May 3, 1949. I. E. McCABE 2,469,124

PRESSURE OPERATED SWITCH

Filed Dec. 2, 1944 2 Sheets-Sheet 1

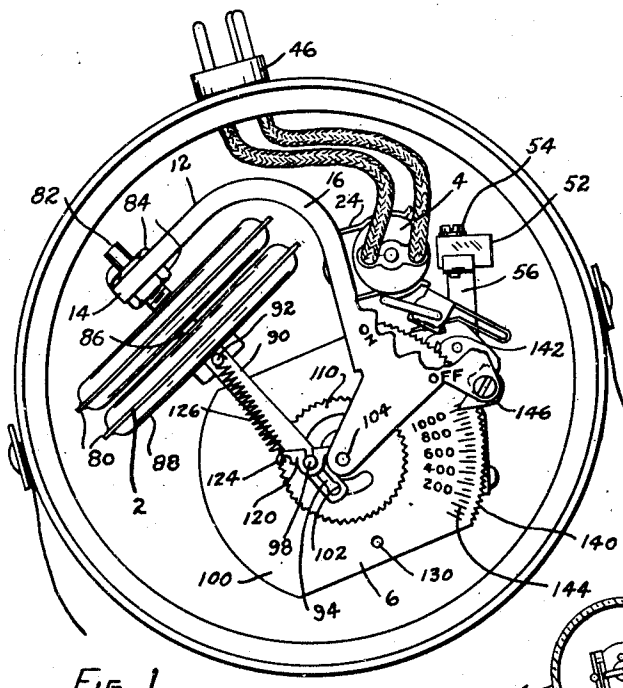

FIG. 1

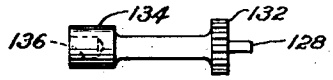

FIG. 10

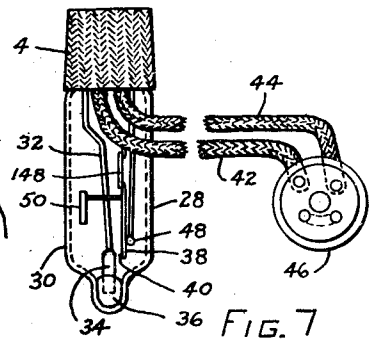

FIG. 7

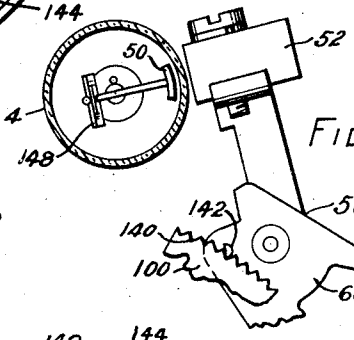

FIG. 11

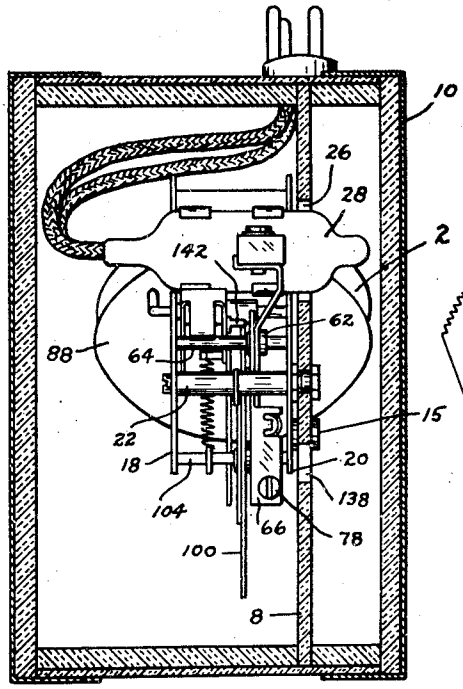

FIG. 2

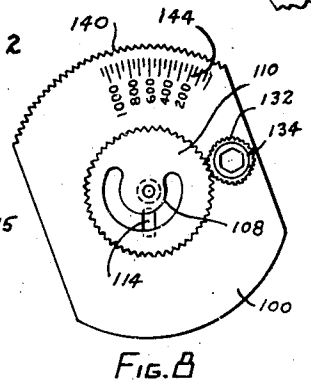

FIG. 8

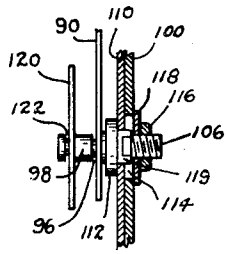

FIG. 9

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May 3, 1949. I. E. McCABE 2,469,124

