Dec. 16, 1952 C. J. BAKER 2,622,176

STRAIN WIRE GAUGE

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Fig. 1.

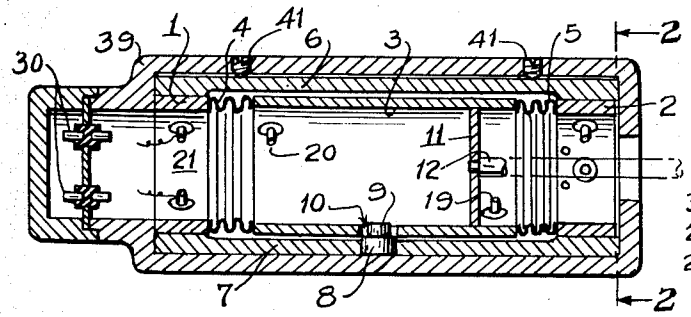


Fig. 2.

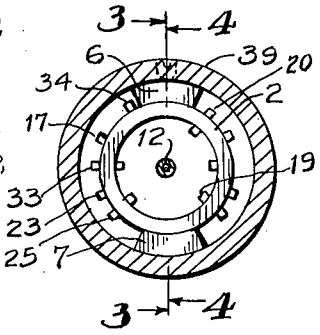


Fig. 3.

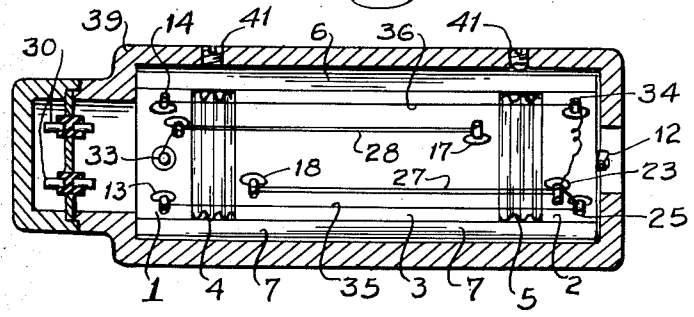
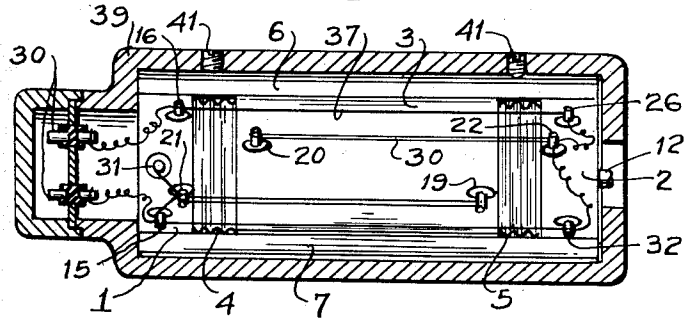


Fig. 4.



INVENTOR.

C. J. BAKER

BY

Philip Lubkow

ATTORNEY.

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STRAIN WIRE GAUGE

Carlos Jay Baker, Chickasha, Okla., assignor to Statham Laboratories, Inc., Beverly Hills, Calif., a corporation of California

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13 Claims. (Cl. 201—48)

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This invention relates to improvements in strain wire gages of the unbonded type such as are described in the Carlson Patent No. 2,036,458 and the Statham Patents Nos. 2,453,548, 2,453,550, 2,453,551, and Serial No. 760,773, Patent No. 2,481,792, filed July 14, 1947, by Louis D. Statham. These devices are characterized by the presence of an electrical resistance strain wire element stretched under tension between two supports, one of which is fixed and the other of which is movable. The movable support is connected to measure force or displacement in such manner that the relative positions of the fixed and movable supports are altered and result in a change of resistance due to variation in the strain in the wire, which change is responsive to the force or displacement employed.

The construction, according to the prior art devices, shown in the above patents and which have gone into wide commercial use, provides for the relative movement of the movable and fixed ends of the wire. By mounting the fixed end on pins, mounted on some structure rigidly connected to the frame of the transducer, and mounting the movable end on a pin positioned in a structure, termed an armature, which is hinged to the frame in such manner that on application to the armature of the force or displacement to be measured, the pin moves in a direction generally parallel to the extension of the wires.

