March 18, 1969 G. K. HOUPT ET AL 3,434,086

GAUGING TRANSDUCER

Filed Oct. 27, 1966 Sheet 1 of 2

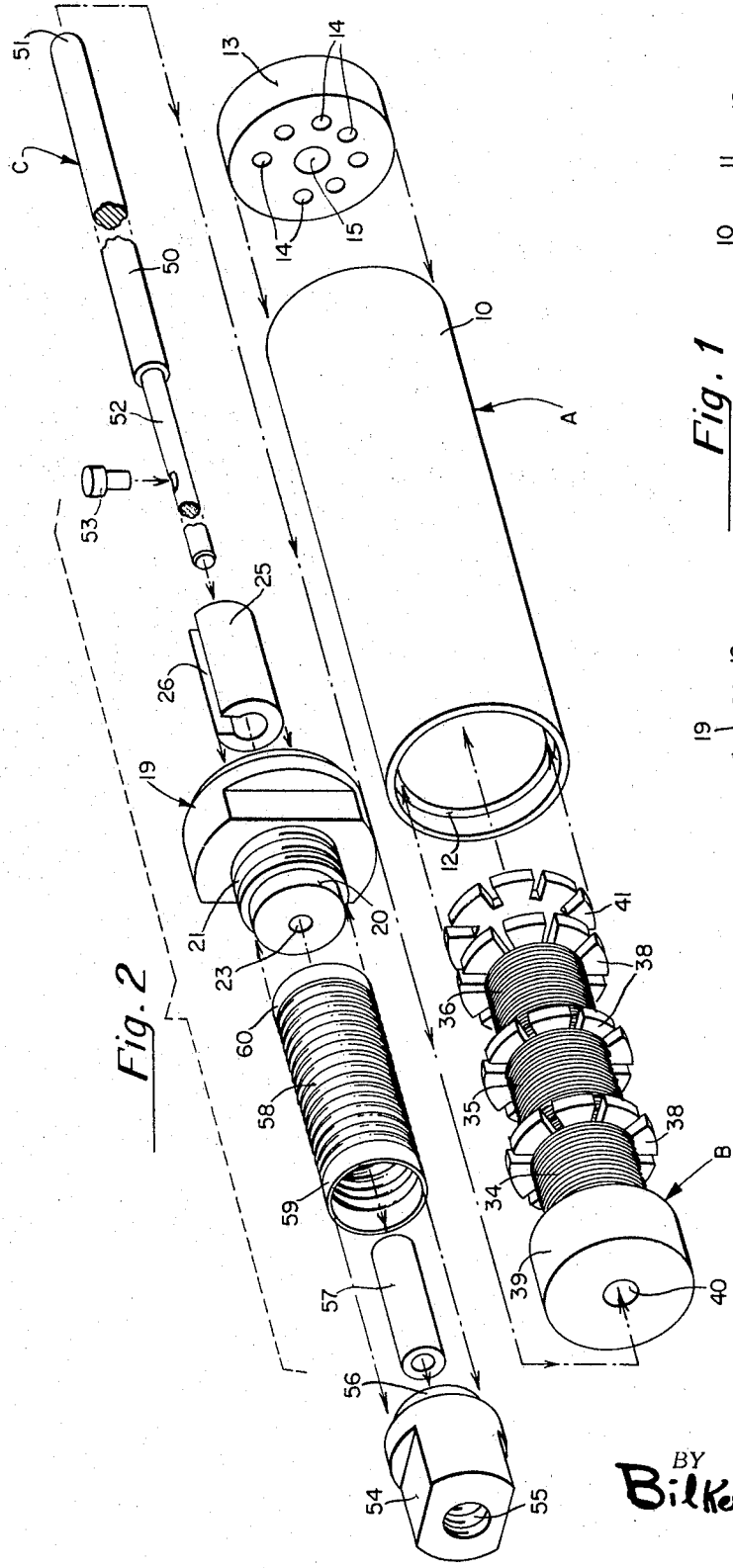


Fig. 2

