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Lelandais

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[54] **DEVICE FOR REMOTE-CONTROLLED RECIPROCAL EMISSION, TRANSMISSION AND RECEPTION OF MECHANICAL INFORMATION**

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[52] **U.S. Cl.**....................................**318/675,** 318/653

[51] **Int. Cl.**..**G05b 11/01**

[58] **Field of Search**........................318/653, 685, 675

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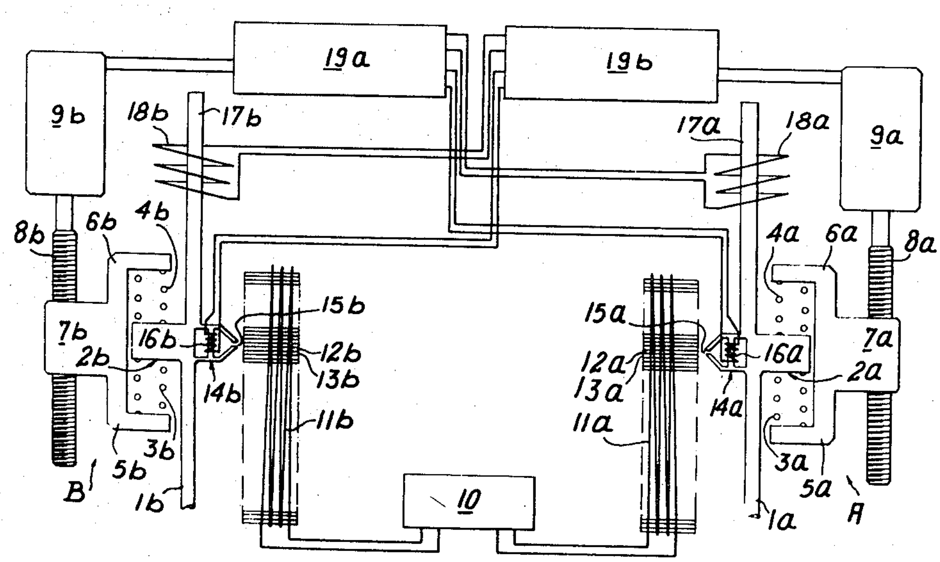
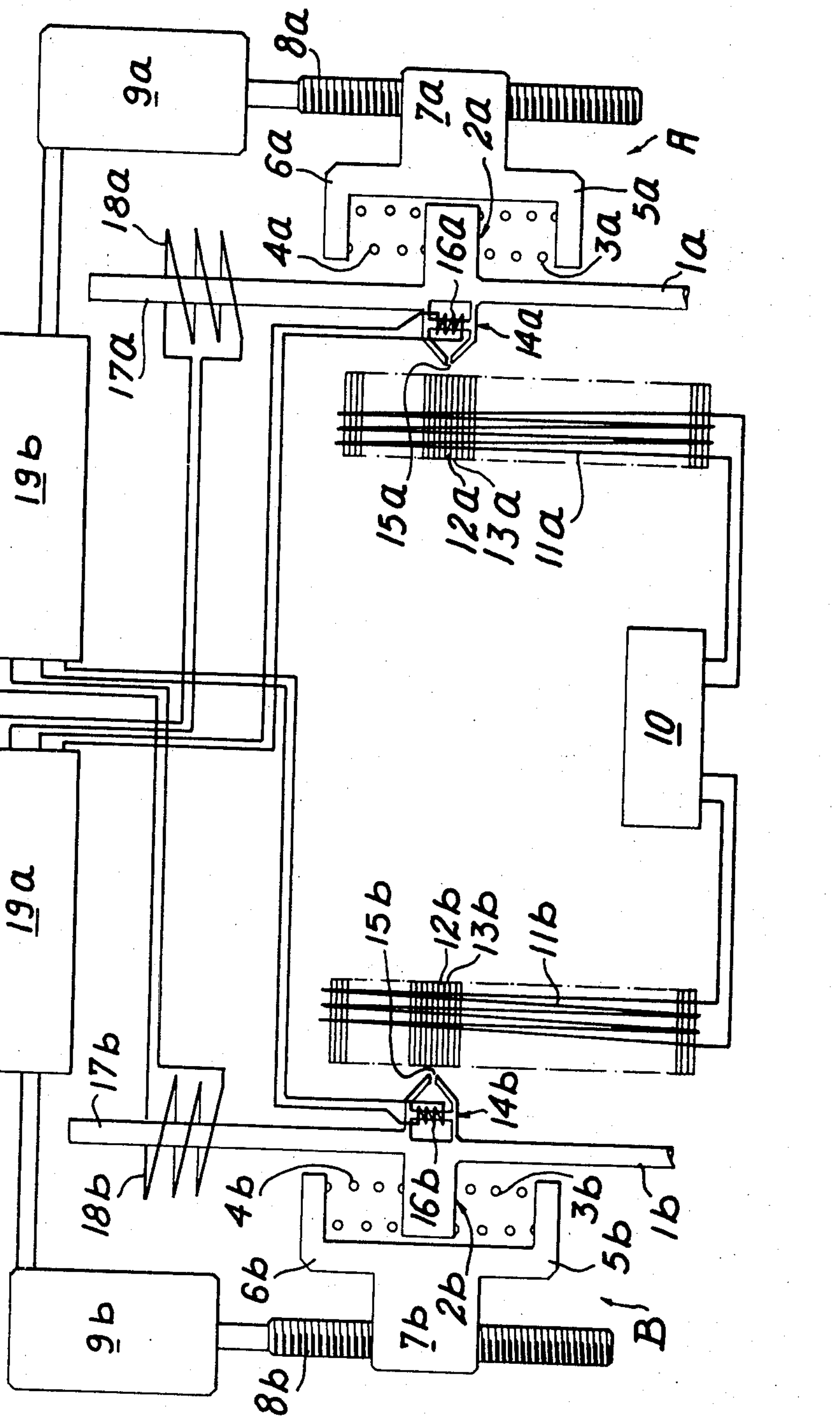
[57] **ABSTRACT**

In a device for the remote-controlled reciprocal emission, transmission and reception of mechanical information between two identical modules, each module comprises a position reader provided with a movable index which converts into successive electrical pulses an item of mechanical information relating to the motion of an actuating member which is associated with the index, a calibrated-compression spring mounted between a supporting carriage and the index so as to compress said spring, a mechanism for controlling the displacement of the supporting carriage parallel to the movement of the index and an indicator for indicating the direction of said movement, the mechanism for controlling one of the modules being actuated by the position reader and direction indicator which are associated with the other module and conversely while causing the displacement of the corresponding supporting carriage so that the initial elongation of the spring should tend to be restored.

