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MECHANO-ELECTRICAL TRANSDUCER

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2 Sheets-Sheet 2

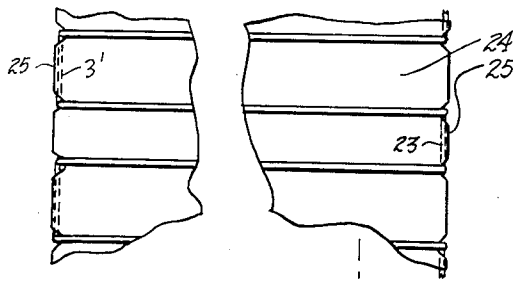
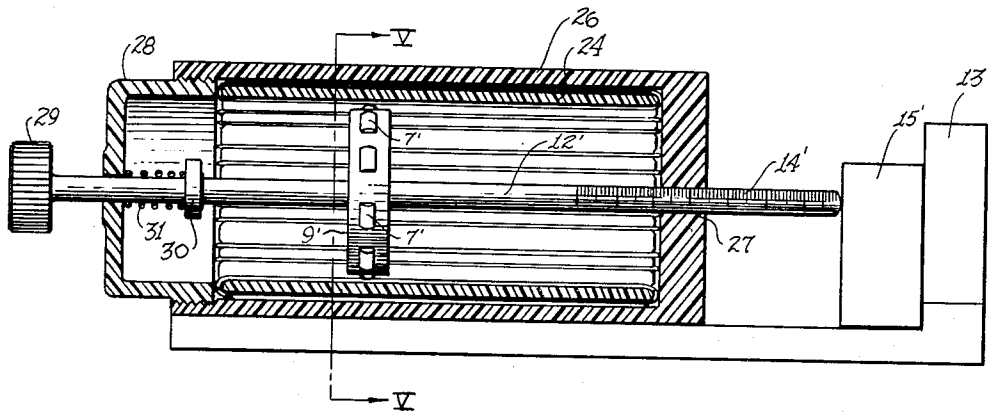


Fig. 7.

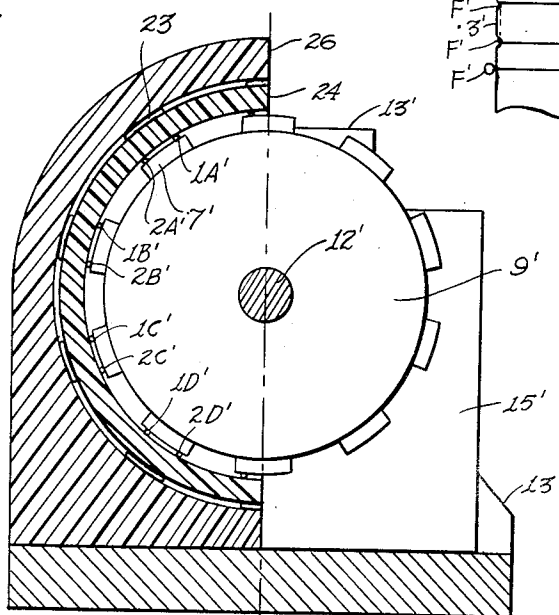


Fig. 5.

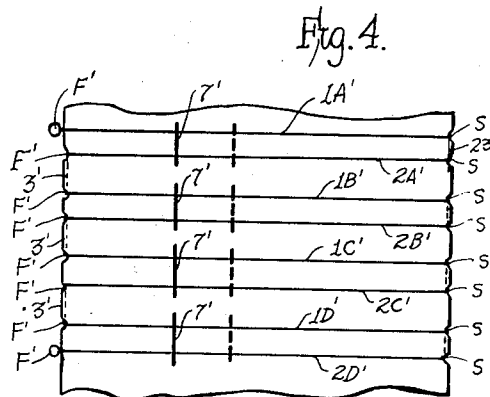


Fig. 6.

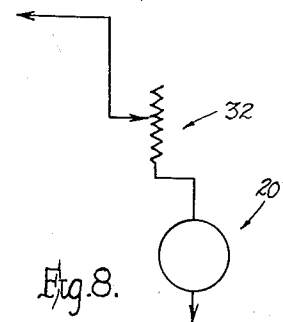


Fig. 8.

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MECHANO-ELECTRICAL TRANSDUCER

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12 Claims. (Cl. 201—62)

Generally speaking, the present invention relates to the transducer art and, more particularly, pertains to an improved mechano-electrical transducer adapted to translate mechanical movement (or variations in physical position) into correlated electrical variations (such as electrical resistance variations, for example). For example, one form of the present invention is particularly well adapted for use as a precision mechanico-electrical micrometer suitable for very rapidly and easily making extremely precise spatial measurements (although, not so limited). Also, the present invention may comprise a variable potentiometer, a variable rheostat, or a mechanically operated variable electrical resistor having virtually infinite resolution.

I am aware of the fact that various mechanico-electrical transducers, variable potentiometers, and variable rheostats have been developed heretofore. However, all of such prior art devices, known to me, have serious disadvantages of one type or another.