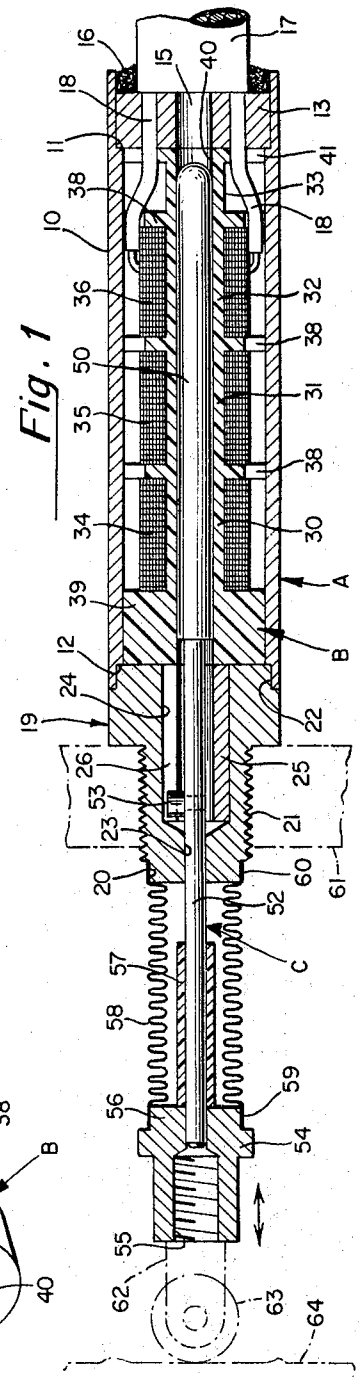


Fig. 1

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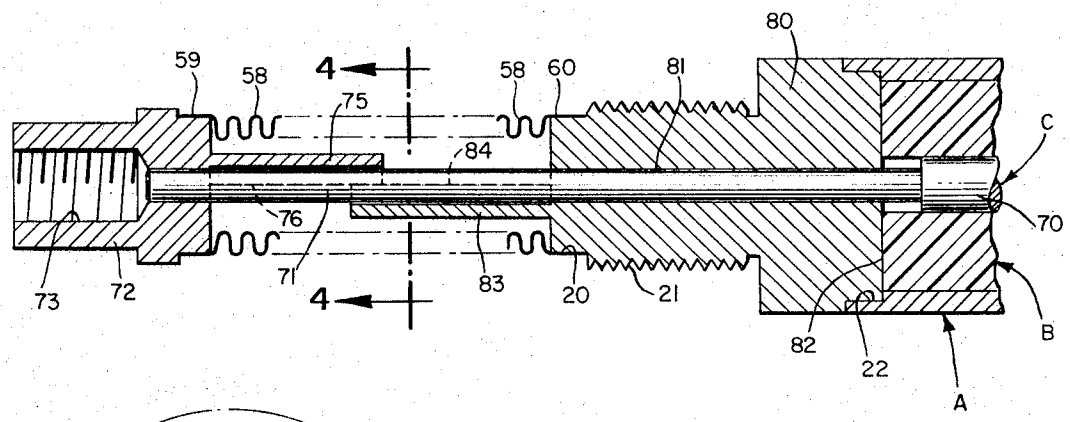