PRESSURE OPERATED SWITCH

Filed Dec. 2, 1944 2 Sheets-Sheet 2

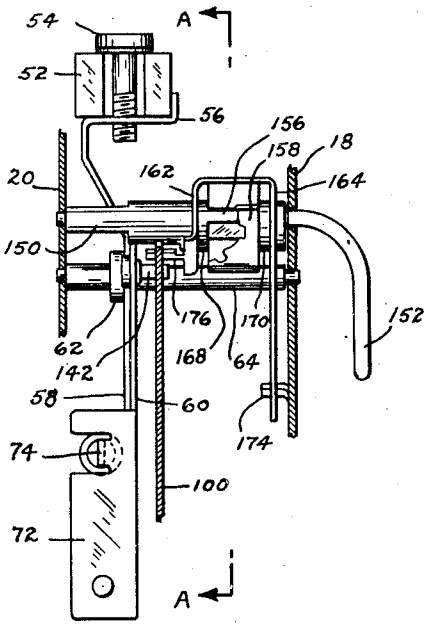

FIG. 3

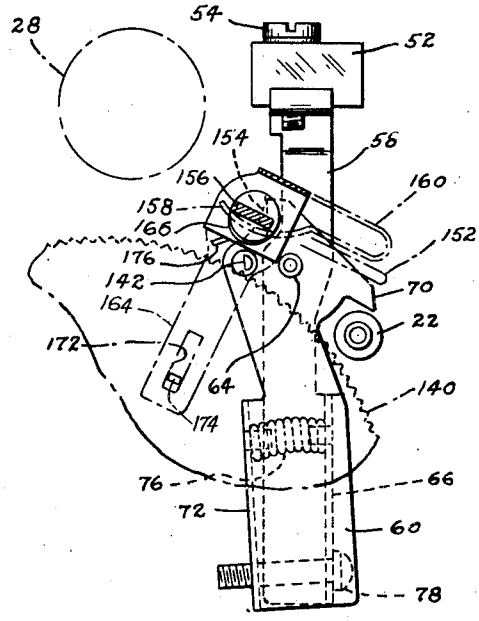

FIG. 4

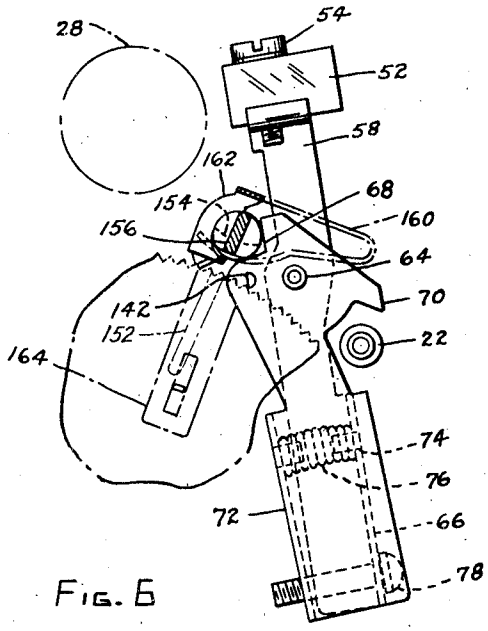

FIG. 6

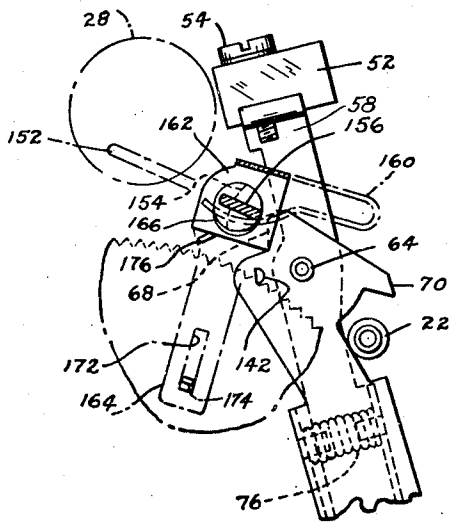

FIG. 5

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Patented May 3, 1949

2,469,124

UNITED STATES PATENT OFFICE

2,469,124

PRESSURE OPERATED SWITCH

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Application December 2, 1944, Serial No. 566,340

11 Claims. (Cl. 200—83)

1

The present invention relates to improvements in pressure recording devices and more particularly to such devices used in conjunction with a radio transmitter whereby a radio signal emitted thereby may be intermittently interrupted in accordance with pressure changes for indicating change in altitude.

Among the objects of the present invention is to provide a novel pressure recording mechanism which is of simplified construction, positive in its operation, and readily calibrated for use in conjunction with a radio transmitter adapted to be sent aloft by a balloon or the like for recording wind direction and velocity at various altitudes which the balloon may attain.

Another object of the present invention is to provide a novel pressure sensitive mechanism for recording changes in pressure and which, through the medium of suitable mechanism, is adapted to actuate a switch of a radio transmitter circuit for interrupting the radio signal in accordance with predetermined pressure changes in order that altitudes may be easily and readily recorded.

More particularly, the invention comprehends the idea of providing pressure responsive means in combination with a magnetically operated switch with suitable interconnecting mechanism for intermittently and successively operating the switch to control the emission of a radio signal of a radio transmitter.

Still a further object of the present invention is to provide a device of the type immediately hereinabove described in which adjustments may be easily and readily made in calibrating the instrument to compensate for manufacturing variances which may exist as between various pressure responsive means.