For example, most such prior art devices have encountered a major problem in attempting to produce a discrete, substantial, measurable change in electrical resistance in response to an extremely small mechanical movement—they have encountered resolution problems. For example, in prior art mechanico-electrical transducers of the type using an electrical resistance element (usually, a wire made of a metal or an alloy of metals having high electrical resistivity), it has been found virtually impossible to make such an electrical resistance element of a relatively short length having as high an electrical resistance as would be desirable in order to provide efficient mechanico-electrical transducing. Therefore, prior art attempts to solve this problem have been made and have taken the form of the employment of such electrical resistant elements of extremely small cross-sectional area (whereby to maximize resistance per unit length) and have also taken the form of such electrical resistance elements of helically coiled electrical resistance wire (to maximize resistance per unit length along the axis of the coil). Both of these prior art attempts to solve the above-referred-to problem have serious disadvantages. In the first case, the employment of an electrical resistance wire of extremely small cross-sectional area has been impractical because such wire is extremely difficult and costly to produce and, in addition is so fragile as to render the entire mechanico-electrical transducer so susceptible to shock and vibration, or movement of any kind, as to be virtually inoperative for all practical purposes. Second, the use of a resistance element of helically coiled wire produces noise and resolution problems of a substantial measure. In this prior art version, it is virtually impossible to maintain small-area contact with a limited portion of an electrical wire forming a part of the helical coil.

Generally speaking, the present invention includes at least a first and second electrical conductor (usually, a plurality of sets thereof) each having electrical resist-

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ance which is a function of the length thereof from a first point thereon (usually, an arbitrary and/or imaginary point) to a second point thereon (usually, an arbitrary and/or imaginary point). The invention may also include electrical contact means cooperably arranged for electrical contact with said first and second electrical conductors whereby to electrically connect said first and second electrical conductors (of each set, independently, when a plurality of sets are employed). The electrical contact means being relatively movably mounted (usually, relatively slidably movably mounted) with respect to said first and second electrical conductors whereby said electrical contact means may be relatively moved in electrical contact (usually slidably moved) with said first and second electrical conductors between said first points thereon and said second points thereon whereby to effectively vary the electrical resistance from said first point on said first electrical conductor to said first point on said second electrical conductor (or in the event that a plurality of sets are used, to effectively vary the electrical resistance from the first point on the first electrical conductor of the first set to the first point on the second electrical conductor of the last set) as a function of the position of the electrical contact means with respect to said first and second electrical conductors.

In the form of the present invention employing a plurality of sets of electrical conductors, means is also provided for electrically connecting the first point of the second electrical conductor of each set (except the last set) to the first point of the first electrical conductor of a different set (except the first set).

One preferred generic form of the present invention may also include measuring means comprising a first member and a second member relatively movable with respect to each other in correlation with the relative movement of the electrical contact means with respect to the first and second electrical conductors (or with respect to the plurality of sets thereof).

From the above description of basic and preferred generic forms of the present invention, it will be apparent to those skilled in the art that virtually all of the hereinbefore-referred-to prior art disadvantages and/or problems are virtually and entirely eliminated and/or overcome in and through the use of the present invention.

For example, it is obvious that the apparatus of the present invention effectively multiplies the normally small electrical resistance change occurring in a single electrical conductor (of high electrical resistance wire) in response to a very small movement of the electrical contact member therealong, by a factor that equals the number of electrical conductors employed. This makes it possible to produce virtually any desired ratio of resistance change with respect to mechanical movement of the electrical contact means and also makes it possible to cause the entire transducer to have a desired overall electrical resistance. Furthermore, the electrical contact means slidably contacts each wire individually in an extremely small contact area—therefore, the device has an extremely high resolution, which can be increased to any desired degree (and, therefore, may be said to be virtually infinite) by merely increasing the number of electrical conductors employed.

Furthermore, it should be noted that the device of the present invention does not require that the electrical conductors be made of such small cross-sectional area as to be extremely fragile. Actually, they may be of relatively rugged construction, and the necessary sensitivity of the device may be provided by merely increasing the number of electrical conductors.

Furthermore, it is obvious that the form of the present invention provided with measuring means comprises a

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very effective mechano-electrical micrometer suitable for precision spatial measurements.

With the above points in mind, it is the object of the present invention to provide an improved mechano-electrical transducer and/or variable potentiometer and/or variable rheostat and/or mechanically operable, variable electrical resistor of simple, cheap and rugged construction and embodying virtually any desired degree of sensitivity and resolution.

It is a further object of the present invention to provide an improved mechano-electrical micrometer for precision spatial measurement and of simple, cheap and rugged construction and embodying virtually any desired degree of sensitivity and resolution.

Other and allied objects will be apparent to those skilled in the art after a careful perusal, examination and study of the accompanying illustrations, the present specification, and the appended claims.

