

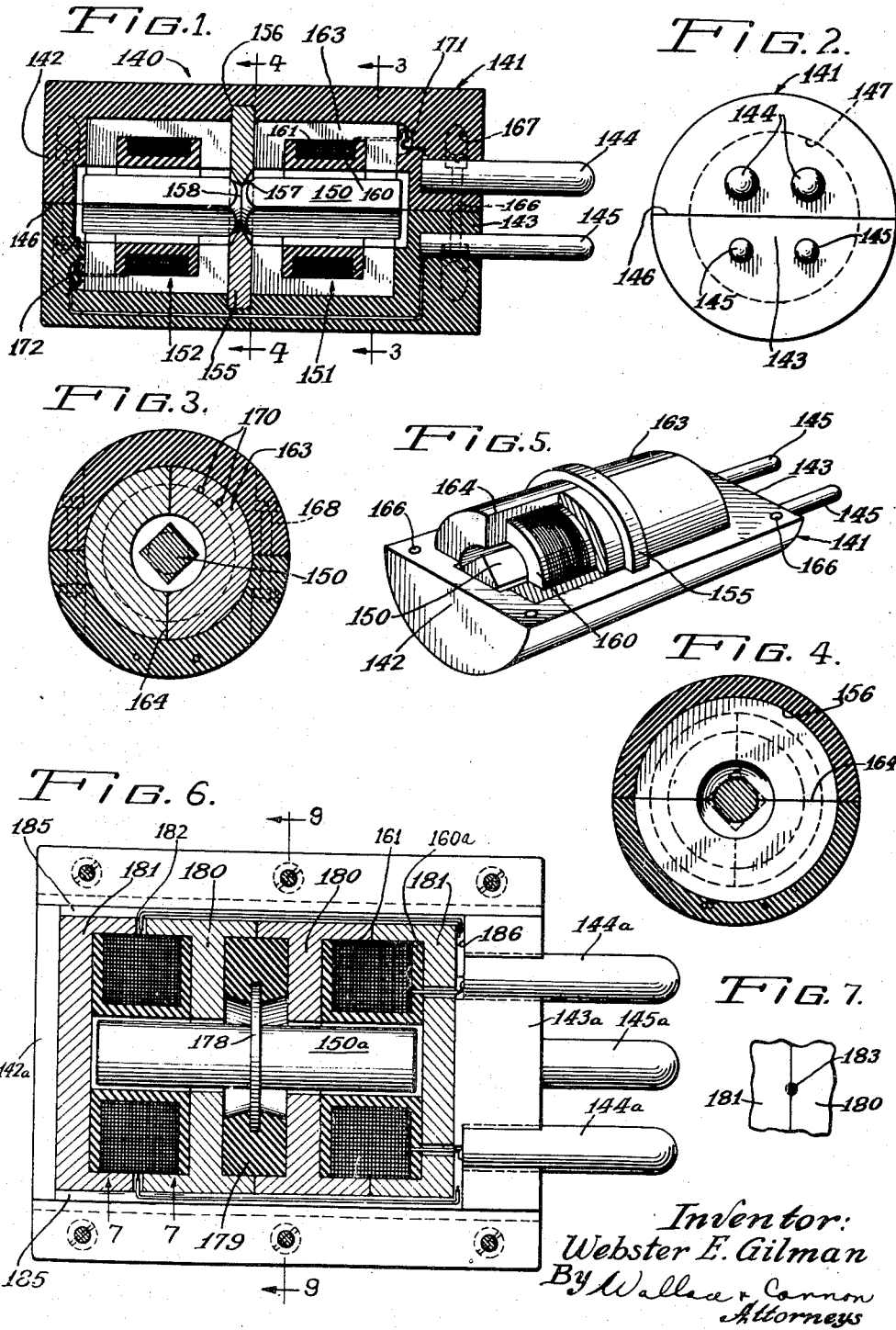
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2,433,898