14 Claims, 7 Drawing Figures





9a
8a
7a
2a
6a
A
5a
18a
4a
16a
3a
1a
17a
14a
19b
15a
12a
13a
11a
10
19a
15b
12b
13b
11b
17b
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16b
3b
1b
6b
2b
5b
9b
7b
B
8b

FIG.1

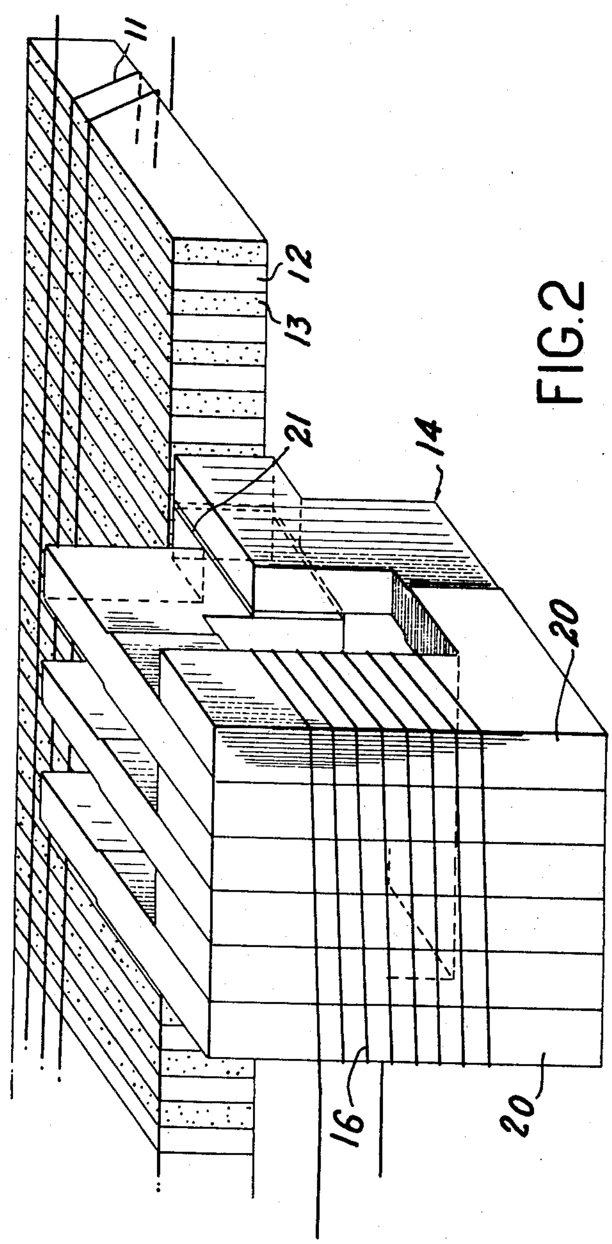
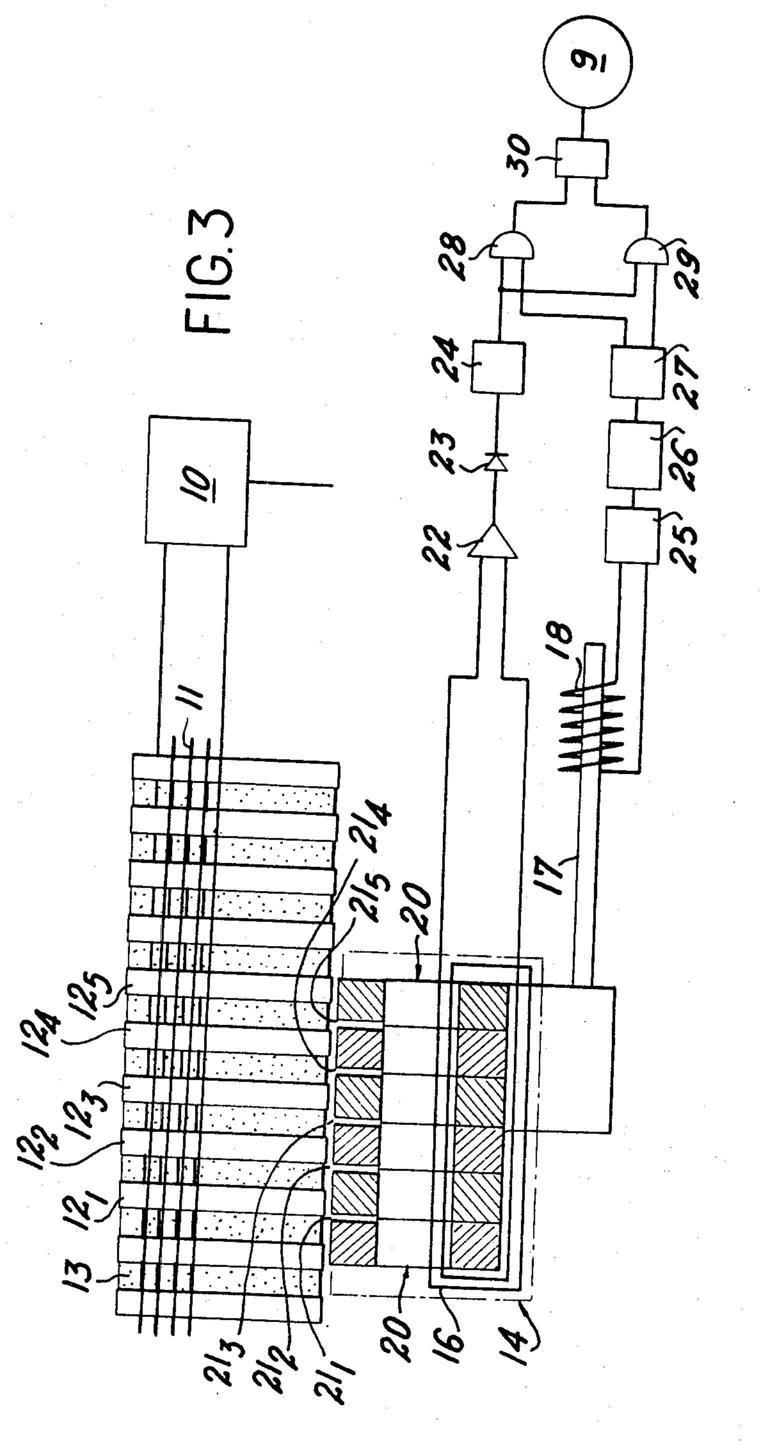