In all such structures it is desirable that the hinge have no lost motion, impart little or no resistance to oppose the movement of the free pin, and be capable of rigid connection to the frame and the armature. Leaf springs have been used generally in these prior art structures. The leaf spring is rigidly connected to the frame and the armature and preferably so mounted that the area available for flexure is of limited width and extends perpendicular to the extension of the wire. Upon imposition of force or displacement to the armature, the leaf spring bends along the desired line.

The result of such structure is that the movement of the armature and the movable pin is not exactly in a straight line parallel to the original extension of the wires and does not move in a predetermined straight line since the motion of the movable pin is arcuate although of small angularity. Some bend is thus imposed in the wires at the pins and also some bend is imposed on the rod connecting the armature to the force or displacement applying means. The variation in strain in the wires is not simply that resulting from axial compression or extension of the wires but also involves bending of the wires.

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Another difficulty with the construction of transducers according to the prior art structures is that the structures are not truly symmetrical in all directions. This introduces certain obscure temperature effects which result in what is known as the zero shift of the instrument.

I have devised a transducer and instruments employing such transducer which avoid these difficulties. In the transducer of my invention the armature and the free pins mounted thereon move in a straight line parallel to the extension of the wires in the rest position of the wires in such fashion that no substantial bending is imposed on the wires at the pins, the wires being in simple tension throughout the whole movement thereof.

Additionally, the structure of my invention is substantially symmetrical in all directions and in all planes perpendicular to its axis.

I have found that by employing cylindrical bellows for connecting the ends of the armature with the stationary parts of the transducer and disposing the bellows in axial alignment with each other, the bellows limit the motion of the armature to a line parallel to the aligned axes of the bellows. The property of the cylindrical bellows which makes this function possible is that it is a means for connecting the movable element to the relatively fixed element, i. e., the frame, which means is radially substantially inflexible, i. e., it is inflexible in a direction perpendicular to the motion of the movable element but the connecting means is flexible in a direction parallel to the motion of the movable element. This is because the flexible cylinders mounted on each end of the movable member have each only one degree of freedom, i. e., in the axis of the cylinder, and are relatively rigid in any direction in any plane perpendicular to the axis. This property of the connecting means constrains the motion of the movable member to the axis of the cylinder. Such a connection may be defined as a connection with a single degree of freedom in a direction parallel to the extension of the strain wires. By positioning the movable, i. e., free, pins for the wire ends upon the armature, which is mounted on the coaxial bellows, and positioning the stationary ends or pins upon the relatively immovable portion of the transducer, any force imparted to the armature will move the armature in a restricted line parallel to the axes of the bellows. By winding the wires on the supporting pins so that the wires are parallel to the axes of the coaxial bellows, the movement of the armature will cause the free pins to move in a direction parallel to

the original extension of the wires. This will result in an alteration in strain in the wires which results in a variation in tension with no substantial imposition of any bending in the wires. Such a structure can be made substantially symmetrical.

This invention will be further described in connection with the drawings, in which

Fig. 1 is a vertical section of one form of my transducer;

Fig. 2 is a section taken on the line 2—2 of Fig. 1;

Fig. 3 is a section taken on the line 3—3 of Fig. 2, showing the transducer in elevation;

Fig. 4 is a section taken on the line 4—4 of Fig. 3, showing the transducer in elevation.

The transducer is formed of an upper collar 1 and a lower collar 2 between which is mounted a cylinder 3 upon an upper cylindrical bellows 4 mounted between collar and cylinder 3, and a lower similar cylindrical bellows 5 mounted between the collar 1 and cylinder 3. The bellows have no top or bottom, being hollow cylinders with corrugated walls of conventional design. Connecting the collars 1 and 2 are guide bars 6 and 7 which also act to rigidly space the collars 1 and 2. Mounted on one of the bars, for example 7, is a pin 8, the shank 9 of which passes through a bore 10 in the cylinder 3, the bore being of somewhat larger diameter than the shank 9 for the purpose described below. A plate 11 is mounted in the cylinder 3 to which may be connected a force transmitting rod 12.