To facilitate understanding, reference will be made to the hereinbelow-described drawings, in which:

Fig. 1 is a perspective view of one illustrative embodiment of the present invention;

Fig. 2 is a front elevation of balancing apparatus and indicating means cooperable with the apparatus illustrated in Fig. 1 to form a mechano-electrical micrometer or spatial measuring apparatus;

Fig. 3 is an electrical schematic view illustrating the cooperative relationship of the apparatus shown in Fig. 1 and the apparatus shown in Fig. 2 (plus a power supply) to comprise a complete mechano-electrical micrometer or spatial measuring apparatus;

Fig. 4 is a longitudinal, vertical sectional view of a slightly modified form of mechano-electrical transducer equivalent to that shown in Fig. 1 but constructed differently therefrom;

Fig. 5 is a vertical sectional view taken in the direction of the arrows V—V in Fig. 4 (and somewhat enlarged with respect to Fig. 4);

Fig. 6 is a fragmentary, diagrammatic, schematic view indicating the operation of the form of the invention shown in Figs. 4 and 5 (although the physical structure has been somewhat simplified in Fig. 6 for reasons of clarity);

Fig. 7 is a fragmentary view similar to Fig. 6 but on a somewhat larger scale;

Fig. 8 is a view similar to a portion of Fig. 3 and illustrates a slight modification of the circuit connecting the meter with respect to the Wheatstone bridge; and

Fig. 9 is a fragmentary plan view of a small portion of the scale carried on the upper surface of the device shown in Fig. 1.

Generally speaking, the device of the present invention includes at least one set of electrical conductors comprising a first electrical conductor having electrical resistance which is a function of the length thereof from the first point thereon to a second point thereon, and a second electrical conductor having electrical resistance which is a function of the length thereof from a first point thereon to a second point thereon. In the specific example illustrated in Fig. 3, this takes the form of four sets of electrical conductors A, B, C, and D, including, respectively, a first electrical conductor 1A and a second electrical conductor 2A, a first electrical conductor 1B and a second electrical conductor 2B, a first electrical conductor 1C and a second electrical conductor 2C, a first electrical conductor 1D and a second electrical conductor 2D. In the specific example illustrated, the first point (mentioned above) on each electrical conductor is indicated at F and the second point on each electrical conductor is indicated at S.

Also, generally speaking, in the form of the present invention employing more than one set of electrical conductors (such as the form illustrated in Figs. 1 and 3 employing four sets of electrical conductors) means may also be provided to electrically connect the first point of the second electrical conductor of each set (except the

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last set) to the first point of the first electrical conductor of a different set (except the first set).

In the specific example illustrated in Fig. 3, said connecting means takes the form of three wire portions 3; the first wire portion connecting the first point F on electrical conductor 2A to the first point F on electrical conductor 1B, the second portion 3 connecting the first point F on the electrical conductor 2B to the first point F on the electrical conductor 1C, and the third wire portion 3 connecting the first point F on the electrical conductor 2C to the first point F on the electrical conductor 1D.

It should be noted that as illustrated in Fig. 1, each of the electrical conductors is mounted in vertically spaced relationship with respect to a base member, indicated generally at 4, and is connected to a plurality of pins which correspond to the second points S. The ends of each of the electrical conductors may be affixed to said pins in any suitable manner. It should also be noted that the first point F on the first electrical conductor 1A and the first point F on the last electrical conductor 2D actually correspond to electrical terminals adapted for connection to the Wheatstone bridge circuit shown in Fig. 3. The ends of the electrical conductors 1A and 2D may be affixed to said terminals at points F in any suitable manner. It should also be noted that, as shown in Fig. 1, the connecting wire portions 3 are actually integral parts of the electrical conductors which they connect, and that the physical mounting of said portions 3 and the adjacent portions of the electrical conductors which they connect, is accomplished by means of a lateral upstanding member 5 provided with a plurality of holes 6 therein adapted to receive therethrough the left end portions of the appropriate electrical conductors and adapted to carry along the left edge thereof, as viewed in Fig. 1, the connecting portions 3.

Also, generally speaking, the present invention may include electrical contact means cooperably arranged for electrical contact with each set (or with only one set) of electrical conductors whereby to electrically connect said first and second electrical conductors (of each set, independently). The electrical contact means being relatively movably mounted with respect to said first and second electrical conductors whereby said electrical contact means may be relatively moved in electrical contact with said first and second electrical conductors (of each set) between the first points thereon and the second points thereon whereby to effectively vary the electrical resistance from the first point on the first electrical conductor to the first point on the second electrical conductor (or when a plurality of sets is employed, to effectively vary the electrical resistance to the first point on the first electrical conductor of the first set to the first point on the second electrical conductor of the last set) as a function of the position of the electrical contact means with respect to the first and second electrical conductors (or plurality of sets thereof).