Still another object of the present invention is to provide a pressure recording device of the type herein under consideration in which the interconnecting mechanism between the pressure responsive means and the switch embodies clutch mechanism of the intermittent actuating type which in its nonoperative position permits freedom of movement of certain of the parts of the interconnecting mechanism to facilitate calibrating the device with a master barometer, but which clutch mechanism in its operative position is responsive to pressure changes for intermittently actuating a switch member for interrupting the radio circuit in which the same is incorporated.

As another object of the present invention, a device made in accordance therewith contemplates the provision of a lost-motion connection

2

between certain elements of the means interconnecting the pressure responsive and switch means, whereby certain elements of the interconnecting means are successively held in pressure recorded positions without returning to prior pressure recorded positions even though the balloon to which the same may be attached descends through an altitude previously recorded.

Another object of the present invention is to provide a device of the type described in which the clutch mechanism is constructed and arranged for holding the switch actuating member in disassociated relation to either the switch or the actuating mechanism therefor to prevent injury to the switch and to eliminate the possibility of a closed switch draining the life of the battery constituting the source of electrical energy for the radio transmitter. Such improved construction also has the further advantage of providing for the free and unrestricted movement of the pressure responsive device and mechanism interconnected therewith so as to prevent injury thereto during its transportation from place to place.

The invention also has the further object of providing a novel clutching mechanism which, in addition to the functions hereinabove set forth, is adapted to engage a clutch element of the interconnecting means so as to position the pressure recording scale associated with the interconnecting means in predetermined position for ready recording so that the operator may definitely know the next successive altitude attained by the balloon upon receiving the first signal from the device.

Other objects, features, capabilities and advantages are comprehended by the invention, as will later appear and as are inherently possessed thereby.

