

Mar. 3, 1925.

1,528,627

O. S. PETERS

ELECTRIC TELEMETRIC DEVICE

Filed Aug. 21, 1922

3 Sheets-Sheet 1

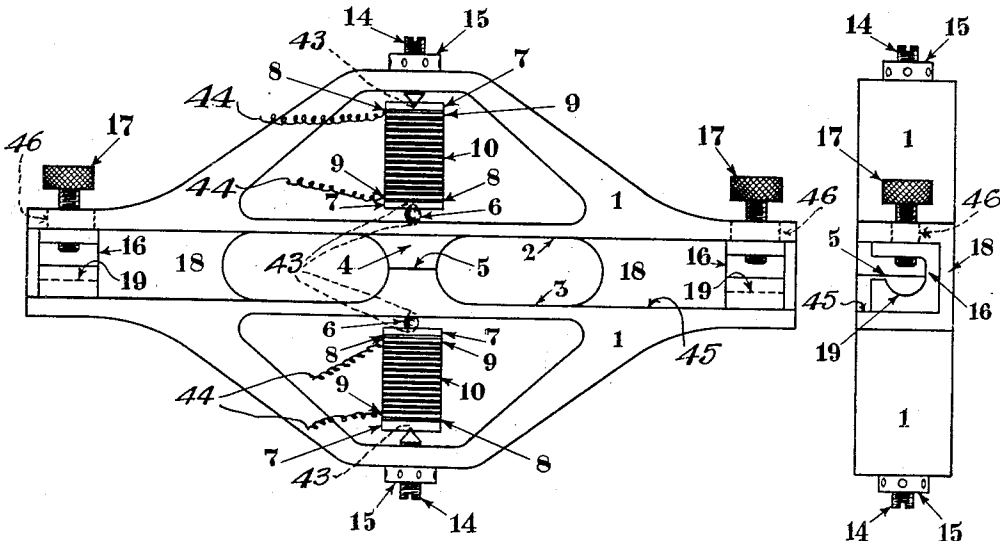


FIG. 1.

FIG. 7.

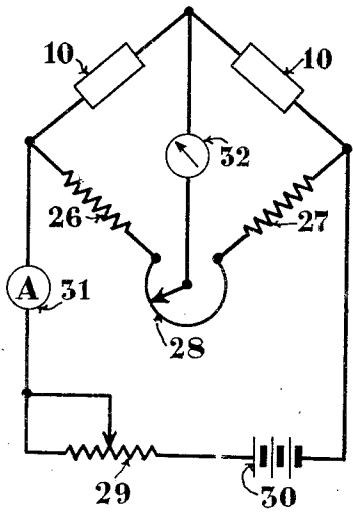


FIG. 5.

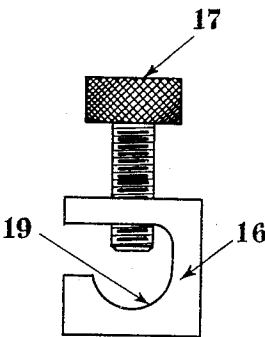


FIG. 2.

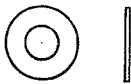


FIG. 6.