Disposed on opposite sides of one end of the cylinder 3 at substantially the same plane are two insulated pins 18 and 23 spaced apart and in line. At the other end of the cylinder 3 are disposed two pins 17 and 19 also at substantially the same plane and disposed 180° apart. These pins may be of sapphire or of any other insulating material such as has been used in the prior art referred to above.

Mounted upon the collar 1 are four metallic pins 14, 15, 16, and 13 insulated from the collar 1 by mounting in an insulating bushing. Mounted on the collar 1 is an insulated pin 21 similar to pins 17 to 20. Pin 21 is mounted on the same side as pin 19 and in line therewith, pin 21 being insulating of the same nature as pin 19. Mounted in collar 2 is a pin 22, like pins 17 to 21, and on the same side and in line with pin 20. Pin 23, like pins 17 to 22, is mounted on collar 2 on the same side as pin 18 and in line therewith, and a similar pin 24 is similarly mounted on collar 1 on the same side as pin 17 and in line therewith.

A metallic pin 25 is mounted in collar 2 in line with pin 13 and on the same side thereof and insulated from collar 2 by an insulating bushing, and a metallic pin 34 is similarly mounted in collar 2 on the same side as pin 14 and in line therewith. Similar metallic pins are similarly mounted on collar 2, pin 32 on the same side and in line with pin 15, and pin 26 on the same side and in line with 16. Additional similar metallic pins of similar construction and insulated in a similar manner are mounted in collar 1, one at 31 and one at 33.

Strain wires such as have been employed in the prior art transducers referred to above are wound in tension in loops, one loop 27 on pins 18 and 23 and one loop 28 on pins 17 and 24, one loop 29 on pins 19 and 21, and one loop 30 on pins 22 and 20. The wires are wound so as to be parallel to the axis of cylinder 3 and the coaxial cylindrical bellows 4 and 5 and spaced from

the surface of the cylinder 3 so as not to be in electrical contact therewith. The end of the wire loop 27 is electrically connected to metallic pins 34 and 25. Pin 34 is connected by a copper wire 36 of relatively low resistance to 14. The wire is stretched and spaced from the surface of the cylinder 3 and collar. Pin 25 is connected by a copper wire 35 to pin 13 in a manner similar to 36. Likewise the ends of the wire loop 28 are electrically connected one to pin 14 and one to pin 33. Pin 33 is connected to terminal 16 by an electrical connection. The ends of the wire 29 are electrically connected one to 15 and the other to pin 31, pin 31 being electrically connected to pin 13. The ends of the wire loop 30 are connected one to pin 26, which is connected by a copper wire 37 to 16 in a manner similar to 35 and 36, and the other end of 30 is electrically connected to pin 32 which is in turn connected by a wire 38 to pin 15 in a manner described for wires 35, 36, and 37. These loops of wires are thus connected as the four arms of a Wheatstone bridge arrangement in a manner similar to the prior are structures.

The transducer may be positioned in case 39 carrying four terminal outlets 30 mutually insulated from each other, to which each of the pins 13, 14, 15, and 16 is electrically connected. The rod 12 projects through the other end of the case to receive the force or displacement to be measured. It will be observed that any displacement of the rod 12 will cause the cylinder 3 to move in an axial direction coaxial with the axes of the bellows 4 and 5, being restricted to this axial direction by the properties of the corrugated metallic cylinders 4 and 5 which act as bellows. The axial movement of 3 is limited by the stop pin 9 and the diameter of the bore 10. This axial movement causes a contraction or extension of the wires, one pair 27 and 30 in one direction and the other pair 28 and 29 in the opposite direction in a manner similar to that described in the prior art devices. The transducer is snugly positioned in the case by means of the guide bars 6 and 7 and may be retained in position by set screws 41, which bear against one of the guide bars, forcing the other guide bar against the opposite wall, thus holding the transducer rigidly in position.