Referring to the drawings—

Figure 1 is a plan view of a pressure recording device made in accordance with the present invention;

Figure 2 is a view in cross section of the device shown in Figure 1 and disclosing the operating mechanism therefor in elevation;

Figure 3 is a detached view partly in section and partly in elevation of certain of the operating parts of the mechanism shown in Figures 1 and 2;

Figure 4 is an enlarged detached view taken in the plane represented by line A—A of Figure 3 of the drawings and showing the elements disclosed in Figure 3 in certain operative relation to one another;

Figure 5 is a view similar to Figure 4 of the drawings disclosing the elements in another operative position with respect to one another;

Figure 6 is a view similar to Figures 4 and 5 of the drawings showing the operating mechanism in a position intermediate those positions as represented in Figures 4 and 5;

Figure 7 is a view in elevation of a switch used in the assembly shown in Figures 1 and 2 of the drawings;

Figure 8 is a detached plan view of certain of the operating mechanism for the device disclosed in Figures 1–6, inclusive;

Figure 9 is a fragmentary view in section through the operating mechanism shown in Figure 8 of the drawings;

Figure 10 is a view of an implement or tool used in connection with certain adjustments which are made in the device as shown on the drawings; and

Figure 11 is a fragmentary sectional view showing the clutch elements in engagement.

Referring now more in detail to the drawings, a device made in accordance with the present invention is disclosed as comprising a pressure responsive means **2**, a switch mechanism **4**, and suitable means **6** interconnecting the same whereby the switch is operated in accordance with predetermined pressure changes of the pressure sensitive mechanism **2**. The device as shown is constructed particularly for use in conjunction with a radio transmitter which in assembled relation is carried aloft by a free balloon for determining by radio direction finding equipment, wind direction and velocities at different altitudes.

In the present form of the device, the mechanism generally described above is attached or mounted to a panel **8** suitably mounted within a container **10** which is so constructed as to be readily assembled with the radio transmitter and carried aloft as above described. The mechanism is secured to the panel **8** through the medium of a bracket **12** connected thereto by rivets **15** or the like, said bracket **12** having a leg **14** serving as a support for the pressure responsive means **2**, an intermediate curved portion **16**, and having at its other end the spaced walls or fingers **18** and **20** serving as a support for certain of the mechanism to be hereinafter more fully described and which walls are secured in rigid relationship to one another by means of a pillar post **22**.

Mounted between the spring fingers **24** attached to the bracket **12**, and extending through the opening **26** of partition **8**, is a switch **28** of the general design disclosed in the McCabe Patent No. 2,325,785 and more particularly disclosed in Figure 7. The switch **28** is of the mercury type including a hermetically sealed tube **30** having a stationary electrode **32** which has a lower tubular portion **34** extending into a pool of mercury **36** normally provided within the lower tip of the tube **30**. The switch is further provided with a movable electrode **38** having a contact **40** adapted to engage a film of mercury at or adjacent the tubular portion **34** for closing a circuit through the leads **42** and **44** which in the present instance are connected to the plug **46** mounted in the casing **10** and which is adapted to complete a circuit through the radio transmitter with which this instrument is associated during normal use for providing a radio signal when the electrodes **32** and **38** are in closed position. The switch is further provided with the abutment member **48** against which the electrode **38** engages in its open position. As clearly set forth in the

McCabe patent above identified, the tubular portion **34** of the electrode **32** provides a meniscus of mercury to assure completion of a circuit through the switch even though the pool of mercury **36** is displaced from its normal position, which in the present instance is of importance inasmuch as the balloon may be subjected to a considerable amount of swinging movement during its ascent.