Fig. 3

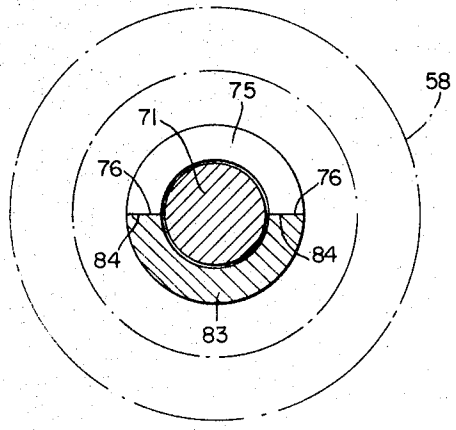


Fig. 4

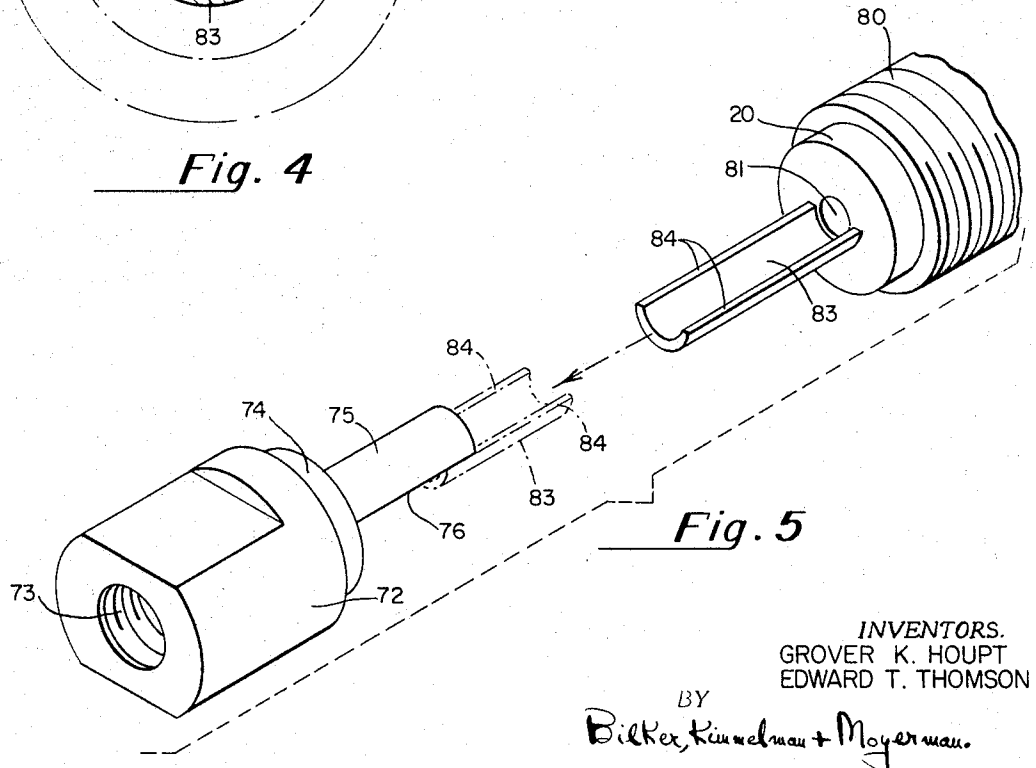


Fig. 5

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3,434,086

GAUGING TRANSDUCER

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U.S. Cl. 336—30 7 Claims
Int. Cl. H01f 21/02, 21/06

ABSTRACT OF THE DISCLOSURE

This gauging transducer includes a tip member which is attached by a metal bellows to a housing member. The tip has one end of an armature fixed axially thereof which passes through an axial passage way in the housing and extends to a region between a plurality of coils located around the path of travel of the armature. The armature shaft may include a projecting pin which rides in a groove in a fixed anti-rotation sleeve within the housing.

This invention pertains to inductance variation type transducers having a mechanical input. More particularly, it relates to novel details of construction for such transducers which enable them to be further miniaturized and which simultaneously simplify their construction and increase their efficiency.

In prior art mechanical input inductance variation type transducers, such as are frequently used in gauges, comparators, and the like, certain elements are always present. These elements include a longitudinally extending housing, within which coils are mounted, and an armature assembly mounted for reciprocation with respect to the interior of the housing. Mechanical inputs produce reciprocation of the armature assembly with respect to the housing, and the electrical components mounted therein, so as to vary the inductance of the unit. The armature is customarily resiliently biased so as to be restored to a predetermined position upon the removal of displacement producing mechanical forces. This biasing, in the past, has been achieved with a wide variety of springs, some devices using coil springs within the housing, others using flat springs and still others using combinations of both.

Additionally, in the prior art, there has been recognition of the need for sealing the end of the housing through which the armature, or a portion of the armature assembly, protrudes. Due to variations in position possible for the armature, a flexible seal such as a bellows diaphragm has often been used.

Finally, it has been found desirable to permit only reciprocation of the armature assembly with respect to the housing while preventing its angular rotation with respect thereto. This is most advantageous where the magnetic characteristics of the armature are not uniform through its cross-section and where, consequently, a calibration made with the armature assembly in one angular orientation would not be valid were the armature assembly to rotate as well as reciprocate within the housing.