FIG.2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10
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13
12_1
12_2
12_3
12_4
12_5
14
16
17
18
20
21_1
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21_3
21_4
21_5
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FIG. 3

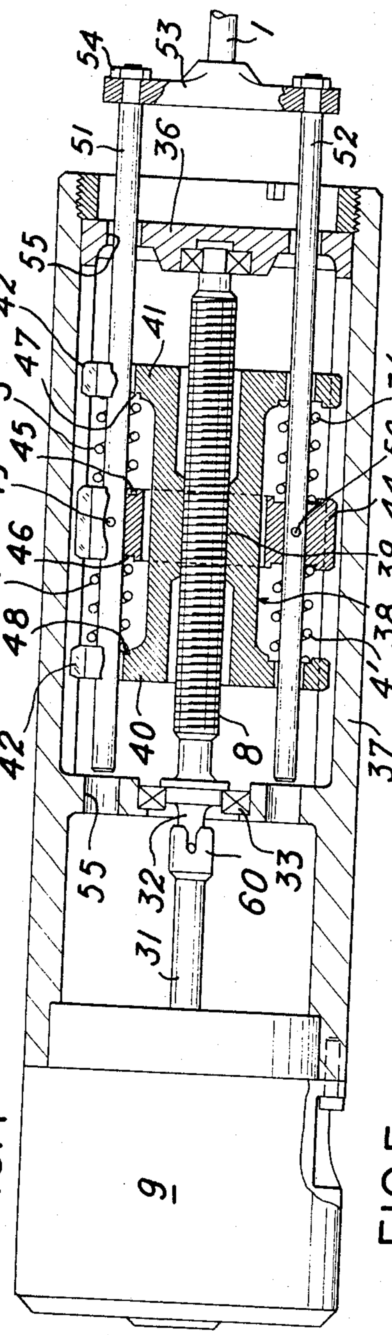


FIG.4

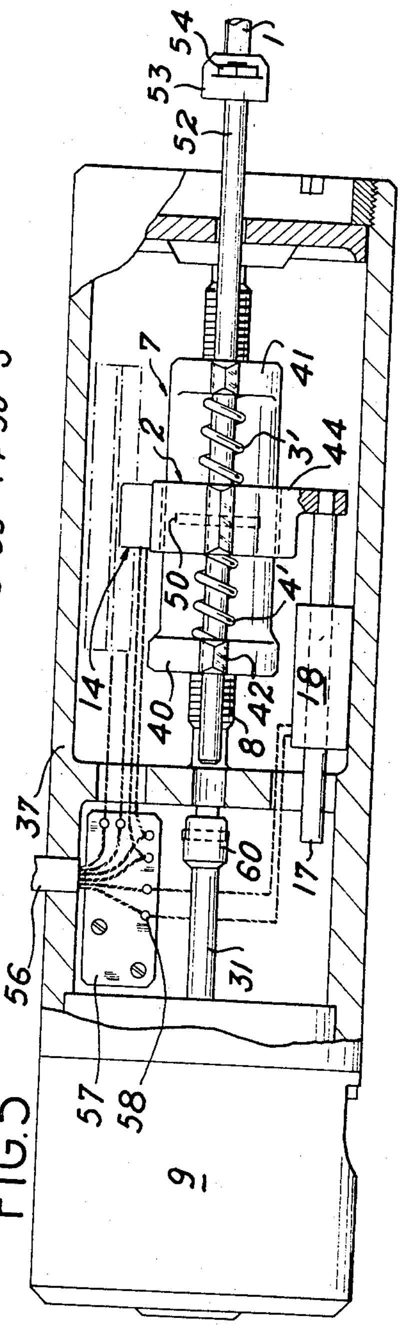


FIG.5

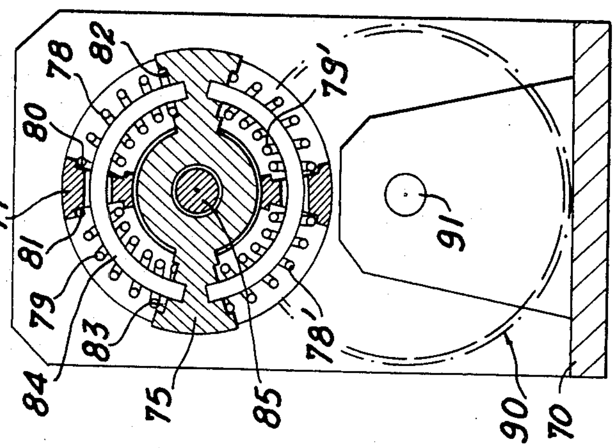
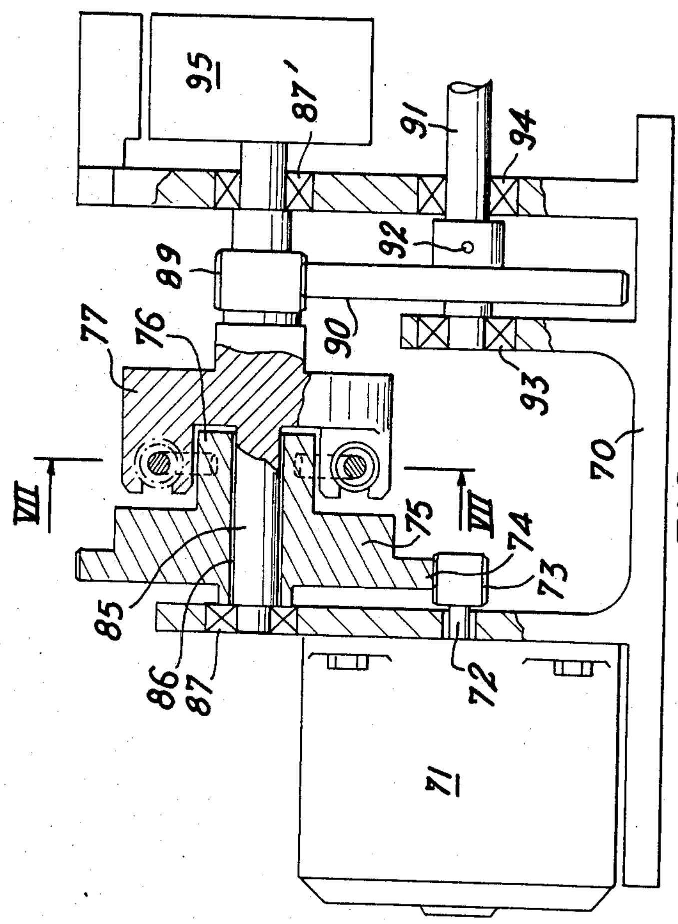

77
78
80
82
79'
81
79
83
84
75
85
78'
91
90
70

FIG. 7


95
87'
91
94
92
89
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77
76
93
70
VIII
VIII
75
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87
72
71

FIG. 6

DEVICE FOR REMOTE-CONTROLLED RECIPROCAL EMISSION, TRANSMISSION AND RECEPTION OF MECHANICAL INFORMATION

This invention relates to an electromechanical device for the remote-controlled emission, transmission and restitution of mechanical information in which said device essentially comprises two identical modules for carrying out simultaneously and towards each other the emission and/or reception of information which is received by each module separately.