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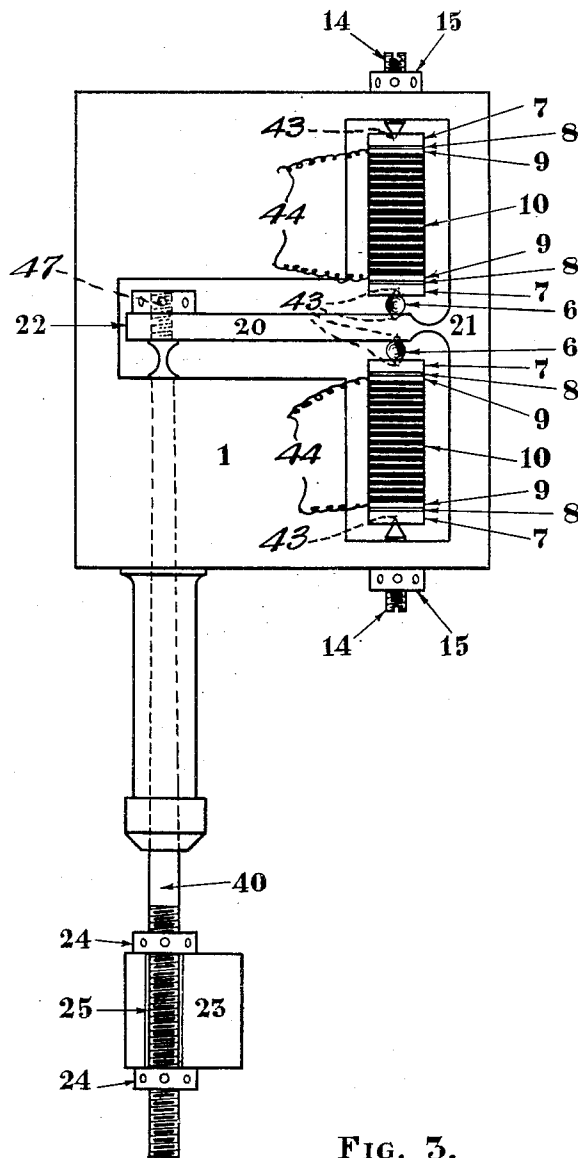


FIG. 3.

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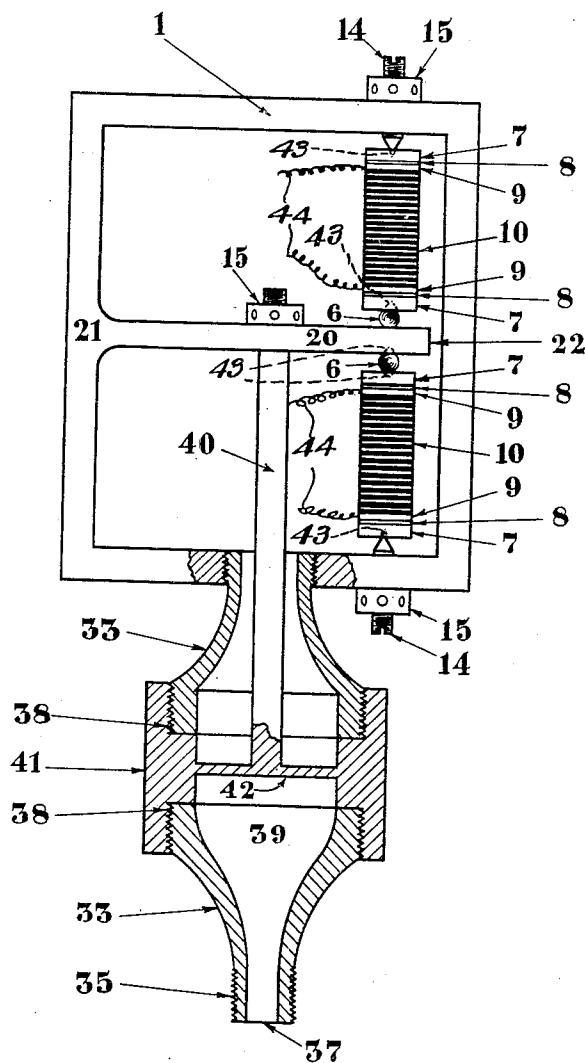


FIG. 4.

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UNITED STATES PATENT OFFICE.

ORVILLE S. PETERS, OF CHEVY CHASE, MARYLAND.

ELECTRIC TELEMETRIC DEVICE.

Application filed August 21, 1922. Serial No. 583,457.

To all whom it may concern:

Be it known that I, ORVILLE S. PETERS, a citizen of the United States of America, residing at 6625 Chestnut Street, Chevy Chase, in the county of Montgomery and State of Maryland, have invented certain new and useful Improvements in Electric Telemetric Devices, of which the following is a specification.