The movable contact element **38** is provided with an armature **50** disposed adjacent the wall of the tube **30** and adapted to be positioned so as to come within the field of a body **52** of magnetized material secured as by means of a screw **54** adjacent the end of a switch actuating member **56**. This actuating member including the magnet **52** comprises adjacently disposed arm elements **58** and **60** mounted for relative pivotal movement with respect to one another upon a hub **62** secured to the shaft **64** mounted in the opposed walls **18** and **20** of the bracket. The arm element **58** which carries the body **52** of magnetized material extends beyond the pivot shaft **64** and is provided with the laterally disposed leg **66** adjacent its other end. The arm element **60** is provided at one end with abutment shoulders **68** and **70** to be hereinafter more particularly described and at its other end with the transversely or laterally extending leg or flange **72** in opposed relation to the leg or flange **66** of the arm element **58**. Interposed between the legs or flanges **72** and **66** and held against displacement by the portions such as **74** struck out from such legs or flanges is a coil spring **76** normally urging the said elements **58** and **60** apart. For adjusting the relative position of the arm elements **58** and **60**, there is provided a screw **78** extending through a suitable opening in the leg **66** and which has threaded engagement with the leg or flange **72** whereby the positioning of the body **52** of magnetized material with respect to the switch **28** can be readily secured for proper operation of said switch.

The pressure responsive means **2** is of the aneroid capsule type which may comprise one or more circular containers such as **80** but which in the present embodiment consists of two formed to provide an exhausted chamber defined on opposite sides by circular distortable walls subject to expansion and contraction by changes in pressure.

The pressure unit according to the present disclosure is secured, through the medium of the threaded shaft **82**, to the leg **14** by the nuts **84** which shaft is connected to the outer wall of the first pressure element, the entire unit being adjustably mounted for positioning the pressure recording device as will be more fully explained hereinafter. The two units of the present embodiment are connected through the element **86** secured to the adjacently disposed inner walls of the said pressure elements. Pivotally connected as at **92** to the front wall **88** of the second pressure element is an actuating arm **90** which is provided with an elongated slot **94** adjacent its outer end operatively positioned within an annular groove **96** of a pin **98** secured to the face of the disc **100**. The elongated slot **94** is provided with an enlarged end portion **102** adapted to fit over the pin in assembling the operating parts of the interconnecting means **6**.

The disc **100** is mounted upon the shaft **104** journaled in the plates **18** and **20** of the bracket **12**. As more particularly disclosed in Figures 8–10 of the drawings, the pin **98** is provided with a threaded shank **106** extending through the ec-

centric slot 108 of a toothed element 110 and an aligned elongated slot 114 provided in the disc 100, the said pin 98 having the shoulder 112 abutting the element 110 for holding the element 110 and the disc 100 in associated relation to one another. The pin 98 is held in assembled relation with the member 110 and 100 through the medium of the nut 116 and the lock washer 118. As will be noted, the pin 98 is formed with the hub 119 fitting the slot 108. Thus by loosening the nut 116 and rotating element 110 with respect to the disc 100, the pin 98 may be adjusted radially with respect to the shaft 104 to change the effective lever-arm for rotating disc 100. The nut 116 may then be tightened to hold pin 98 in its adjusted position.

Under normal operations of the mechanism hereinabove described, deflection of the diaphragm upon a decrease in atmospheric pressure causes rotation of disc 100 in a counterclockwise direction as viewed in Figure 1 of the drawings. In order to provide proper seating relation between the pin 98 and its actuating arm 90, a yoke 120 is provided which has seating relation in the groove 122 of pin 98 intermediate its ends, one of the other ends thereof being seated in a groove formed in the shaft 104 and the other end being provided with a hook portion 124 to which one end of a coil spring 126 is attached, the other end of the coil spring being attached to the pivot pin 92.

In order to adjust the toothed element 110 with respect to the disc 100, a special tool is provided as shown in Figure 10 of the drawings, the same being formed with a projection 128 at one end thereof adapted to be received in the opening 130 of the disc element 100 and adjacent which projection 128 is a tooth gear 132 meshing with the teeth formed at the periphery of the element 110 whereby, upon rotation of the tool, relative movement of element 110 with the disc 100 is accomplished upon loosening of the nut 116. As previously described, adjustment of element 110 is effective in adjusting pin 98 radially with respect to shaft 104 in order to compensate for differences in the deflection or distortion of the pressure responsive means occurring upon decreasing atmospheric pressures which may be experienced in different units even though constructed for similar deflection over the same pressure operating range.