The invention applies more particularly in a device of this type to the transmission of information corresponding to a one-to-one displacement of a master element to a slave element which is designed to reproduce the movements of the master element ; the module which is associated with said master element effects the transmission of movement information to the module of the slave element which checks said information and transfers back towards the module of the master element the information resulting from the displacement proper of the master element. In other words, the device under consideration carries out not only a transmission of information from the master element to the slave element but returns said information from the slave element to the master element, said information being modified if necessary by the conditions of motion of said master element in its own medium, while thus providing the master element with a controlled return of sensitivity in the displacement of the slave element.

To this end, the device under consideration is characterized in that each module comprises a position reader provided with a movable index which converts into successive electrical pulses an item of mechanical information relating to the motion of an actuating member which is associated with said index, a flexible calibrated-compression component mounted between a supporting carriage and said index so as to compress said flexible component, a mechanism for controlling the displacement of said supporting carriage parallel to the movement of the index and a direction indicator for indicating the direction of said movement, the mechanism for controlling one of the modules being actuated by the position reader and direction indicator which are associated with the other module and conversely while causing the displacement of the corresponding supporting carriage so that the initial elongation of the flexible element should tend to be restored.

In one embodiment of the invention, the mechanism for controlling each module comprises a precision worm-screw which cooperates with a nut carried by the supporting carriage and is driven in rotation by a stepping motor, the thread of the worm-screw and the steps of the motor being selected so as to ensure that the displacement of the supporting carriage in respect of one step of the motor should be substantially equal to the displacement of the movable index of the position reader between two successive pulses.

According to a further characteristic feature, the position reader comprises an inductive circuit constituted by a fixed winding which is wound around a stack of identical and parallel magnetic laminations separated by insulating strips and extending in planes at right angles to the direction of displacement of the movable index, and an induction head carried by said movable index and comprising at least one magnetic element fitted with an induction coil, said magnetic element being provided with a discontinuity forming an air-gap which is intended to move in the immediate vicinity of the stack of magnetic laminations. As an advantageous feature, the laminations of the inductive circuits are equal in thickness to the insulating strips provided between the successive laminations, the induction head being made up of a plurality of adjacent magnetic elements each having an air-gap, the distance between two air-gaps within two adjacent elements being in a simple ratio with respect to the distance between two laminations in the inductive circuit.

According to yet another characteristic feature of the invention, each module comprises within an external protective casing antifriction bearings for centering and supporting the worm-screw in the axis of the casing whose end-walls support the stepping motor for actuating said worm-screw, and a moving weight-head which constitutes the index of the position reader, said weight-head being capable of sliding freely over a bushing of the supporting carriage and provided in the opposite faces thereof with bearing recesses for the ends of calibrated springs which are stressed solely in compression and the other ends of which are applied against two transverse shoulders formed on the bushing.

The reader-actuating member can consist in particular of at least one control tie-rod which passes through the springs of the weight-head and the shoulders of the bushing, said tie-rod being provided with an extension outside the outer casing. Nevertheless, in order to balance the force applied to the weight-head on each side of the worm-screw, said weight-head is preferably rigidly fixed to two parallel actuating tie-rods associated with four springs arranged in opposition in pairs on a common tie-rod and stressed in compression simultaneously in pairs. Finally, in order to ensure guidance of the supporting carriage within the interior of the outer casing, the transverse shoulders of the bushing are preferably provided with projecting portions having the shape of triangular prisms in which the external edges located in a plane which passes through the axis of the worm-screw engage in longitudinal grooves provided in the internal surface of the casing.

Further characteristic features of the device under consideration will become apparent from the following description of two exemplified embodiments which are given by way of indication without any implied limitation, reference being made to the accompanying drawings, wherein :

FIG. 1 is a general view of the device in which the two modules employed and their relative connections are illustrated diagrammatically ;

FIG. 2 is a view in perspective showing a particular embodiment of position reader of one of the modules ;

FIG. 3 is a more diagrammatic view of the same reader, of the direction indicator and of the associated electronic circuits ;

FIGS. 4 and 5 are views respectively in cross-section and in elevation showing a mechanical embodiment of one of the modules ;

FIGS. 6 and 7 are views respectively in elevation and in cross-section taken along line VII—VII of FIG. 6 and showing another embodiment.

In the first example which is described hereinafter, consideration is given to the case of transmission and controlled reception of mechanical information corresponding to a rectilineal displacement from any given master element to a slave element which is intended to reproduce the movements of said master element and to transfer back to this latter information representing the actual movement of said slave element within the medium of this latter and especially information corresponding to braking, locking or conversely to an acceleration, thereby obtaining a continuously controlled return of sensitivity in the master element which is located at a distance from the slave element. According to the invention, the device essentially comprises two identical modules which are designated respectively by the references A and B, the module A being assumed to be associated with the master element and the module B being assumed to be associated with the slave element. In the following description, the components of the module A will be designated by a numeral to which is assigned the index *a*, it being understood that provision is also made in the module B for identical components which are followed in this case by the index *b*.

The module A comprises an actuating member which is represented diagrammatically in the drawings by a rod **1***a* and capable of undergoing a displacement along its axis in one-to-one correspondence. Said rod **1***a* is joined to a position reader comprising a movable index **2***a* associated with two springs which are subject to accurately calibrated compression and respectively designated by the references **3***a* and **4***a*, said springs being mounted so as to bear at one end on the index **2***a* and at the other end on two transverse shoulders **5***a* and **6***a* of a support **7***a* which will be designated hereinafter as a carriage. Said carriage is provided with a nut in cooperating relation with a worm-screw **8***a* having a precision thread and extending parallel both to the rod **1***a* and to the axis of the springs **3***a* and **4***a*. Said worm-screw **8***a* is rigidly fixed to the output shaft of a stepping motor **9***a* of conventional type, namely a motor which is so arranged that a suitable electric pulse should control the rotation of said motor through a given fixed angle without overshoot or oscillations, said angle of rotation being exactly reproducible as each control pulse is applied to the motor windings.