In the specific example illustrated, the electrical contact means comprises a plurality of electrical contact members 7, each of which comprises a metallic spring mounted by suitable rivet means 8 (or the like) with respect to a transverse member 9, which is provided with two laterally spaced, inwardly directed, tongue means 10 slidably engaged in two opposed outwardly directing corresponding grooves 11 in the base member 4. The arrangement is such that the entire member 9 (which is preferably of insulating material) may be slidably moved with respect to the base member 4 in a manner whereby to similarly slidably move each of the electrical contact members 7 along each set A, B, C, and D of longitudinal electrical conductors whereby the effective electrical resistance from the first point F on the first electrical conductor 1A through a portion of said conductor, through the first electrical contact member 7, through a portion of electrical conductor 2A to the first point F on the electrical conductor 2A, through the first connecting wire 3 to the first point F on the elec-

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trical conductor 1B, through a portion of said conductor, through the second contact member 7, through a portion of the conductor 2D to the first point F thereon, through the second connecting portion 3 to the first point F on electrical conductor 1C, through a portion of said conductor, through the third contact member 7, through a portion of electrical conductor 2C to the first point F thereon, through the third connecting wire 3 to the first point F on the electrical conductor 1D, through a portion of said electrical conductor, through the fourth contact member 7, and through a portion of electrical conductor 2D to the first point F thereon, will be effectively varied in accordance with the positions of the contact members 7 with respect to the sets of longitudinal conductors.

Also, generally speaking, the present invention may include measuring means comprising a first member and a second member relatively movable with respect to each other in correlation with the relative movement of the electrical contact means with respect to the first and second electrical conductors (or plurality thereof).

In the specific example illustrated, the first member of said measuring means actually comprises the member 9 and a longitudinal rod 12 carried thereby, and the second member of said measuring means comprises the base member 4, an upstanding end-plate 13 and a scale 14 carried by the upper surface of the base member 4 immediately adjacent and virtually underlying the longitudinal rod 12. The arrangement is such that a device to be measured, such as the object indicated at 15, may be removably placed against the upstanding end-plate 13 slidable member 9 may be slidably moved towards the right, as viewed in Fig. 1, until the longitudinal rod 12 abuts the member 15, as shown in Fig. 1. This will cause each of the contact members 7 to assume a position with respect to each set of longitudinal conductors A, B, C, and D correlated with respect to the longitudinal dimension of the object 15, and will, therefore, cause the overall resistance from the first point F on the first electrical conductor 1A to the first point F on the last electrical conductor 2D to be of a value correlated with respect to the longitudinal dimension of the object 15 between the end of the rod 12 and the upstanding plate 13.

This will cause the balance of the Wheatstone bridge, shown in Fig. 3, to be disturbed and altered with respect to its former position. An operator of the device then visually observes the scale 14 on the upper surface of the base member 4 to determine the measurement of the object 15 to the nearest tenth of an inch and to the nearest fiftieth of an inch, as shown in Fig. 9, and he then adjusts rheostat 16 to the corresponding nearest tenth of an inch reading, and he then adjusts rheostat 17 to the corresponding nearest fiftieth of an inch reading. He then adjusts rheostat 18 until he reaches the highest thousandths of an inch reading which will allow the indicating needle 19 of the meter, indicated generally at 20, to remain at null position. He then adjusts rheostat 21 until he reaches the highest ten-thousandths of an inch position which will allow the needle 19 of the meter 20 to remain at null position. He then adjusts rheostat 21 into the next lowest ten-thousandths of an inch position. He then reads the position of the meter needle 19 to the nearest hundred-thousandth of an inch and approximates the nearest millionth of an inch. Thus the operator may read the longitudinal measurement of the object 15, to a millionth of an inch by merely reading the scale indications of rheostats 16, 17, 18 and 21 and meter 20. For example, the settings of rheostats 16, 17, 18 and 21 and the meter 20, as shown in Fig. 2, correspond with the position of the object 15 with respect to the scale 14, indicated in Figs. 1 and 9, and indicate a measurement of 0.621223 inch. A switch 22 may be employed to effectively disconnect the meter 20 from the Wheatstone bridge until the re-

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balancing operation is substantially completed by adjustment of rheostats 16 and 17 (and possibly, the adjustment of rheostat 18 may be approximated). This will tend to protect the meter 20 from excessive current. However, another and better way, is to employ a meter of the type which, under heavy current overload, rotates to the point where torque is lost or greatly reduced, thus preventing any damage to the spring-biasing means associated with the needle 19. Also, the meter wiring can be sufficiently heavy to prevent coil burn-out under any expected current overload conditions.

Figs. 4, 5, 6 and 7 illustrate a slight modified form of the present invention (Figs. 6 and 7 in fragmentary, diagrammatic, schematic form). Referring to Fig. 6, it will be seen that electrical conductors 1A' and 2A', 1B' and 2B', 1C' and 2C', and 1D' and 2D' correspond to the electrical conductors shown in Fig. 3 illustrating the first form of the present invention. Also, the first points F' on said electrical conductors correspond to the points F shown in Fig. 3 illustrating the first form of the present invention. Also, four electrical contact members 7' correspond to the contact members 7 shown in Fig. 3. Also, the connecting wire portions 3' correspond to those shown in the first form of the present invention at 3. However, in Fig. 4 the second points S of each set of electrical conductors are connected together by wire portions 23. This does not change the electrical operation of the device, since each of the contact members 7' shorts out the corresponding connecting wire portion 23. The connecting wire portions 23 are merely provided for physical convenience in manufacturing the modified form of the present invention. As best shown in fragmentary form in Fig. 7, the plurality of electrical conductors actually comprise one long continuous wire with the electrical conductors 1A', 2A', 1B', 2B', 1C', 2C', 1D' and 2D' positioned on the inner surface of a cylindrical insulating shell 24 with the connecting wire portions 23 and 3' at opposite ends alternately looped behind projecting end portions 25 of the cylindrical shell 24 whereby to effectively mount the plurality of electrical conductors in the shell 24.