Accordingly, it is an object of the invention to provide a transducer, of the type described above, which includes simple and effective means for preventing rotation of the armature assembly with respect to the housing even when the former is reciprocating.

It is also an object of the invention to provide a transducer having a resiliently biased armature assembly wherein the means for producing the resilient bias are external to the housing and are readily accessible and/or visible.

Still another object of the invention is to provide a transducer wherein the same component both seals and resiliently biases the armature, with respect to the housing, thus eliminating internal springs and performing two prior art functions simultaneously.

These and other objects of the invention will be apparent to those skilled in the art from a consideration of the specification when read in conjunction with the drawing, wherein:

FIGURE 1 represents a longitudinal cross-section taken through a transducer embodying the invention with the parts shown in phantom representing a conventional application for the unit.

FIGURE 2 represents a perspective exploded view, partially fragmented, of the transducer shown in FIGURE 1.

FIGURE 3 represents a fragmentary longitudinal cross-section taken through another transducer embodying the invention.

FIGURE 4 represents a section taken on line 4—4 of FIGURE 3.

FIGURE 5 represents a fragmentary exploded perspective view of portions of the transducer shown in FIGURE 3 with the phantom lines indicating the working relationships between the parts shown.

Referring now to the drawings, wherein like reference numerals designate like parts, it will be observed that the transducer comprises a longitudinally extending, generally cylindrical housing A, within which is mounted an annular bobbin assembly B having a plurality of windings. An armature assembly C is mounted in the axial core of bobbin assembly B and is adapted to reciprocate therein.

Housing assembly A comprises a generally cylindrical metal shell **10**, the distal end of which is provided with an internal shoulder **11** and the proximal end of which is provided with another internal shoulder **12**. A metallic bushing **13**, having a plurality of circular wireways **14** and an axial armature ventway **15** is mounted across the distal end of the housing in contact with shoulder **11** and is retained in that position by the application of an insulating sealing composition **16**. This composition is preferably applied during assembly after a cable **17**, having a plurality of conductors **18**, is positioned (as shown in FIGURE 1) with conductors **18** passing through wireways **14** en route to bobbin assembly B.

The proximal end of shell **10** is adapted to be closed with a metal cap, generally **19**, which includes a leading neck **20**, an externally threaded portion **21** and an externally shouldered portion **22** adapted to fiit within the shell **10** in juxtaposition with shoulder **12**. The cap may be cemented into place or otherwise affixed. Neck **20** is provided with an axial bore **23** which is enlarged, once it passes the neck **20**, into a cylindrical chamber **24** having a circular cross-section. Fixedly mounted in chamber **24**, as by being cemented to the walls thereof or press fitted thereinto, is a metallic anti-rotation bushing or sleeve **25** having a guide way **26** extending longitudinally in or through a wall thereof. As shown in the instant embodiment, the bushing is longitudinally split but a groove, keyway or other construction permitting only longitudinal motion of a pin riding therein, would be equally suitable.

Bobbin assembly B is formed with a plurality of annular spools **30**, **31** and **32** as well as an annular wireway **33**. Coils **34**, **35** and **36** are wound, respectively, on spools **30**, **31** and **32** and the various lead ends (not shown) are passed through slots or orifices in spool separators **38** into wireway **32** where connections are made to conductors **18**.

The construction and function of the coils are conventional. For example, coil **35** may be a primary coil ex-

cited from a suitable source whereas coils **34** and **36** may be secondary coils. The specifics of the magnetic and electrical circuits form no part of the instant invention and are well known in the art as reflected, for example, by the disclosure in U.S. Patent #3,221,281.

The bobbin assembly also includes a proximal cylindrical end portion **39** having an O.D. slightly less than the I.D. of shell **10** which, when the unit is assembled, abuts sealing cap **19** proximate shoulder **12**. An axial bore **40** extends longitudinally through the assembly, from end **39** to slotted distal end **41**, and is in axial alignment with ventway **15**. The slots in end **41** are cut so as to be in registration with holes **14** to permit connection of appropriate conductors **18** to their electrically related coils. As assembled, end **41** abuts bushing **13** proximate shoulder **11**. Assembly B may be cemeted in housing A or merely held in place by bushing **13** and cap **19**.