In accomplishing the adjustment immediately above described, the tool shown in Figure 10 of the drawings is provided at its other end with an enlarged hub 134 formed with a non-circular recess 136 adapted to correspond to the shape of and receive the nut 116 when introduced through the opening 138 of partition member 8. After the pin adjustment has been accomplished, the nut 116 may again be tightened to secure proper operation of the pressure responsive device as compared to master instruments used in calibrating the same.

Movement of the pressure responsive mechanism through the actuating arm 90 and disc 100 to the switch actuating member 56 is accomplished through a clutch mechanism consisting of ratchet teeth 140 formed on the periphery of disc 100 and which teeth are engaged by a pawl 142 projecting laterally from the arm element 60. Adjacent the teeth 140 is a suitable scale 144 calibrated in terms of millibars of pressure, which pressure is readilly translated in terms of altitude as the device is used in securing wind direction and velocities. It is to be noted that upon a decrease in pressure as the altitude increases, the

diaphragm 88 is moved or expanded outwardly to operate disc 100 so that the scale as shown provides for a graduated decrease in millibar pressure from the position as indicated by the pointer 146 to the lower-most part of the scale at the bottom portion of the disc 100 as shown in Figure 1 of the drawings. Accordingly, the instrument as shown in Figure 1 of the drawings is illustrative of the relative position of the elements at the time when readings are to be initiated and the balloon sent aloft.

It will, therefore, be clearly apparent that recordable pressure changes, due to a decrease in atmospheric pressures, are operative to rotate disc 100 counterclockwise as shown in Figure 1 of the drawings successively from tooth to tooth relative to the pawl 142. Each recordable change of pressure causes a tooth on the disc 100 to displace the pawl 142 to rotate the switch actuating member 56 about its pivot point, thereby moving the magnetic field of the magnet 52 away from armature 50 and allowing electrode 38, under the impulse of its spring element 148, to move into engagement with the abutment 48 and to break the circuit so as to interrupt the radio signal which is then recorded by the radio direction finding equipment. Operation of the magnet 52 is effected through the medium of magnetic attraction for the armature 50 of the switch, thus maintaining the switch arm in its operative position to close the switch and to maintain engaging relation of the pawl 142 with the ratchet teeth 140. Each recordable change in pressure in accordance with the calibration of the instrument is indicative of a certain increase in altitude. Accordingly, with such recorded information with respect to altitude and other information with respect to wind direction and velocity observations which are simultaneously taken, wind conditions at each of the altitudes can be properly recorded.

The present mechanism further includes clutch control means for engaging and disengaging the switch actuating member 56 from the operating disc 100 and for initially setting the disc 100 in a predetermined operative position. Such means essentially includes a cam shaft 150 journalled in the side walls 18 and 20, as more clearly shown in Figure 3 of the drawings, which cam shaft is operated from "on" to "off" positions, as shown in Figure 1, by the laterally extending handle portion 152. This cam shaft is provided with a cam surface 154 which is adapted to engage an abutment shoulder 68 of the switch actuating arm 60 when the device is in the "off" position, as shown in Figure 4, to hold said arm substantially immovable in a position between the cam and pillar post 22, the latter serving as an abutment for the projection 70 extending from the switch actuating arm 60. In this position the arm 60 prevents the body of magnetized material 52 from engaging the receptacle or container 30 of the switch and thus prevents closing of the switch until ready for use as well as removing the danger of injury to the switch in any way which might otherwise occur by the magnet striking it when the device is handled before being used. At the same time the pawl 142 is disengaged from the teeth 140 of the disc 100 to release the disc from its interconnected relation with the switch actuating member, permitting unrestrained movement of the pressure means 2 upon subsequent changes in pressure. When the pawl is disengaged from the teeth of the disc, the device may be readily calibrated through adjustments of the

nuts 84 and pin 98 so that the scale 144 may properly indicate the initial pressure to which the device is adjusted and so that subsequent recordations are in accordance with the scale readings.