The shell 24 carrying the electrical conductors is mounted in an insulated manner within an outer housing 26, which is closed at the right end, as viewed in Fig. 4, except for a central aperture 27 therein, and which is closed at the left end by a threaded and centrally apertured cap member 28.

In this modified form of the present invention, the plurality of electrical contact members is indicated at 7' and functionally corresponds to the contact members 7 is shown in the first form of the present invention. The contact members 7' are carried in circumferentially spaced relationship around the periphery of (and an insulating relationship with respect to) a disc-like, slidable member 9', which functionally corresponds to the member 9 shown in Fig. 1. The member 9' is provided with a rod 12' which extends to the right, as viewed in Fig. 4, and which is functionally similar to the rod 12 shown in Fig. 1, and which is adapted to abut an object 15' which rest against an upstanding end-plate 13', similar to the corresponding elements shown in Fig. 1. However, in the modification shown in Fig. 4, a scale 14' (functionally similar to the scale 14 shown in Figs. 1 and 9) is carried by the right end of the rod 12' and the scale reading for the setting of rheostats 16 and 17 is taken from the junction of the scale 14' with the end wall of the housing 26.

In this modification, the rod 12' is also provided with a leftwardly directed extension (as viewed in Fig. 4) which extends through the apertured cap 28 and which is provided with an actuating handle 29 at the left end thereof. Said leftward extension of the rod 12' is also provided with a shoulder 30 abutting a coil compression spring 31, the opposite end of which abuts the inner surface of the cap 28 whereby to normally bias the right

end of the rod 12' into contact with the object to be measured 15'.

The operation of this modified form of this present invention is functionally similar to the first form hereinbefore-described. Therefore, additional description is thought to be unnecessary.

Fig. 8 illustrates a slight modification of the present invention and comprises the insertion of a variable rheostat 32 into the circuit shown in Fig. 3 between the Wheatstone bridge and the meter 20' for the purpose of compensating for any overall change in the impedance of the entire Wheatstone bridge resulting from substantial modification of the resistance of the transducing leg and the balancing leg. Ordinarily, such overall impedance change is so slight so as to be unimportant. However, if desired, the compensating rheostat 32 may be employed and may be adjusted in a manner correlated with the reading of any or all of the rheostats 16, 17, 18 and 21 (or the position of the transducer) so as to fully compensate such overall bridge impedance change. If desired, the correlation of the rheostat 32, as just mentioned, may be automatically accomplished by effectively coupling it with respect to any or all of the other rheostats and/or with respect to the transducer.

Numerous modifications and variations of the present invention will occur to those skilled in the art after a careful study hereof. All such properly within the basic spirit and teachings of the present invention are intended to be included and comprehended herein as fully as if specifically described, illustrated and claimed herein.

For example, various means for producing electric output from the apparatus of the present invention, other than the specific multiple-rheostat, Wheatstone bridge and meter arrangement illustrated herein, may be employed. Null or balancing apparatus may be employed, or positive output signal measuring apparatus may be employed—and either of these may assume a variety of types.

It should also be understood that the electrical conductors which are effectively connected by the contact means need not necessarily be adjacent—in fact, they may be oriented in any desired manner. It should also be understood that the two specific structures shown herein, are for illustrative purposes only. The mechanico-electrical transducer may assume a great variety of physical structures within the basic teachings hereof. Also, the first and second points, the first and second conductors and similar phraseology employed in connection with the plurality of sets may be interchangeable, and such expressions are to be interpreted broadly and not necessarily in the specific manner described herein for illustrative purposes only.

The exact compositions, configurations, constructions, relative positionings, and cooperative relationships of the various component parts of the present invention are not critical, and can be modified substantially within the spirit of the present invention.

The embodiments of the present invention specifically described and illustrated herein are exemplary only, and are not intended to limit the scope of the present invention, which is to be interpreted in the light of the prior art and the appended claims only, with due consideration for the doctrine of equivalents.

I claim:

1. A mechano-electrical transducer, comprising: a plurality of sets of electrical conductors including at least a first set and a last set, each set including a first electrical conductor having electrical resistance which is a function of the length thereof from a first point thereon to a second point thereon, and a second electrical conductor having electrical resistance which is a function of the length thereof from a first point thereon to a second point thereon; means electrically connecting the first point of the second electrical conductor of the first set to the first point of the first electrical conductor of the last set; electrical contact means cooperably arranged for electrical contact

with said first and second electrical conductors of each set whereby to independently electrically connect said first and second electrical conductors of each set, said electrical contact means comprising a unit relatively movably mounted for simultaneous movement as a unit with respect to each set of electrical conductors whereby said electrical contact means may be relatively moved in electrical contact with and independently communicating said first and second electrical conductors of each set between said first points thereon and said second points thereon whereby to effectively vary the electrical resistance from said first point on said first electrical conductor of said first set to said first point on said second electrical conductor of said last set as a function of the position of the unitary electrical contact means with respect to said plurality of sets of electrical conductors.