Armature assembly C, which is mounted for reciprocation between fixed limits within bore **40**, may be made in several sections which are screwed or cemented together. As is conventional, it is metallic and forms an important part of the flux circuit. The armature comprises a terminal section **50**, having an O.D. slightly less than the I.D. of bore **40**, which further includes a hemispherical end **51**. Adjoining section **50** is a section **52** having a smaller diameter, which extends longitudinally past the proximal end of shell **10**. Fitted into section **52**, and extending radially therefrom, is an anti-rotation pin **53** which is adapted to ride in guideway **26**. This pin also serves to limit reciprocal motion of armature C when it contacts the closed end of axial chamber **24**.

A metal seal **54** having an internally threaded bore **55** and a neck portion **56** is mounted on the free end of armature section **52** and moves with it as part of the armature assembly. Mounted coaxially about armature portion **52**, and affixed to seal **54**, is a non-metallic (e.g. nylon) stop sleeve **57**. This sleeve limits distal motion of the armature C with respect to housing A, proximal motion being limited as described above.

The armature assembly is resiliently biased in the extended position shown in FIGURE 1 by a metallic bellows **58** having shaped ends **59** and **60**. End **59** mounts on and is affixed to neck portion **56** of the metal seal **54**, whereas end **60** mounts on and is affixed to neck **20** of cap **19**. Bellows **58** has the elasticity of a spring and functions as such while, simultaneously, sealing the end of the armature assembly where it emerges from bore **23**. In its spring function the bellows has a great advantage over a helical spring. Whereas a helical spring applies forces only at a point of contact, the ends **59** and **60** insure an even distribution of thrust forces around the armature. Thus there are no unbalanced transverse force vectors which would tend to axially misalign the armature with respect to the bobbin assembly or the housing. Further, such a bellows-like spring has a highly predictable spring rate. Suitable bellows are preferably formed by electro deposition on a shaped mandrel and are made of corrosion resistant metal.

In use the transducer may be mounted in a fixed retaining surface **61** utilizing, for example, threaded portion **21**. Into bore **55** may be threaded a gauging link **62** on which is mounted a gauging roller or tip **63**. Roller **63** is placed in juxtapositon with a moving surface **64**, irregularities of which are to be gauged. Motion components along the axis of the transducer, caused by the irregularities, are transmitted to the armature as the mechanical input of the device. The spring characteristics of the bellows insure normal contact with the surface and the spring rate predictability prevents galling or scratching of surface **64** by tip **63**. Truly precise calibration is possible because the armature is prevented from rotating (and thereby changing magnetic circuit characteristics) but not from reciprocating by the anti-rotation means described above.

In the embodiment shown in FIGURES 3 to 5 inclusive, the armature assembly C includes a large diameter shaft portion **70** and a portion **71**, having a reduced diameter, which latter portion projects outwardly from housing A. The armature assembly is completed by a metal end seal **72** having an internally threaded bore **73** and a shouldered neck portion **74**. Additionally, it is provided with a projecting half sleeve **75** which extends toward housing A. Sleeve **75** includes a flat transverse bearing surface **76**.

Generally, end seal **72** functions in the same manner as seal **54**, with bore **73** receiving a gauging link, such as **62** and with one end of bellows **58** mounting on neck portion **74**. The seal is fixed, as by cementing or press fitting, to the free end of shaft **71**. Bellows portion **59** is cemented or otherwise affixed to neck **74**. The primary difference between the two seals involves sleeve **75**.

Housing assembly A is also somewhat different in that the end sealing cap **80** is provided with an internal bore **81** whose diameter complements the outside diameter of shaft section **71** and provides a bearing for it as it reciprocates in the housing. The cap also includes a transverse terminal face **82** which serves as a stop to limit the outward travel of enlarged shaft portion **70**. This sealing cap is provided with a cantilevered outwardly extending half sleeve **83** which includes a flat transverse bearing surface **84**. Surface **84** is complementary to surface **76** and seal **72** and cap **80** are so positioned that these two surfaces make sliding contact with each other as the armature assembly reciprocates. The other portions of sealing cap **80** are identical in function and appearance to similar portions of cap **19**, and have been so marked in the figures.

