accordance with variations in some meteorological condition, of a variable resistance, said variable resistance and receiver element being situated in parallel-connected circuits, a galvanometer connected to said circuits to indicate any change in the relative resistance of said circuits, a rest over which the galvanometer needle moves as it is deflected, said rest presenting two insulated sections, means operating periodically to press the galvanometer needle against the rest, a recording device, and means to move the recording device in one direction or the other, depending on which of the sections of the rest the galvanometer needle is pressed against.

31. In a device of the class described, the combination with a record sheet and means

to support it, of a pen having an ink-receiving chamber, a marking point and a wick extending into the chamber and leading to the point, the portion of the wick between said chamber and point being raised above the level of the ink in said chamber whereby ink will be conducted to the point by capillary attraction, and means to move the pen relative to the record sheet.

32. In a device of the class described, the combination with a record sheet and means to support it, of a pen having an ink-receiving chamber, a marking point and a wick extending into the chamber and leading to the point, the portion of the wick between said chamber and point passing over the wall of the chamber whereby the ink will be conducted to the point by capillary attraction, and means to move the pen relative to the record sheet.

33. A pen for a recording instrument comprising a stem provided with an ink-receiving chamber and a point, and a wick extending into said chamber and leading to the point, the portion of the wick between said chamber and point being raised above both the level of the ink in said chamber and said point whereby the ink will be fed to the point by capillary attraction and gravity.

34. In a device of the class described, the combination with a tungsten photo-sensitive element, a variable resistance and a galvanometer, all connected as a Wheatstone bridge, of means actuated by the galvanometer to vary the resistance of the variable resistance as the resistance of the photo-sensitive element varies, and means to indicate visually such variations.

35. In a device of the class described, the combination with a tungsten photo-sensitive element, a variable resistance and a galvanometer all connected as a Wheatstone bridge, of means actuated by the galvanometer to vary the resistance of the variable resistance as the resistance of the photo-sensitive element varies, a recording device, and means to actuate the latter to cause a record to be made of the variations in the resistance of the photo-sensitive element.

36. In a device of the class described, the combination with two circuits connected in parallel, of a tungsten photo-sensitive element in one circuit, a variable resistance in the other circuit, and means rendered operative by any difference in the resistance between said circuits due to variations of resistance in the photo-sensitive element for recording such variations.

37. In a device of the class described, the combination with a photo-sensitive element comprising a tungsten filament situated in a chamber from which the air has been exhausted, a variable resistance and a galvanometer, all connected as a Wheatstone

bridge, of means actuated by the galvanometer to vary the resistance of the variable resistance as the resistance of said tungsten filament varies, and means to indicate visually such variations.

38. In a device of the class described, the combination with a photo-sensitive element comprising a tungsten filament situated within a chamber from which the air is exhausted, of a variable resistance connected in parallel with said element, means to vary the resistance of the variable resistance as the resistance of said tungsten filament varies, and a recording device actuated by variations in said variable resistance.

39. In a device of the class described, the combination with a photo-sensitive element

comprising a tungsten filament situated within a chamber from which the air is exhausted, of a recording device, and means rendered operative by the variations of the resistance of said photo-sensitive element to actuate the recording device thereby to make a record of such variations.

40. In a device of the class described, the combination with a tungsten photo-sensitive element, of a recording device, and means rendered operative by variations of the resistance of said photo-sensitive element to actuate the recording device thereby to make a record of such variations.

In testimony whereof, I have signed my name to this specification.

FREDERICK A. SWAN.