In order to maintain the cam shaft in either the "on" or "off" positions when so rotated, the same is formed with a flat section 156 engaged by a spring component 158 of a spring element 160. To support the spring in position the element 160 is provided with depending leg portions 162 and 164, both of which are provided with openings such as 166 embracing eccentric bearings 168 and 170 disposed on both sides of the flat 156, as shown in Figure 3. The top leg of element 160 extends beyond the bearing 170 and is provided with an elongated slot 172 adapted to embrace a lug 174 struck out from the wall 18 to assure proper positioning of the spring element and its alignment at all times with respect to the associated elements. The spring component 158 under tension thus constantly engages the cam shaft to hold it in the position it assumes upon movement of the handle 152 to either "off" or "on" position.

In order to assure that the first altitude recorded by the device is definitely known, the lower leg 162 of the spring element 160 is formed with a laterally extending pawl 176, which upon movement of the shaft 150 from its "off" to its "on" position, engages a tooth of the disc 100 to rotate the disc so that the pawl 142 will assume a position one tooth lower on the scale when thus operatively associated therewith than it would normally do if movement of the disc did not accompany such rotation of handle 152 and the shaft 150. By noting the reading of the dial and recording it the operator may readily determine from the first signal received after the instrument is sent aloft the exact altitude at which it is recorded. The upper leg 164 of the spring element 160 serves to maintain the pawl 176 in its proper relative position with the teeth of disc 100 so as to engage the disc and move the same with each movement of handle 152 from "off" to "on" position. As heretofore described, the lug 174, extending into slot 172 of leg 164, assures of this alignment.

During movement of the device to higher altitudes, the switch actuating arm 58 is intermittently moved out of operative association with the switch to interrupt the radio circuit and to thereby audibly indicate to the operator such intervals of increase in altitude that are commensurate with the pressure changes of the pressure responsive means. During this operation, the disc 100 and the switch actuating member 58 are interlocked by means of the pawl 142 engaging in the teeth 140 of the disc 100. The relationship of pawl 142 to the teeth in the disc is such as to permit counter-clockwise rotation of the disc, upon decreasing atmospheric pressure to intermittently actuate the pawl and rock the switch member 56 and thus the magnet 52, and to also result in a locking arrangement between them to prevent clockwise rotation of the disc. By virtue of the elongated slot 94 in the actuating arm 90, the lost motion connection is provided between the pressure responsive means and the disc 100 so that with the disc locked against clockwise movement the pressure responsive means may not be retarded in its contractual movement, which takes place upon increasing atmospheric pressures. Consequently, although the balloon may reach any given altitude as recorded by an interruption in the radio signal and thereafter descend to an altitude previously recorded, no signal will again be transmitted until the altitude next intended to be recorded, higher than the last, is reached. That is to say, increases in altitude are successively recorded but because of the lost-motion connection these hereinabove described lower recordations are impossible and such pressure changes due to decrease in altitude which may cause movement of the diaphragm 88 are not effective in moving disc 100 to interrupt the radio signal.

It will be apparent that after an operation and the device is again made ready for use, the dial may be reset to its initial position by turning the cam shaft 150 to "off" position at which time such release of the disc causes spring 126 to return the disc to its initial position automatically.

By actual tests it has been found that in a device constructed in accordance with this disclosure in which suitable materials have been used accuracy within 1–2 millibars has been obtained at 50 millibar intervals based on absolute pressure readings. Furthermore, repeated use of the same device has been possible without the need of field adjustment to retain the same degree of accuracy and throughout a temperature range of −50 to −70° C.