My invention relates to improvements in electric telemetric devices in which the essential element consists of a series of contacts between electrically conducting discs or plates which, when held under continuous pressure and in rigid relative positions with regard to each other, have been found to have an accurately reproducible variation of electrical resistance with repeated cycles of change of pressure and corresponding changes of length of the stack of plates or discs forming the aforementioned series of contacts if the changes of length be accomplished without mechanical friction in the holding device or relative slippage among the contacts themselves. An example of a series of contacts between electrically conducting discs or plates is found in a stack of carbon plates, although my improvements apply not only to electric telemetric devices using carbon, but also to devices of a similar nature using other substances. The objects of my improvements are, first, to provide a means of holding the stack of plates forming the above-mentioned series of contacts under continuous pressure and in rigid relative positions as between the plates themselves; second, to provide a means by which small changes of length may be caused to take place simultaneously and in opposite senses in a pair of stacks of plates placed coaxially, with a minimum of mechanical friction; third, to afford facilities for adjusting the initial length of and pressure upon the pair of stacks, just mentioned, at equal or different values as desired; fourth, to communicate to the stacks small changes of length or suitable values of pressure with a minimum of distortion of the stacks at right angles to their axes; fifth, to provide a reducing device to enable the measurement of large changes of length or pressure in a fixed ratio of reduction; sixth, to prepare and assemble the stacks of plates with the view of making the electrical resistance

stable in value with repeated changes of length of the stacks within limits determined by experiment, and also to vary the method of preparation with the view of giving to different stacks different ranges of change of length for different purposes through which the electrical resistance remains stable and reproducible at different times under like conditions, the percentage change of resistance being substantially the same for stacks prepared in different ways.

I attain the first five of these objects by means of the principles illustrated in the accompanying drawings:

Of the drawings:

Fig. 1 shows a type of holder for the stacks of plates forming the series of contacts mentioned above, which is adapted for measuring either steady or rapidly varying tensions in flexible elastic members such as steel cables, and which may be modified to measure forces from any source.

Fig. 2 is a part of Fig. 1 in detail.

Fig. 3 is a type of holder suitable for clamping to rigid elastic members subject to forces in tension or compression, and which may be modified to measure either steady or rapidly varying displacements or changes of length from any source.

Fig. 4 shows a combination of the principles illustrated in Figs. 1 and 3 into a device which is suited to the measurement of gas or liquid pressures of either steady or rapidly varying value.

Fig. 5 is a diagrammatic representation of the electrical circuit containing the stacks of plates as arranged for making measurements and is included for the purpose of showing the manner in which the various improvements outlined above affect the operation of the device.

Fig. 6 shows the form of plate I prefer to use, the sixth object, in regard to the treatment of which, as far as it applies to plates of carbon, being attained as herein-after described. Similar numerals refer to similar parts throughout the several views.

Fig. 7 is an end view of Fig. 1.

In Fig. 1, part 1 is a framework consisting of an integral piece of metal, made so by welding, brazing, casting, or stamping, or machine cutting from a solid piece, of which elements 2 and 3 function as a single spring, being rigidly connected together at

their midpoints by the yoke 4, which at 5 is formed into a saddle having its longitudinal center line substantially coincident with a plane passing through the respective longitudinal center lines of elements 2 and 3. At 6—6 are two metal balls resting in cups 43—43 made on the center lines of elements 2 and 3 and midway between their ends which in turn support two metal discs 7—7 cupped centrally on one side to fit the metal balls and plane on the other. Next to the metal discs are two thin insulating discs 8—8, and next to these two more metal discs 9—9 with copper wires 44—44 electrically connected to them, the purpose of the metal discs last named being to make electrical contact with the stacks of conducting plates 10—10. At the outer ends of the stacks of plates 10—10 are two metal discs 9—9 with copper wires 44—44 attached, two insulating discs 8—8, and two metal discs 7—7 plane on one side and cupped centrally on the other to receive the pointed screws 14—14, which are threaded into the framework 1 and provided with locknuts 15—15. With these screws 14—14 an initial pressure is applied to the stacks of plates in sufficient degree to give the desired initial resistance. The initial resistances of the stacks may be adjusted to any desired relative values, equal or unequal, by proper manipulation of the screws 14—14, since any difference in pressure upon the two stacks of plates will be absorbed in deflecting the spring formed by elements 2—3. This is a great advantage because in many applications of the device the range of values that can be measured is greatly increased over that which would be covered were the construction such as to permit adjustment only to equal or nearly equal values of resistance. This feature of construction is preserved in all of the embodiments of the device shown in the accompanying drawings.