In operation the two sleeves **75** and **83** act as means for preventing rotation of the armature assembly with respect to the housing. They further serve as means for limiting compression of bellows **58**. Stated in an alternative manner, they act effectively as a single sleeve, split transversely, to limit rotation of the armature with respect to the housing. They also limit reciprocation in one direction, and reciprocation in the opposite direction is limited by contact between face **82** and the end of enlarged shaft portion **70**. This embodiment presents greater resistance to side-thrust at gauging tip **63** than the embodiment shown in FIGURE 1. It also provides greater bearing surface for the armature assembly C and a more positive anti-rotation action.

While a plurality of embodiments of my invention have been described in detail it is apparent that many applications exist in the transducer field for the resilient bellows and/or anti-rotation means disclosed. Accordingly, my invention is intended to be defined and limited only by the appended claims.

Having described our invention, we claim:

1. In an inductance variation transducer having a longitudinally extending housing in which are mounted a plurality of coils and along the axis of which an armature assembly is mounted for reciprocation in response to a mechanical input and wherein a portion of the armature projects beyond the housing, the improvement which comprises providing a unitary flexible means which simultaneously resiliently biases the armature assembly with respect to the housing and acts as a flexible seal around the projecting armature portion and further comprises slotted bushing means surrounding the armature and cooperating therewith for preventing rotation of the armature assembly with respect to said housing without interfering with reciprocation.

2. The improved transducer of claim **1** which further includes sleeve means surrounding said armature for limiting reciprocation of the armature assembly with respect to the housing.

3. In an inductance variation transducer having a longitudinally extending housing in which are mounted a plurality of coils and along the axis of which an armature assembly is mounted for reciprocation in response to a mechanical input and wherein a portion of the armature

assembly projects beyond that housing, the improvement which comprises providing a unitary flexible means which simultaneously resiliently biases the armature assembly with respect to the housing and acts as a flexible seal around the projecting armature portion and which further includes means which serve both to prevent rotation of the armature assembly with respect to the housing and to limit reciprocation of the armature assembly with respect to the housing, said limit means comprising a pin radially extending from a portion of the armature which is within the housing, and a longitudinally extending groove, fixed with respect to said housing, into which pin extends, at least one end of the groove being enclosed to limit longitudinal travel of the pin therein.

4. The transducer of claim 3 wherein said limit means comprises a longitudinally extending sleeve coaxially mounted about said projecting armature portion, said sleeve being transversely split into two portions, each having flat surfaces, which bear on each other, one of said portions being fixed with respect to said armature assembly and the other of said portions being fixed with respect to said housing, whereby travel of the armature toward the housing is limited and rotation of the armature with respect to the housing is also limited.

5. In an inductance variation transducer having a longitudinally extending housing in which are mounted a plurality of coils and along the axis of which an armature assembly is mounted for reciprocation in response to a mechanical input and wherein a portion of the armature essembly projects beyond the housingz, the improvement which comprises providing a unitary flexible means which simultaneously resiliently biases the armature assembly with respect to the housing and acts as a flexible seal around the projecting armature portion, said unitary flexible means comprising a resilient metal bellows diaphragm coaxially mounted about the projecting portion of the

armature, one end of said diaphragm being sealingly coupled to the housing and the other end of said diaphragm being sealingly coupled to said armature assembly at a point longitudinally spaced away from the housing, and also including a longitudinally extending sleeve coaxially mounted about said projecting armature portion inside said diaphragm which limits compression of said sleeve and thereby limits the travel of said armature assembly toward said housing.

6. The transducer of claim 5 which further includes a longitudinally extending sleeve coaxially mounted about said projecting armature portion, inside said diaphragm said sleeve being transversely split into two portions, each having flat surfaces, which bear on each other, one of said portions being fixed with respect to said armature and the other of said portions being fixed with respect to said housing, whereby travel of the armature toward the housing is limited and rotation of the armature with respect to the housing is also limited.

7. The transducer of claim 6 wherein a portion of said armature assembly, located within said housing, limits extension of said projecting portion with respect to said housing.

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