2. A mechano-electrical transducer, comprising: a plurality of sets of electrical conductors including a first set, a last set and at least one intermediate set, each set including a first electrical conductor having electrical resistance which is a function of the length thereof from a first point thereon to a second point thereon, and a second electrical conductor having electrical resistance which is a function of the length thereof from a first point thereon to a second point thereon; means electrically connecting the first point of the second electrical conductor of the first set to the first point of the first electrical conductor of an intermediate set and connecting the first point of the second electrical conductor of said intermediate set to the first point of the first electrical conductor of the last set; electrical contact means cooperably arranged for electrical contact with said first and second electrical conductors of each set whereby to independently electrically connect said first and second electrical conductors of each set, said electrical contact means comprising a unit relatively movably mounted for simultaneous movement as a unit with respect to each set of electrical conductors whereby said electrical contact means may be relatively moved in electrical contact with and independently communicating said first and second electrical conductors of each set between said first points thereon and said second points thereon whereby to effectively vary the electrical resistance from said first point on said first electrical conductor of said first set to said first point on said second electrical conductor of said last set as a function of the position of the unitary electrical contact means with respect to said plurality of sets of electrical conductors.

3. A mechano-electrical transducer, comprising: a plurality of sets of electrical conductors including a first set, a last set and a plurality of intermediate sets, each set including a first electrical conductor having electrical resistance which is a function of the length thereof from a first point thereon to a second point thereon, and a second electrical conductor having electrical resistance which is a function of the length thereof from a first point thereon to a second point thereon; means electrically connecting the first point of the second electrical conductor of each set except the last set to the first point of the first electrical conductor of a different set except the first set; electrical contact means including a plurality of electrically independent but mechanically connected electrical contact members each cooperably arranged for independent electrical contact with said first and second electrical conductors of each set whereby to independently electrically connect said first and second electrical conductors of each set, said electrical contact means comprising a unit relatively movably mounted for simultaneous movement as a unit with respect to each set of electrical conductors whereby said electrical contact means may be relatively moved in electrical contact with and independently communicating said first and second electrical conductors of each set between said first points thereon and said second points thereon whereby to effectively vary the electrical resistance from said first point on said first electrical conductor

of said first set to said first point on said second electrical conductor of said last set as a function of the position of the unitary electrical contact means with respect to said plurality of sets of electrical conductors.

4. A mechano-electrical transducer, comprising: a plurality of sets of electrical conductors including at least a first set and a last set, each set including a first electrical conductor having electrical resistance which is a function of the length thereof from a first point thereon to a second point thereon, and a second electrical conductor having electrical resistance which is a function of the length thereof from a first point thereon to a second point thereon; means electrically connecting the first point of the second electrical conductor of the first set to the first point of the first electrical conductor of the last set; electrical contact means cooperably arranged for electrical contact with said first and second electrical conductors of each set whereby to independently electrically connect said first and second electrical conductors of each set, said electrical contact means comprising a unit relatively movably mounted for simultaneous movement as a unit with respect to each set of electrical conductors whereby said electrical contact means may be relatively moved in electrical contact with and independently communicating said first and second electrical conductors of each set between said first points thereon and said second points thereon whereby to effectively vary the electrical resistance from said first point on said first electrical conductor of said first set to said first point on said second electrical conductor of said last set as a function of the position of the unitary electrical contact means with respect to said plurality of sets of electrical conductors; measuring means including a first member and a second member relatively movable with respect to each other in correlation with the simultaneous relative movement of the unitary electrical contact means with respect to each set of electrical conductors.

5. A mechano-electrical transducer, comprising: a plurality of sets of electrical conductors including a first set, a last set and at least one intermediate set, each set including a first electrical conductor having electrical resistance which is a function of the length thereof from a first point thereon to a second point thereon, and a second electrical conductor having electrical resistance which is a function of the length thereof from a first point thereon to a second point thereon; means electrically connecting the first point of the second electrical conductor of the first set to the first point of the first electrical conductor of an intermediate set and connecting the first point of the second electrical conductor of said intermediate set to the first point of the first electrical conductor of the last set; electrical contact means cooperably arranged for electrical contact with said first and second electrical conductors of each set whereby to independently electrically connect said first and second electrical conductors of each set, said electrical contact means comprising a unit relatively movably mounted for simultaneous movement as a unit with respect to each set of electrical conductors whereby said electrical contact means may be relatively moved in electrical contact with and independently communicating said first and second electrical conductors of each set between said first points thereon and second points thereon whereby to effectively vary the electrical resistance from said first point on said first electrical conductor of said first set to said first point on said second electrical conductor of said last set as a function of the position of the unitary electrical contact means with respect to said plurality of sets of electrical conductors; measuring means including a first member and a second member relatively movable with respect to each other in correlation with the simultaneous relative movement of the unitary electrical contact means with respect to each set of electrical conductors.