The position reader of the module A comprises in addition to the movable index **2***a* an electromagnetic unit whose precise function is to permit the possibility of measuring the displacements of said index and converting these latter into a series of electrical pulses which are capable of initiating the rotation of the stepping motor of the other module in the manner which was explained earlier after said pulses have been suitably shaped and amplified. Said electromagnetic unit is composed of an electric supply **10** for a winding **11***a* of a fixed inductive circuit constituted by a stack of magnetic laminations **12***a* which are separated from each other by insulating strips **13***a*. As a preferable feature and as will be explained in greater detail with reference to FIGS. **2** and **3**, the laminations **12***a* (or **12***b*) of the inductive circuits of the two modules are designed in the form of small elongated and parallelepipedal bars of magnetic material which produce as a result of the induction set up by the flow of current through the winding **11***a* (or **11***b*) a magnetic field in which the lines of flux extend substantially in planes at right angles to the rod **1***a* (or **1***b*) and consequently at right angles to the direction of displacement of the movable index **2***a* (or **2***b*). The laminations **12***a* (or **12***b*) preferably have a given thickness which is chosen so as to be equal to the thickness of the insulating strips **13***a* (or **13***b*) which serve to separate said laminations.

The movable index **2***a* is provided opposite to the laminations **12***a* of the fixed inductor with a magnetic element **14***a* of the same type as a magnetic reading head and designed in the form of a ring which is completely closed except for a discontinuity **15***a* which forms a very narrow air-gap. A winding **16***a* which constitutes an induction coil is wound onto the element **14***a* and an electrical pulse induced by the fixed inductor is developed within said winding as the gap **15***a* passes through a region of the inductor each time the direction of the magnetic field is reversed. In fact, when the gap **15***a* is located exactly opposite to any one lamination **12***a*, the magnetic element **14***a* is subjected to the field produced by said lamination ; no appreciable current flows through the coil **16***a* since the flux variation within the element **14***a* is negligible. On the other hand, as soon as the gap **15***a* reaches the end of the same lamination **12***a*, a portion of the element **14***a* is accordingly placed in front of an insulating strip **13***a* and in a field of opposite sign by virtue of the gap **15***a*. The resultant variation in flux in the coil **16***a* induces within this latter an electrical pulse which is more clearly defined as the gap **15***a* is narrower. Similarly, a new pulse which is opposite in sign to the preceding will be developed as the index **2***a* continues its displacement and when the gap **15***a* accordingly reaches the end of the following lamination **12***a* and so forth.

It is therefore apparent that the position reader which is constituted by the movable index **2***a*, the field winding **11***a*, the magnetic laminations **12***a*, the head **14***a* and the induction coil **16***a* produces a series of alternate pulses each time the gap **15***a* passes in front of a lamination or an insulating strip. Since these two components have the same design thickness, all the pulses produced will therefore be separated by the same interval which will be adopted hereinafter as a unit of reference for the displacement of the actuating rod **1***a*. In point of fact, since each suitably shaped pulse is intended to initiate a one-step rotation of the motor **9***b* which is associated with the other module, the thread of the worm-screw **8***b* is chosen in such a manner that the displacement of the carriage **7***b* which is produced as a result of rotation of said worm-screw should itself be substantially equal to the distance of displacement of the movable index between two successive pulses. Thus and by way of non-limitative example, if the selected reference distance between the points of delivery of two pulses by the position reader is equal to one one-hundredth mm, it will be possible by way of example to make use of a commercially available stepping motor in which the angle of rotation in respect of each one-step displacement is 3°45′, which corresponds to a total of 96 steps for each complete revolution. If the worm-screw **8** is in turn provided with a helical thread having a pitch of 1 mm, it is apparent that each angular displacement of the motor will result in forward motion of the carriage **7** which is engaged with the worm-screw over a distance of one ninety-sixty mm, namely a value which is substantially equal to the reference value of one one-hundredth mm.

The electrical pulses produced within the induction coil 16a of the module A as a result of a displacement of the index 2a under the action of the actuating rod 1a are transmitted to an electronic circuit for shaping said pulses which receives at the same time a complementary item of information indicating the direction of displacement of the index, depending on whether the rod 1a compresses either of the two springs 3a or 4a. In the simplest form of construction, said direction indicator is formed by means of a magnetic rod 17a which is rigidly fixed to the index 2a and is capable of moving along the axis of a coil 18a while inducing within this latter a current whose phase is representative of the direction of displacement of said rod and consequently of the movable index.

The electrical pulses delivered by the position reader and the output signal of the direction indicator are processed in a rectifying and amplifying unit 19a which will be described in greater detail with reference to FIG. 3 and the output of which supplies the motor 9b of the module B. At the same time, the position reader and the direction indicator of the module B effect the control of the motor 9a, the two corresponding circuits being of strictly identical design.

The operation of the device according to the invention can now be briefly explained in relation to the foregoing description and to the diagram of FIG. 1 which illustrates the principle of the essential elements and of their connections :

If a tractive force, for example, is applied to the actuating rod 1a in the downward direction with reference to the figure and initiates the displacement of the index 2a over a given distance, the spring 3a is put in compression since the carriage 7a remains motionless on the worm-screw 8a. This displacement of the index 2a produces at the same time one or a number of electrical pulses within the induction coil 16a, the number of pulses being dependent on the distance of displacement of the index 2a. It will be assumed hereinafter that said displacement corresponds to the delivery of a single pulse. This pulse is shaped and amplified in the circuit 19a and accordingly initiates a single-step rotational displacement of the motor 9b in the suitable direction which results in a movement of rotation of the worm-screw 8b and this latter accordingly displaces the carriage 7b in the direction of motion of the actuating rod 1a, that is to say in this case towards the bottom of the drawing. This control of the correct direction of rotation of the motor 9b is ensured by the signal emitted by the direction indicator of the module A which comprises the rod 17a and the coil 18a.