While I have described a particular embodiment of my invention for the purpose of illustration, it should be understood that various modifications and adaptations thereof may be be made within the spirit of the invention as set forth in the appended claims.

I claim:

1. An electrical strain wire transducer comprising an elongated movable member, a cylindrical bellows mounted at one end thereof, a cylindrical bellows mounted on the other end thereof, the axes of said bellows being in alignment, a relatively fixed member connected to each of said bellows, and electrical resistance strain wires mounted on said movable member and said fixed member.

2. A structure as defined in claim 1 in which the strain wire connected to said fixed member is mounted on the movable member at a point remote from the fixed member.

3. An electrical strain wire transducer comprising a pair of cylindrical collars adapted to be fixed in a case, an elongated movable member, a cylindrical bellows connected to each of said collars, one of said bellows being connected to each end of said elongated member, said bel-

lows being in axial alignment, insulated pins mounted in said collars, pins mounted adjacent the ends of said elongated member, electrical resistance strain wires mounted on said pins and spaced from said collars, elongated members, and said bellows, said wires extending between a pin on said collars and a remote pin positioned on said elongated member.

4. An electrical strain wire transducer comprising a pair of cylindrical collars adapted to be fixed in a case, an elongated movable member, a cylindrical bellows connected to each of said collars, one of said bellows being connected to each end of said elongated member, said bellows being in axial alignment, insulated pins mounted in said collars, pins mounted adjacent the ends of said elongated member, electrical resistance strain wires mounted on said pins and spaced from said collars, elongated member, and said bellows, said wires extending between a pin on said collars and a remote pin positioned on said elongated member, terminal pins on one of said collars, and an electrical connection between the ends of said wires and said terminal pins connecting said strain wires as the four arms of a Wheatstone bridge.

5. An electrical strain wire transducer comprising a movable member, a fixed frame member, an electrical strain wire, a support at one end of said electrical strain wire mounted on said frame member, a support mounted on said movable member, the other end of said wire mounted on said second support, a connecting means for movably connecting said movable member to said frame member, said connecting means including means to constrain the movement of said movable wire support on said movable member in a straight line of extension of said wire between said supports.

6. An electrical strain wire transducer comprising a movable member, a fixed frame member, a pin mounted in said movable member, a pin mounted in said frame member, an electrical strain wire mounted on said pins and extending therebetween, a connecting means for movably and flexibly connecting said frame member and said movable member, said connecting means including means for constraining motion of said movable member with respect to said frame member and the said pin mounted thereon to constrain the motion of said pin to a straight line parallel to the original extension of said wire, means for imposing a force on said transducer to move said movable member with respect to said frame member, said transducer transposing said force into a simple variation in tension, no portion of said force imposing a bending force on said wire at said pin during said motion.

7. An electrical strain wire transducer comprising an elongated movable member, a cylindrical bellows mounted at one end thereof, a cylindrical bellows mounted on the other end thereof, the axes of said bellows being in alignment, a relatively fixed member connected to each of said bellows, and electrical resistance strain wire mounted on said movable member and said fixed member, the strain wire connected to said fixed member being mounted on the movable member at a point remote from the fixed member, said strain wire extending parallel to the axis of said bellows.

8. An electrical strain wire transducer comprising a pair of cylindrical collars adapted to be fixed in a case, an elongated movable member, a cylindrical bellows connected to each of said collars, one of said bellows being connected to each end of said elongated member, said bellows being in axial alignment, insulated pins mounted in said collars, pins mounted adjacent the ends of said elongated member, electrical resistance strain wires mounted on said pins and spaced from said collars, elongated members, and said bellows, said wires extending between a pin on said collars and a remote pin positioned on said elongated member parallel to the axis of said bellows.