That portion of the device embracing end-pieces 7—7, insulating discs 8—8, metal discs 9—9, and contact pieces 10—10, of each of the embodiments hereinafter described I sometimes refer to as a displacement resistance device.

It will be noted that the framework 1 of Fig. 1 is slotted from end to end with a slot 45, the upper and lower halves being held together by the web 18—18. In the outer ends of the slot 45 are fitted two slightly movable blocks 16—16 which are hollowed longitudinally to form saddles 19—19 as shown in Fig. 2 and provided with clamping screws 17—17 which move in slits 46—46 in the framework 1. Saddle 5 and saddles 19—19 are slightly out of line, saddle 5 being displaced in the direction of the side on which are the clamping screws 17, the object of this displacement being to

cause a bend in a flexible elastic member when laid in saddles 5 and 19—19 and clamped with screws 17—17. Tension in the flexible member then tends to straighten the bend and produce pressure on saddle 5, which in turn deflects springs 2 and 3 and communicates a part of the pressure to the stack of plates on the side in the direction of pressure and release pressure from the stack of plates on the opposite side. These changes of pressure are accompanied by changes in the electrical resistance of the stacks of plates which in turn, by a proper arrangement of electrical circuits described hereafter, may be utilized to determine the tension in the flexible member. It will be seen that the value of the pressure upon saddle 5 in relation to the tension upon the flexible member depends upon the magnitude of the bend in the flexible member. Further, the portion of the pressure upon saddle 5 that is communicated to the stacks 10—10 depends upon the stiffness of spring elements 2 and 3. These, therefore, namely, the spring elements 2 and 3, and the bend in the cable serve as a reducing device, enabling the measuring of large tensions or forces in any suitable ratio of reduction.

In Fig. 3, part 1 is a frame consisting of an integral piece of metal made so by welding, brazing, casting, or stamping or machine cutting from a solid piece, of which the element 20 functions as a cantilever beam which may be of uniform or of non-uniform cross-section, fixed at the end 21 and free at the end 22. At 6—6 are two metal balls resting in cups 43—43 in the cantilever 20, the bottoms of which are made as close as may be to the neutral axis of the cantilever 20, which in turn support two metal discs 7—7 cupped centrally to fit the metal balls on one side and plane on the other. Next to the metal discs are two insulating discs 8—8, and next to these two metallic discs 9—9 with copper wires 44—44 attached for the purpose of making electrical contact with the stacks of plates 10—10. At the outer ends of the stacks of plates are two more metallic discs 9—9 with copper wires 44—44 attached for the purpose of making electrical contact with the stacks of plates 10—10, two insulating discs 8—8, and two metal discs 7—7, plane on one side and cupped centrally on the other to receive the pointed screws 14—14 which are threaded into the framework 1 and provided with locknuts 15—15 and which serve to produce initial pressures upon stacks 10—10 in sufficient degree to give the desired initial electrical resistance. Here also, the initial resistances and pressures may be made equal or unequal in the same manner as described for the device shown in Fig. 1 for the same reason and with the same attendant advantages. Attached to the free end of cantilever 20

lever 20 by a thread and nut 47 is a rod 40 of suitable length which passes through a hole in frame 1, is threaded with a fine thread at its outer end, and which rests in a slot 25 in a block 23, to which the rod may be clamped by the nuts 24—24.