Rotation of the worm-screw 8b which is thus initiated is accompanied by the displacement of the carriage 7b over a distance which corresponds substantially to the interval between two successive pulses in the case of the movable index of the position reader if the choice of the number of steps of the motor and of the screw-thread is correct. The displacement of the carriage 7b is accompanied by the displacement of the index 2b by means of the spring 4b and consequently of the rod 1b, the index 2b being transferred under these conditions in front of the laminations 12b of the fixed inductor of the module B over the distance thus defined. This transfer motion in turn induces an electrical pulse within the induction coil 16b, said pulse is shaped and amplified in the circuit 19b and in turn initiates rotation of the motor 9a in the appropriate direction. The single-step rotation of said motor and of the worm-screw 8a causes the displacement of the carriage 7a, thereby releasing the spring 3 a which is restored to its initial elongation. The rod 1b has therefore been accurately re-set in opposite relation to the rod 1a and the foregoing demonstration can subsequently be repeated irrespective of the amplitude and direction of displacements of said rods.

The case of an obstacle to the displacement of the rod 1b which is consequently locked in position and the consequential effect on the actuating rod 1a can accordingly be postulated. If the rod 1b is locked in position, the displacement of the carriage 7b results in compression of the spring 4b over the corresponding distance. A further tractive force which is then applied to the rod 1a again compresses the spring 3a and, in accordance with the process already explained, causes a single-step rotation of the motor 9b and consequently a further compression of the spring 4b which is added to the previous compression and so forth. It is then found that the tractive force applied to the rod 1a is equal to the compression of the spring 4b. The resistance which is set up by the obstacle and prevents displacement of the rod 1b as measured by the identical compressions of the springs 3a and 4b can thus be accurately observed by the user as he displaces the rod 1a. Similarly, in the case of the rod 1a, it can readily be demonstrated that the user will observe any effect of dynamic resistance which is set up by said rod and prevents the corresponding displacement of the rod 1b. Under these conditions, any action which prevents or is added to the action produced on the rod 1b as a result of displacement of the rod 1a causes a relative compression of one of the springs 3b or 4b and modifies the displacement of the movable index 2b with respect to the displacement of the carriage 7b ; the response of the position reader of the module B as converted into electrical pulses then gives rise in the module A to a similar compression of the springs 3a or 4a, thereby transferring to the rod 1a the sensitivity of movement of the rod 1b.

It is wholly evident that the operation of the device as has been brought out by the foregoing explanations would not be modified to the least extent in the event that the two modules A and B which remain identical both in structural design and practical application were to have a given ratio of proportionality with respect to each other. In particular, if the springs 3a and 4a of the module A which is considered as the master module and the springs 3b and 4b of the module B which is considered as the slave module are in a given calibration ratio, the force exerted by the actuating rod 1a will accordingly be multiplied by the same ratio in the rod 1b. Since these position readers which produce action on the driving motors in fact only take linear displacements into account, two different forces will be obtained in respect of two similar displacements. Similarly, it can readily be appreciated that the modules could be so designed that different displacements which nevertheless remain in a previously determined ratio should correspond to identical forces.

FIG. 2 shows in perspective and on a larger scale one particular embodiment of the position reader as employed in the modules A and B described above. The stacked parallelepipedal magnetic laminations 12 separated by insulating strips **13** having the same thickness are again shown in this figure, the complete assembly being surrounded by the field winding **11**. The magnetic element **14** and its induction coil **16** are capable of displacement in front of the above-mentioned assembly which constitutes the fixed inductor of the reader, said magnetic element being rigidly fixed to the movable index and formed by assembling together thin bars **20** which have complementary profiles and which are placed in adjacent relation. Separations **21** which form air-gaps of the magnetic circuit are placed between said thin bars in front of the laminations **12** and are each fabricated from a thin sheet of non-magnetic material, especially gold foil. In the example shown, the magnetic element **14** which forms the reading head is made up of six thin bars **20** and five separations or air-gaps **21** between said thin bars.

FIG. 3 accordingly shows the manner in which the magnetic laminations **12** and their insulating strips **13** are placed in oppositely facing relation to the thin bars **20** and their air-gaps **21**. The thickness of the thin bars **20** is advantageously chosen in a given simple ratio with respect to the thickness of the magnetic laminations **12** in such a manner that the displacement of the movable index **2** of the reader which is necessary for obtaining an electrical pulse within the coil **16** should be smaller than the thickness of each lamination **12** but also in the same ratio. If the laminations **12** in fact have a thickness of five one-hundredths mm which appears technologically to constitute a lower limit, the thin bars **20** will have a thickness of nine one-hundredths mm whilst the width of the air-gaps **21** is negligible. In fact, under these conditions, a displacement of the movable index over a distance of one one-hundredth mm which is taken as a reference will be sufficient to produce an electrical pulse within the induction coil **16**. As can in fact be seen from FIG. 3, five successive laminations **12** are designated by indices ranging from 1 to 5 whilst the six opposite thin bars **20** have five air-gaps **21** which are also designated by indices from 1 to 5 ; if the initial electrical pulse accordingly corresponds to the reference displacement of one one-hundredth mm of the first air-gap 21_1 which passes into the field of the lamination 12_1, the second pulse will be obtained as a result of the following displacement of one one-hundredth mm, thereby causing the second air-gap 21_2 to enter the field of the lamination 12_2 and so on in the case of each reference displacement until the fifth pulse which is obtained as a result of penetration of the last air-gap 21_5 into the field of the lamination 12_5. However, since each lamination has a thickness of five one-hundredths mm, it is apparent that the sixth pulse will be produced in the case of the following reference displacement by the output of the first air-gap 21_1 of the field of the lamination 12_1 and so on up to the tenth pulse which is obtained from the output of the last air-gap 21_5 of the field of the lamination 12_5. The foregoing arrangement thus virtually constitutes a vernier and accordingly makes it possible to obtain pulses in respect of unitary or reference displacements which are appreciably smaller than the effective width of the laminations employed.

FIG. 3 also illustrates the detail of one of the electronic circuits **19** which is coupled with the induction coil **16** of the movable index **2** of the position reader of the associated module and with the corresponding direction indicator **17**, **18**. The pulses derived from the coil **16** are directed to an amplifier **22**, then from the output of said amplifier to a rectifier **23** and towards a shaping circuit **24**, with the result that said pulses finally have the shape of square waves having very steep leading edges. Similarly, the signal which is produced within the coil **18** as a result of displacement of the rod **17** is directed to a differential amplifier **25**, then towards a shaping circuit **26** and finally towards a bistable circuit **27** which initiates the opening of a gate **28** or **29**, thereby permitting the transmission of the electrical pulse having the shape of a square wave and delivered by the circuit **24** which in turn operates an assembly **30** so as to initiate and control the rotation of the motor **9** of the other module in the appropriate direction.