6. A mechano-electrical transducer, comprising: a

plurality of sets of electrical conductors including a first set, a last set and a plurality of intermediate sets, each set including a first electrical conductor having electrical resistance which is a function of the length thereof from a first point thereon to a second point thereon, and a second electrical conductor having electrical resistance which is a function of the length thereof from a first point thereon to a second point thereon; means electrically connecting the first point of the second electrical conductor of each set except the last set to the first point of the first electrical conductor of a different set except the first set; electrical contact means including a plurality of electrically independent but mechanically connected electrical contact members each cooperably arranged for independent electrical contact with said first and second electrical conductors of each set whereby to independently electrically connect said first and second electrical conductors of each set, said electrical contact means comprising a unit relatively movably mounted for simultaneous movement as a unit with respect to each set of electrical conductors whereby said electrical contact means may be relatively moved in electrical contact with and independently communicating said first and second electrical conductors of each set between said first points thereon and said second points thereon whereby to effectively vary the electrical resistance from said first point on said first electrical conductor of said first set to said first point on said second electrical conductor of said last set as a function of the position of the unitary electrical contact means with respect to said plurality of sets of electrical conductors; measuring means including a first member and a second member relatively movable with respect to each other in correlation with the simultaneous relative movement of the unitary electrical contact means with respect to each set of electrical conductors.

7. A mechano-electrical transducer, comprising: a plurality of sets of electrical conductors including at least a first set and a last set, each set including a first long thin electrical conductor having electrical resistance which is a function of the length thereof from a first point thereon to a second point thereon, and a second long thin electrical conductor having electrical resistance which is a function of the length thereof from a first point thereon to a second point thereon, said first and second long thin electrical conductors and said first and second points thereon being in laterally adjacent, similarly oriented relationship; means electrically connecting the first point of the second electrical conductor of the first set to the first point of the first electrical conductor of the last set; electrical contact means cooperably arranged for relative slidable electrical contact with said first and second electrical conductors of each set whereby to independently electrically connect said first and second electrical conductors of each set, said electrical contact means comprising a unit relatively slidably mounted for simultaneous movement as a unit with respect to each set of electrical conductors whereby said electrical contact means may be relatively moved in electrical contact with and independently communicating said first and second electrical conductors of each set between said first points thereon and said second points thereon whereby to effectively vary the electrical resistance from said first point on said first electrical conductor of said first set to said first point on said second electrical conductor of said last set as a function of the position of the unitary electrical contact means with respect to said plurality of sets of electrical conductors.

8. A mechano-electrical transducer, comprising: a plurality of sets of electrical conductors including a first set, a last set and at least one intermediate set, each set including a first long thin electrical conductor having electrical resistance which is a function of the length thereof from a first point thereon to a second point thereon, and a second long thin electrical conductor having electrical

resistance which is a function of the length thereof from a first point thereon to a second point thereon, said first and second long thin electrical conductors and said first and second points thereon being in laterally adjacent, similarly oriented relationship; means electrically connecting the first point of the second electrical conductor of the first set to the first point of the first electrical conductor of an intermediate set and connecting the first point of the second electrical conductor of said intermediate set to the first point of the first electrical conductor of the last set; electrical contact means cooperably arranged for relative slidable electrical contact with said first and second electrical conductors of each set whereby to independently electrically connect said first and second electrical conductors of each set, said electrical contact means comprising a unit relatively slidably mounted for simultaneous slidable movement as a unit with respect to each set of electrical conductors whereby said electrical contact means may be relatively slidably moved in electrical contact with and independently communicating said first and second electrical conductors of each set between said first points thereon and said second points thereon whereby to effectively vary the electrical resistance from said first point on said first electrical conductor of said first set to said first point on said second electrical conductor of said last set as a function of the position of the unitary electrical contact means with respect to said plurality of sets of electrical conductors.

9. A mechano-electrical transducer, comprising: a plurality of sets of electrical conductors including a first set, a last set and a plurality of intermediate sets, each set including a first long thin electrical conductor having electrical resistance which is a function of the length thereof from a first point thereon to a second point thereon, and a second long thin electrical conductor having electrical resistance which is a function of the length thereof from a first point thereon to a second point thereon, said first and second long thin electrical conductors and said first and second points thereon being in laterally adjacent, similarly oriented relationship; means electrically connecting the first point of the second electrical conductor of each set except the last set to the first point of the first electrical conductor of a different set except the first set; electrical contact means including a plurality of electrically independent but mechanically connected electrical contact members each cooperably slidably arranged for electrically independent but physically simultaneous slidable electrical contact with said first and second electrical conductors of each set whereby to independently electrically connect said first and second electrical conductors of each set, said electrical contact means comprising a unit relatively slidably mounted for simultaneous slidable movement as a unit with respect to each set of electrical conductors whereby said electrical contact means may be relatively moved in electrical contact with and independently communicating said first and second electrical conductors of each set between said first points thereon and said second points thereon whereby to effectively vary the electrical resistance from said first point on said first electrical conductor of said first set to said first point on said second electrical conductor of said last set as a function of the position of the unitary electrical contact means with respect to said plurality of sets of electrical conductors.