While I have herein described and upon the drawings shown an illustrative embodiment of the invention, it is to be understood that the invention is not limited thereto but may comprehend other constructions, arrangements of parts, details and features without departing from the spirit of the invention.

What is claimed is:

1. A pressure recording device comprising a switch adapted to be included in an electrical circuit, switch actuating means, pressure responsive means, means for operating said switch actuating means, said means including a clutch for intermittently actuating said actuating means upon expansion of said pressure responsive means, said clutch comprising clutch elements having a holding action on the operating means when the clutch elements are in engagement to prevent return of the operating means to a prior pressure recorded position, and said operating means having a lost motion connection between said pressure responsive means and said actuating means for permitting said pressure responsive means to move through any of the prior pressure recorded positions.

2. A pressure recording device as defined by claim 1, additionally including control means for manually engaging and disengaging said clutch elements.

3. A pressure recording device as defined by claim 1, additionally including control means for manually engaging and disengaging said clutch elements, said control means having a member operable upon actuation of the control means for presetting said operating means.

4. A pressure recording device as defined by claim 1, additionally including control means for manually engaging and disengaging said clutch elements, said control means in one position of adjustment locating and holding the switch actuating means in inoperative position.

5. A pressure recording device as defined by claim 1, additionally including control means for manually engaging and disengaging said clutch elements, said control means in one position of adjustment locating and holding the switch actuating means in inoperative position, and a member actuated by the control means into engagement with one of the clutch elements for setting

said clutch elements in predetermined relation to one another when the device is initially set for operation.

6. A pressure recording device comprising a magnetically operated switch adapted to be included in an electrical circuit, a switch actuating member having a pawl, pressure responsive means including a diaphragm expansible upon a decrease in pressure, means for operating said actuating means in accordance with the expansion of said diaphragm due to predetermined successive recordable reductions in pressure, said operating means comprising a rotatable member having a plurality of peripheral teeth forming a ratchet engageable by said pawl, a pin spaced with respect to the axis of rotation of said member, and an operating bar connected to said diaphragm and operating through said pin to rotate said member for intermittently actuating said switch actuating member through said pawl and ratchet.

7. A pressure recording device as defined by claim 6, wherein said bar is provided with an elongated slot embracing said pin and forming a lost motion connection therebetween, said connection being constructed and arranged whereby the bar is operative to rotate said rotatable member only upon expansion of the diaphragm as a result of decreasing pressures.

8. A pressure recording device as defined by claim 6, wherein means are provided for adjustably positioning said pin with respect to the axis of rotation of said member.

9. A pressure recording device comprising a magnetically operated switch adapted to be included in an electrical circuit, a switch actuating member having a pawl, pressure responsive means including a diaphragm expansible upon a decrease in pressure, means for operating said actuating means in accordance with the expansion of said diaphragm due to predetermined successive recordable reductions in pressure, said operating means comprising a rotatable member

having a plurality of peripheral teeth forming a ratchet engageable by said pawl, a pin spaced with respect to the axis of rotation of said member, an operating bar connected to said diaphragm and operating through said pin to rotate said member for intermittently actuating said switch actuating member through said pawl and ratchet, said bar being provided with an elongated slot embracing said pin and forming a lost motion connection therebetween, said connection being constructed and arranged whereby the bar is operative to rotate the member only upon expansion of the diaphragm as a result of decreasing pressures, and control means including a cam shaft rotatable to engage and disengage said pawl from said ratchet teeth, said control means in one position of adjustment locating and holding the switch actuating member in inoperative position.

10. A pressure recording device as defined by claim 9, wherein said control means has spring means associated therewith for yieldingly holding said shaft in its operative and inoperative positions.

11. A pressure recording device as defined by claim 9, additionally including a member actuated by said control means into engagement with a tooth of said ratchet for positioning said ratchet in predetermined position with respect to said pawl on the switch actuating member as said control means is moved from inoperative to operative positions.

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