FIGS. 4 and 5 illustrate in sectional elevation one practical form of construction of one of the modules of FIG. 1. The shaft **31** of the stepping motor **9** is provided with a coupling **60** which is adapted to engage with the extremity of the worm-screw **8**. Said worm-screw is rotatably mounted in bearings **33** and **34** carried by housings **35** and **36** which are braced within an outer protective casing **37**. The supporting carriage **7** through which the worm-screw **8** passes comprises a longitudinal bushing **38** provided with a central internally threaded nut **39** and transverse annular end-shoulders **40** and **41**. Said annular shoulders are provided in their outer surfaces with projecting members **42** which have the shape of triangular prisms as shown more especially in FIG. 5 and the top edges of which are adapted to engage in longitudinal grooves **43** formed in the internal surface of the casing **37** in order to ensure longitudinal guidance of the carriage **7** ; the displacement of said carriage along the worm-screw **8** is controlled by rotation of said worm-screw which is driven by the motor **9**. A weight-head **44** which constitutes the index of the position reader and is intended to be employed in conjunction with the fixed inductive circuit as has been explained earlier is mounted on the bushing **38** and capable of sliding freely with respect to this latter. Recesses **45** and **46** are formed in the opposite faces of said weight-head in order to accommodate the two calibrated-compression springs **3** and **4**, the other ends of which are applied against the annular shoulders **40** and **41** of the carriage **7** within oppositely facing recesses **47** and **48**. Preferably and in order to balance the movable weight-head **44** more effectively with respect to the carriage **7**, the springs **3** and **4** are duplicated on each side of the bushing by two additional springs **3'** and **4'** as shown in FIG. 4. The springs **3** and **3'** on the one hand, **4** and **4'** on the other hand are simultaneously stressed in compression as a result of the relative displacements of the weight-head with respect to the bushing **38**. Finally, two tie-rods **51** and **52** which are parallel to each other and to the worm-screw **8** are fixed on the weight-head **44** by means of locking-pins **49** and **50**. Said two tie-rods serve to control the displacement of the weight-head while being secured externally of the casing **37** to a cross-member **53** by means of nuts **54**, said cross-member **53** being in turn rigidly fixed to the actuating rod **1** of the module considered. The bearing housings **35** and **36** as well as the shoulders **40** and **41** are provided with bores **55** for the insertion of the tie-rods **51** and **52**. There is also shown in FIG. **5** an electric cable **56** of the multiple conductor type for supplying the necessary current to the position reader and to the position indicator by means of terminals **57** which are provided on a connection plate or terminal strip **58**.

In the exemplified embodiment which has just been described, the member which serves to actuate the weight-head consists of at least one rod which is subjected to an axial movement so as to produce the compression of one or a number of springs which are mounted in parallel on the supporting carriage. However, in another alternative embodiment, it would be wholly feasible to replace said rod by a fly-wheel or the like so as to apply a torque to the driving member by means of a rack, a set of gears or any other means for transmission of motion to the weight-head, thereby putting the calibrated springs in compression in accordance with the same basic principle. In this case, said springs need no longer be disposed in axially aligned and opposite relation but along two opposite arcs having the same circumference. An alternative arrangement of this type is illustrated diagrammatically in FIGS. **6** and **7**.

As shown in these figures, each module of the device comprises a frame **70** on which is fixed a stepping motor **71**. The output shaft **72** of said motor carries a pinion **73** and this latter is disposed in meshing engagement with a set of teeth **74** formed at the periphery of a component **75** which performs the function of supporting carriage. Said component **75** has an extension **76** in the form of a tubular sleeve and a weight-head **77** is placed over said sleeve **76** and rotatably mounted thereon. As can be more readily seen from the sectional view of FIG. **7**, the weight-head **77** is associated with two springs respectively designated by the numerals **78** and **79** and having perfectly calibrated compression, said springs being positioned with respect to the weight-head by being engaged at one end in recesses **80** and **81** of this latter and by being applied at the opposite ends within two other recesses **82** and **83** which form part of the component **75**. The springs **78** and **79** are advantageously maintained in position with respect to the component **75** on the one hand and with respect to the weight-head **77** on the other hand by means of an arcuate guide rod **84** which is rigidly fixed to the component **75** and passes axially through the springs **78** and **79** and through a bore formed in the weight-head **77**. In addition, the springs **78** and **79** are preferably duplicated by two further springs **78'** and **79'** which are symmetrical with respect to the axis of the component **75**, said springs **78'** and **79'** being so arranged as to be subjected to compressive forces which are equal respectively to those applied to the springs **78** and **79** as a result of the relative displacements of the weight-head **77** with respect to the component **75**.

The weight-head **77** is rigidly fixed to a shaft **85** which passes through a bore **86** formed in the component **75** and is rotatably mounted in bearings **87** and **87'** which form part of the frame **70**. A spur pinion **89** which is disposed in meshing engagement with a toothed ring **90** is mounted on the shaft **85** on the other side of the weight-head **77**. Said toothed ring **90** is rigidly fixed to a shaft **91** by means of a locking-pin **92** ; said shaft **91** extends parallel to the shaft **85** and is mounted in bearings **93** and **94** which also form part of the frame **70**. Said shaft **91** extends towards the right-hand side of FIG. **6** in order to enable an operator who is actuating the module shown in the drawing to rotate said shaft and thus to carry out by means of the toothed ring **90** and the pinion **89** the relative rotation of the weight-head **77** and the compression of the springs **78** and **78'** or **79** and **79'** depending on the direction of said rotation. Finally, a device **95** of the selsyn motor type or the like is mounted on the extension of the shaft **85** on the other side of the bearing **87'** ; said device constitutes the position reader and the direction indicator for the displacement of the weight-head **77**. It is readily apparent that the other module which is associated with the module hereinabove described is constructed in an identical manner since it is intended in accordance with the invention to permit recopy of the movements of rotation of the driving shaft **91** and retransmission to this latter of the particular efforts which result from its own displacement, the displacement indications provided by the reader **95** of one of the modules being intended to produce action on the stepping motor of the other module and conversely.

The operation of the device in the alternative embodiment according to FIGS. **6** and **7** is exactly similar to the operation which was contemplated in the first embodiment. The rotation of the shaft **91** which constitutes the actuating member in this case causes displacement of the weight-head **77** and compression of one of the springs **78** or **79** while the position reader **95** delivers a series of electrical pulses at the same time. Said pulses are suitably shaped and in turn initiate rotation of the shaft of the stepping motor **71** of the associated module, thereby producing by means of the pinion **73** and the set of teeth **74** the displacement of the component **75** which forms a supporting carriage and the angular re-setting of this latter with respect to the weight-head, the springs **78** or **79** being restored to their initial elongations which may be modified by the actual conditions of displacement to which the shaft **91** of the other module is subjected. It is nevertheless wholly evident that the principle of operation of the device is not directly influenced by the particular arrangement of its components. In particular, the pinion **89** and the toothed ring **90** could readily be dispensed with and in this case the shaft **91** which constitutes the operating member produces action directly on the shaft **85** and the position reader **95**.