10. A mechano-electrical transducer, comprising: a plurality of sets of electrical conductors including at least a first set and a last set, each set including a first long thin electrical conductor having electrical resistance which is a function of the length thereof from a first point thereon to a second point thereon, and a second long thin electrical conductor having electrical resistance which is a function of the length thereof from a first point thereon to a second point thereon, said first and second long thin electrical conductors and said first and second points thereon being in laterally adjacent, similarly oriented relationship; means electrically connecting the first point

of the second electrical conductor of the first set to the first point of the first electrical conductor of the last set; electrical contact means cooperably arranged for relative slidable electrical contact with said first and second electrical conductors of each set whereby to independently electrically connect said first and second electrical conductors of each set, said electrical contact means comprising a unit relatively slidably mounted for simultaneous movement as a unit with respect to each set of electrical conductors whereby said electrical contact means may be relatively moved in electrical contact with and independently communicating said first and second electrical conductors of each set between said first points thereon and said second points thereon whereby to effectively vary the electrical resistance from said first point on said first electrical conductor of said first set to said first point on said second electrical conductor of said last set as a function of the position of the unitary electrical contact means with respect to said plurality of sets of electrical conductors; measuring means including, a first member fixed with respect to said sets of electrical conductors, and a second member fixed with respect to said electrical contact means whereby said first member and said second member will be relatively movable with respect to each other in correlation with the simultaneous relative movement of the unitary electrical contact means with respect to each set of electrical conductors.

11. A mechano-electrical transducer, comprising: a plurality of sets of electrical conductors including a first set, a last set and at least one intermediate set, each set including a first long thin electrical conductor having electrical resistance which is a function of the length thereof from a first point thereon to a second point thereon, and a second long thin electrical conductor having electrical resistance which is a function of the length thereof from a first point thereon to a second point thereon, said first and second long thin electrical conductors and said first and second points thereon being in laterally adjacent, similarly oriented relationship; means electrically connecting the first point of the second electrical conductor of the first set to the first point of the first electrical conductor of an intermediate set and connecting the first point of the second electrical conductor of said intermediate set to the first point of the first electrical conductor of the last set; electrical contact means cooperably arranged for relative slidable electrical contact with said first and second electrical conductors of each set whereby to independently electrically connect said first and second electrical conductors of each set, said electrical contact means comprising a unit relatively slidably mounted for simultaneous slidable movement as a unit with respect to each set of electrical conductors whereby said electrical contact means may be relatively slidably moved in electrical contact with and independently communicating said first and second electrical conductors of each set between said first points thereon and said second points thereon whereby to effectively vary the electrical resistance from said first point on said first electrical conductor of said first set to said first point on said second electrical conductor of said last set as a function of the position of the unitary electrical contact means with respect to said plurality of sets of electrical conductors; measuring means including, a first member fixed with respect to said sets of electrical conductors, and a second member fixed with respect to said electrical contact means whereby said first member and said second member will be relatively movable with respect to each other in correlation with the simultaneous relative movement of the unitary electrical contact means with respect to each set of electrical conductors.

12. A mechano-electrical transducer, comprising: a plurality of sets of electrical conductors including a first set, a last set and a plurality of intermediate sets, each set including a first long thin electrical conductor having electrical resistance which is a function of the length thereof

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from a first point thereon to a second point thereon, and a second long thin electrical conductor having electrical resistance which is a function of the length thereof from a first point thereon to a second point thereon, said first and second long thin electrical conductors and said first and second points thereon being in laterally adjacent, similarly oriented relationship; means electrically connecting the first point of the second electrical conductor of each set except the last set to the first point of the first electrical conductor of a different set except the first set; electrical contact means including a plurality of electrically independent but mechanically connected electrical contact members each cooperably slidably arranged for electrically independent but physically simultaneous slidable electrical contact with said first and second electrical conductors of each set whereby to independently electrically connect said first and second electrical conductors of each set, said electrical contact means comprising a unit relatively slidably mounted for simultaneous slidable movement as a unit with respect to each set of electrical conductors whereby said electrical contact means

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may be relatively moved in electrical contact with and independently communicating said first and second electrical conductors of each set between said first points thereon and said second points thereon whereby to effectively vary the electrical resistance from said first point on said first electrical conductor of said first set to said first point on said second electrical conductor of said last set as a function of the position of the unitary electrical contact means with respect to said plurality of sets of electrical conductors; measuring means including, a first member fixed with respect to said sets of electrical conductors, and a second member fixed with respect to said electrical contact means whereby said first member and said second member will be relatively movable with respect to each other in correlation with the simultaneous relative movement of the unitary electrical contact means with respect to each set of electrical conductors.

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