In use the framework 1 is clamped immovably to a rigid elastic member and at a suitable distance from it the block 23 is clamped immovably to the same member in such a way that the rod 40 lies in the slot 25. The nuts 24—24 are then tightened to connect cantilever 20 and block 23 rigidly together after being adjusted to bring cantilever 20 to the zero position as they are tightened. Any stress in the elastic member in the direction of the axis of rod 40 then causes relative displacement of framework 1 and block 23, which displacement is in turn communicated to the free end of cantilever 20 causing it to move away from its zero position relative to framework 1. This relative displacement is communicated to the stacks of plates 10—10 in diminished amount because of the fact that the cantilever 20 acts as an elastic lever with its fulcrum near the end 21. This displacement causes a decrease of length in one of the stacks and an increase in the other with corresponding changes of electrical resistance, which by a suitable arrangement of electrical circuits described hereafter may be utilized to determine the strain in the member under test. In order to increase the lever action over what would be obtained with a cantilever of uniform cross-section, the thickness of cantilever 20 may be made small near the end 21, enabling the greater part of the bending to take place there. The cantilever functions as a reducing device, enabling the measurement of relatively large displacements as compared to the changes of length communicated to the stacks. The ratio of reduction may be changed at will by changing the distance of the point of attachment of the rod 40 from the contact point of the balls 6—6, and also by changing the length of the span included between the framework 1 and block 23 on the elastic member, since the total change of length with a given stress is proportional to the length of the span.

In Fig. 4 is shown a combination of the features illustrated in Figs. 1 and 3 into a device suitable for measuring gas or liquid pressures of steady or rapidly varying value. Here part 1 is a metal framework consisting of an integral piece of metal made so by welding, brazing, casting, or stamping or machine cutting from a solid piece, of which 20 acts as a cantilever of uniform cross-section, fixed at end 21 and free at end 22. At 6—6 are two metal balls resting in cups 43—43 coaxially placed on opposite sides of cantilever 20, and in line with the

centers of screws 14—14. Balls 6—6 in turn support two metal discs 7—7 cupped axially on one side to fit balls 6—6 and plane on the other. Next are two insulating discs 8—8 and then two metal discs 9—9 with copper wires 44—44 attached to make electrical contact with the stacks of conducting plates 10—10. At the outer ends of stacks 10—10 are two more metal discs 9—9 with copper wires 44—44 attached, two insulating discs 8—8 and two metal discs 7—7 plane on one side and cupped axially on the other to receive the pointed pressure screws 14—14 which are threaded into frame 1 and provided with locknuts 15—15 which serve to produce initial pressures upon stacks 10—10 in sufficient degree to give the desired initial electrical resistance. Part 40 is a rod having one end threaded and passing through cantilever 20 on its center line and provided with a locknut 15, and the other end rigidly attached to the center of the metal diaphragm 42 which is integral with ring 41. Parts 33—33 are threaded into ring 41 with gas-tight ground joints at 38—38, and also into frame 1, with a lower threaded end 35. A hole 37 leads into the chamber 39.

In use the device is screwed into a threaded aperture in the chamber containing the gas or liquid, the pressure of which is to be measured, by means of the threaded end 35. Through hole 37 the pressure is communicated to chamber 39 and deflects diaphragm 42 upward and exerts force along the axis of rod 40, bending cantilever 20, and communicating pressure to the upper stack 10 and releasing pressure from lower stack 10. This causes corresponding changes of electrical resistance of the stacks, which by means of a suitable arrangement of electrical circuits described hereafter may be utilized to determine the value of the pressure under test. From the laws governing the physical performance of beams and diaphragms under load it is known that the amount of bending of cantilever 20 due to a given force from pressure in chamber 39 is inversely proportional to the cube of the thickness or depth, and that the deflection of diaphragm 42 due to a given pressure is also an inverse function of the thickness, so both of these elements act in combination as a reducing device, enabling large pressure to be measured in reduced ratio, this ratio depending in value upon the dimensions of the parts 20 and 42.

In order to utilize the changes of resistance of the stacks of plates due to changes of length the stacks of plates 10—10 in the several views are made two of the arms of a Wheatstone bridge, Fig. 5, fixed resistances 26 and 27 of suitable value forming the other two arms with a small variable resistance 28 serving to balance out small

variations of resistance of the stacks 10. Current to the bridge circuit is supplied from battery 30, measured by the ammeter 31 and kept at a constant predetermined value by the variable resistance 29. At 32 is the bridging instrument, which may be in the form of an ordinary ammeter suitable for measuring small currents, or in the form of a bifilar oscillograph element carrying a mirror. With the bridge balanced zero current flows in 32. Then any displacement in opposite senses communicated to the stacks 10 destroys the bridge balance, causing current to flow in 32 which may be read or recorded as desired.