No matter what embodiment may be adopted, the assembly for transmission of mechanical information which is thus provided is particularly simple, reliable and well suited to problems of recopy of movements of a master element by a slave element. Said device can advantageously be employed in the field of application of either direct or radio-controlled remote manipulation facilities with return of sensitivity to the user who is operating the master element to which the slave element restitutes its own movement information arising either from the operation or from the medium of said slave element. However, other applications could also be contemplated, especially in the field of machines or toys which are remote-controlled either by means of direct or indirect mechanical linkages or by means of emission and reception of radiowaves. Similarly, consideration could be given to applications in the field of handling or earth-moving appliances, machine-tools or finally any simulation installation. The particular structure of the modules as hereinabove described could naturally be modified without changing the basic principle of operation. In particular, the springs of the modules could be replaced by any other flexible components having calibrated compression, especially by pneumatic capsules or even by blocks of material having suitably determined elasticity. Similarly, it is readily apparent that the position reader and direction indicator could be provided in accordance with modes of construction other than those contemplated in the foregoing ; in particular, it would be possible to employ a system of photoelectric cells which are carried by the movable index and intended to count lines which are cut on an oppositely facing stationary rule, a digital coder, a rotary transmitter or any other system for converting a displacement into electrical pulses. In particular, it would be possible to employ a potentiometric control system comprising a potentiometer which has a wholly linear response and the sliding contact of which is rigidly fixed to the movable index. The electrical voltage supplied between the sliding contact and one terminal of the potentiometer is calibrated or in other words is such that a repetitive variation in voltage by a given unit should correspond to each movement of the index or reference displacement, for example. It should be noted that the direction of this variation indicates ipso facto the direction of displacement of the movable index. Said variable voltage is passed into the associated electronic assembly which delivers to the control stepping motor the pulses which are necessary to reset the index of the reception module with respect to the function of the emission module or conversely in the manner which has already been indicated.

As has clearly been brought out by the foregoing, the invention is not limited in any sense to the examples which have been described with reference to the accompanying drawings but extends on the contrary to any or all alternative forms.

I claim

1. A device for the remote-controlled reciprocal emission, transmission and reception of mechanical information between two identical modules, wherein each module comprises a position reader provided with a movable index which converts into successive electrical pulses an item of mechanical information relating to the motion of an actuating member which is associated with said index, a flexible calibrated-compression component mounted between a supporting carriage and said index so as to compress said flexible component, a mechanism for controlling the displacement of said supporting carriage parallel to the movement of the index and a direction indicator for indicating the direction of said movement and mechanism for controlling one of said modules actuated by said position reader and by said direction indicator of the other of said modules and for causing the displacement of the corresponding one of said supporting carriages whereby the initial elongation of said flexible component is reduced.

2. A device according to claim 1, wherein the mechanism for controlling each module comprises a precision worm-screw which cooperates with a nut carried by the supporting carriage and driven in rotation by a stepping motor, the thread of the worm-screw and the steps of the motor being selected so as to ensure that the displacement of the supporting carriage in respect of one step of the motor should be substantially equal to the displacement of the movable index of the position reader between two successive pulses.

3. A device according to claim 1, wherein the position reader comprises an inductive circuit constituted by a fixed winding which is wound around a stack of identical and parallel magnetic laminations separated by insulating strips and extending in planes at right angles to the direction of displacement of the movable index, and an induction head carried by said movable index and comprising at least one magnetic element fitted with an induction coil, said magnetic element being provided with a discontinuity forming an air-gap which is adapted to move in the immediate vicinity of the stack of magnetic laminations.

4. A device according to claim 3, wherein the laminations of the inductive circuit are equal in thickness to the insulating strips provided between the successive laminations, the induction head being made up of a plurality of adjacent magnetic elements each having an air-gap, the distance between two air-gaps within two adjacent elements being in a simple ratio with respect to the distance between two laminations in the inductive circuit.

5. A device according to claim 1, wherein the position reader is constituted by a potentiometric control system in which the sliding contact is rigidly fixed to the movable index.

6. A device according to claim 1, wherein the position reader is constituted by a graduated rule in which the lines are counted by a photoelectric cell carried by the movable index.

7. A device according to claim 1, wherein each module comprises within an external protective casing antifriction bearings for centering and supporting the worm-screw in the axis of the casing whose end-walls support the stepping motor for actuating said worm-screw and a moving weight-head which constitutes the index of the position reader, said weight-head being capable of sliding freely over a bushing of the supporting carriage and provided in the opposite faces thereof with bearing recesses for the ends of calibrated springs which are stressed solely in compression and the other ends of which are applied against two transverse annular shoulders formed on the bushing.

8. A device according to claim 7, wherein the reader-actuating member is constituted by at least one control tie-rod which passes through the springs of the weight-head and the annular shoulders of the bushing, said tie-rod being provided with an extension outside the outer casing.

9. A device according to claim 7, wherein the weight-head is rigidly fixed to two parallel actuating tie-rods associated with four springs which are arranged in opposition in pairs on a common tie-rod and stressed in compression simultaneously in pairs.

10. A device according to claim 7, wherein the transverse annular shoulders of the bushing are provided with projecting portions having the shape of triangular prisms in which the external edges located in a plane which passes through the axis of the worm-screw are adapted to engage in longitudinal grooves formed in the internal surface of the casing.

11. A device according to claim 1, wherein the direction indicator is constituted by a magnetic rod joined to the movable index and capable of displacement within an induction coil.

12. A device according to claim 1, wherein each module comprises opposed calibrated springs mounted between a weight-head which is capable of moving about a shaft and a component which forms a supporting carriage, said springs being disposed along two arcs having the same circumference which is centered on the axis of the weight-head, the driving member being directly or indirectly connected to said weight-head and to a position reader so as to initiate rotation of said weight-head about its axis.

13. A device according to claim 12, wherein the component which forms a supporting carriage comprises an external set of teeth in cooperating relation with a pinion and said pinion is rigidly fixed to the shaft of a stepping motor which constitutes the control mechanism.

14. A device according to claim 12, wherein the position reader is constituted by an electromagnetic transmitter of the selsyn motor type.

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