9. An electrical strain wire transducer comprising a pair of cylindrical collars adapted to be fixed in a case, an elongated movable member, a cylindrical bellows connected to each of said collars, one of said bellows being connected to each end of said elongated member, said bellows being in axial alignment, insulated pins mounted in said collars, pins mounted adjacent the ends of said elongated member, electrical resistance strain wires mounted on said pins and spaced from said collars, elongated member, and said bellows, said wires extending between a pin on said collars and a remote pin positioned on said elongated member in a direction parallel to said axis, terminal pins on one of said collars, and an electrical connection between the ends of said wires and said terminal pins connecting said strain wires as the four arms of a Wheatstone bridge.

10. An electrical strain wire transducer, comprising a pair of longitudinally spaced cylindrical coaxial collars, insulated pins mounted on said collars, an elongated armature flexibly connected at each end of said armature to the periphery of each of said cylindrical collars for movement of said armature restricted to a line parallel to the axis of said collars, insulated wire supports positioned on each of said collars, said supports being positioned on each collar displaced 180° from each other and the supports on one of the collars being displaced only 90° from the insulated supports on the other of said collars, two pins positioned on each end of said armature, the pins at each end being displaced 180° from each other and displaced 90° from the pins at the other end of said armature, four electrical resistance strain wires mounted on said pins, each wire extending from a support at one end of said armature to a support on the frame element flexibly connected to the other end of said armature, all of said wires being parallel and displaced 90° from each other and all of said wires being parallel to the axes of said collars.

11. An electrical strain wire transducer, comprising a pair of longitudinally spaced cylindrical coaxial collars, an elongated armature, each end of said armature being flexibly connected to the periphery of one of said collars for movement of said armature, restricted to a line parallel to the axes of said collars, insulated wire supports on opposite ends of said armature, said supports being displaced 180° from each other, a wire support on one of said collars, a wire support on the other of said collars, said supports on said collars being displaced 180° from each other, electrical resistance strain wires mounted on the supports one on each of the collars and on the wire support on the end of the armature connected to the other of said collars, said wires being parallel to each other and the axes of said collars and said wires being displaced 180° from each other.

12. An electrical strain wire transducer, comprising a frame, said frame having a first portion and a second portion, said portions being

longitudinally spaced from each other, an elongated armature positioned between said spaced frame portions, a flexible connection between each of the ends of said armature and one of said spaced-apart frame portions, said flexible connections being flexible in the line of movement of said armature, said flexible connection being rigid in all other directions, a first wire support on said armature near one end of said armature, a second wire support on said armature near the other end of said armature and spaced from said first wire support 180° in a plane perpendicular to the said line of movement of said armature, a third wire support mounted on said frame adjacent the first named end of said armature and spaced 180° from said first named wire support, a fourth wire support on said frame adjacent the other end of said armature and spaced 180° from the third mentioned wire support, electrical resistance wires connected to the first mentioned and third mentioned wire supports, a second electrical strain wire connected to the second and fourth mentioned wire support, the extension of said wires being parallel to each other and to the line of movement of said armature and said wires being displaced from each other 180°.

13. An electrical strain wire transducer, comprising a frame, said frame having a first portion and a second portion, said portions being longitudinally spaced from each other, an elongated armature positioned between said spaced frame portions, a flexible connection between each of the ends of said armature and one of said spaced apart frame portions, said flexible connections

being each flexible in the line of movement of said armature, a first wire support on said armature near one end of said armature, a second wire support on the same end of said armature, said wire supports being displaced from each other 180°, a third wire support near the other end of said armature and displaced 90° from the first and second wire supports, a fourth wire support on said other end of said armature displaced 180° from said third wire support, two wire supports on one of said frame portions and two wire supports on the other of said frame portions, each of said wire supports on each of said frame portions being in line with a wire support on that end of said armature which is flexibly connected to the other of said frame armatures, electrical resistance strain wires extending between a wire support on the frame element and a wire support on the end of said armature connected to the other of said frame elements, all of said wires being parallel and displaced 90° from each other and all of said wires being parallel to the line of motion of said armature on said flexible supports.

CARLOS JAY BAKER.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,036,458	Carlson	Apr. 7, 1936
2,248,301	Krause	July 8, 1941
2,488,347	Thurston	Nov. 15, 1949