The deflections of instrument 32 depends upon the current in ammeter 31 and the changes of resistance in stacks 10—10. In order that these deflections may be alike from time to time under like conditions of measurement, it is necessary that the changes of resistance of stacks 10—10 be the same for like conditions, which necessitates constancy of the initial resistance of the stacks, and also the ability of the stacks to reproduce their pressure-resistance curves. This constancy of initial resistance and ability to reproduce the pressure-resistance curve depends upon the stacks of plates being held rigidly in relative position to each other and the pressure upon the stacks being applied axially, conditions which are fulfilled in every particular by the structures described herein.

In Fig. 6 I show the form of plate or contact piece I prefer to use. This is in the form of an annular ring, made with parallel faces, which, if of carbon, I grind with grinding material of different degrees of fineness for different purposes. Where it is desired that for a given change of resistance the accompanying change of length be relatively large I use the coarser grades of grinding material, that is, those corresponding in size to No. 100 emery. Where it is desired that for a given change of resistance the accompanying change of length be relatively small I use the finer grades of grinding material. For the greatest degree of sensitivity I use polished surfaces. By polished surfaces I mean surfaces that give undiffused reflection of light, as compared with unpolished surfaces which give diffused reflection of light. I prefer to use the harder grades of carbon since the softer grades have been found by experiment to be unsuitable.

I do not claim the invention of a device using stacks of plates of electrically conducting material forming a series of contacts for the purpose of measuring physical phenomena broadly. My invention relates to improvements only, and those which are new may be enumerated as follows:

(1) The provision of a frame for holding

the stacks of plates forming the essential series of contacts of an integral piece of metal, which eliminates mechanical friction. (2) The provision of a stiff spring, or a combination of a spring and diaphragm, as a means of communicating pressures and displacements to the stacks of plates which prevents distortion of the stacks at right angles to their axes. (3) The provision of a stiff spring which makes the adjustment of the resistance of the stacks of plates in the same instrument substantially independent of each other. (4) The arrangement of the springs and diaphragm in such a relationship to the stacks of plates that the pressures or displacements are communicated to them in a fixed ratio of reduction. (5) The grinding of the plates with parallel faces in order to insure that each contact face lies in a plane perpendicular to the axis of the stack. All of the features hereinbefore described as being improvements are mutually independent.

I claim—

1. A device for telemetric purposes consisting of a displacement-resistance device with mounting terminals mounted within a frame, said frame being an integral piece of metal.

2. A device for telemetric purposes consisting of a displacement-resistance device with mounting terminals mounted within a frame, said frame being made an integral piece of metal by welding.

3. A device for telemetric purposes, consisting of a displacement-resistance device with mounting terminals mounted within a frame, said displacement-resistance device with its mounting terminals being embraced between supporting terminals, said supporting terminals being integral with the said frame.

4. A device for telemetric purposes consisting of a displacement-resistance device, mounting terminals, supporting terminals, and mounting frame, one of said supporting terminals being a stiff spring through the deflection of which pressures or displacements are communicated to the said displacement-resistance device.

5. A device for telemetric purposes consisting of a displacement-resistance device, mounting terminals, mounting frame, and supporting terminals, one of said supporting terminals being a stiff spring the resistance to bending of which permits the essential parts of the said displacement-resistance device on opposite sides of the said spring to be adjusted to equal or different initial values of electrical resistance.

6. A device for telemetric purposes consisting of a displacement-resistance device mounting terminals, mounting frame, and supporting terminals, one of said supporting terminals being an elastic lever by means of

which pressures and displacements are communicated to the said displacement-resistance device in reduced ratio.

5 7. A device for telemetric purposes consisting of a displacement-resistance device, mounting terminals, mounting frame, and supporting terminals, said displacement-resistance device comprising a stack of annu-

lar rings of conducting material, said annular rings having parallel plane faces, and 10 being assembled with the said faces perpendicular to the axis of the said stack of annular rings.

In testimony whereof I do hereby affix my signature.

ORVILLE S. PETERS.