MAGNETOSTRICTIVE VIBRATOR UNIT

Original Filed Nov. 23, 1942 2 Sheets-Sheet 1

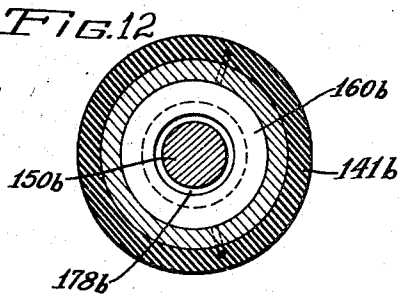
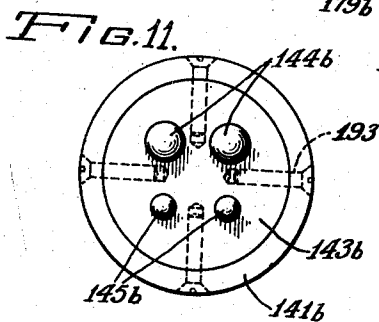
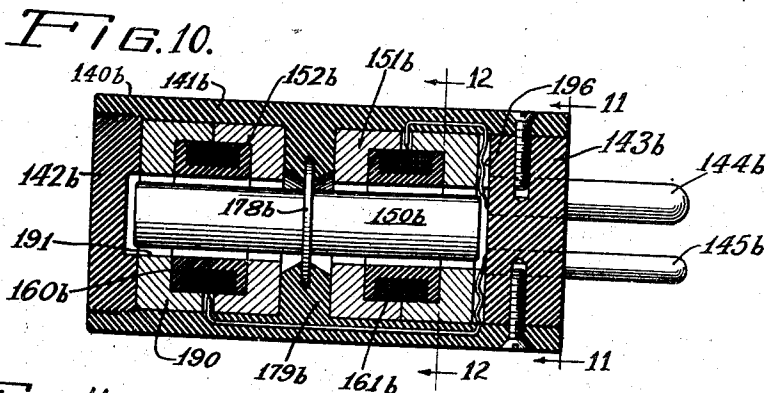
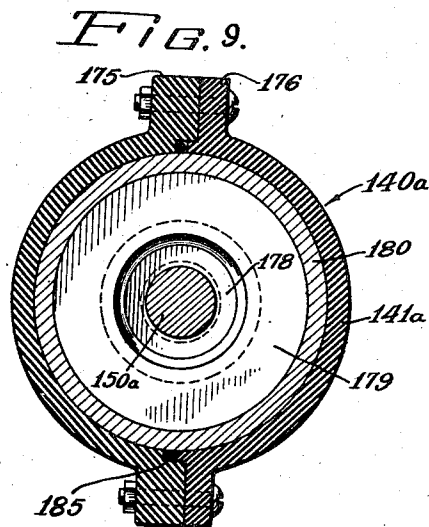


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MAGNETOSTRICTIVE VIBRATOR UNIT

Original Filed Nov. 23, 1942 2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

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MAGNETOSTRICTIVE VIBRATOR UNIT

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Original application November 23, 1942, Serial
No. 466,560. Divided and this application Feb-
ruary 1, 1946, Serial No. 644,793

13 Claims. (Cl. 171-777)

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This application is a division of my copending application Serial No. 466,560 filed November 23, 1942, now abandoned.

High frequency electrical oscillations are utilized in many instances in most of which it is usually desirable that the frequency be accurately controlled so as to avoid undesired variation in such frequency, this accuracy or control being necessary in order that the desired result may be accomplished and in order to prevent interference with other types of electrical apparatus. One such use of accurately controlled high frequency electrical oscillations is found in the communications field, as for example, in carrier wave radio transmission. In such instances it is necessary that the frequency of the electrical oscillations which provide the carrier wave be accurately controlled in order that optimum reception of the signal may be attained and in order that interference may be avoided with other channels of communication employing other carrier waves which are relatively close thereto in a frequency sense. Such accuracy of control, or stability of the frequency of a carrier wave is in most instances attained through the use of crystal oscillators which depend for their accuracy of frequency control upon the use of piezo-electric crystals which are incorporated in a controlling relation with an oscillator such as an electron tube.

Where the desired frequency is relatively high and relatively few frequencies are to be afforded, such crystal oscillators, having an individual crystal for each frequency, provide an effective means for attaining the desired result, but it is well-known that the production of the relatively large crystals required to afford relatively low frequencies is impractical and costly, and in addition, such crystals are subject to objectionable heating and cracking under many conditions of use. As a result it has been common practice heretofore to utilize a crystal oscillator for producing a relatively high frequency and to afford still higher frequencies through the use of one or more frequency-doublers in association with the output of such a high frequency crystal oscillator.

The use of frequency doublers in association with a relatively low frequency crystal oscillator has also enabled a plurality of fixed or accurately controlled frequencies to be afforded, as for example, in a multi-band radio transmitter, but since an electron tube is desirable in each such frequency doubler, the number of different frequencies which may be thus afforded is, in a practical sense, quite limited. Moreover, since prac-

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tical considerations of cost and size which dictate the use of a crystal which affords a relatively high fundamental frequency, the resort to one or more frequency doublers is also found to be objectionable in most instances because of the wide band spacing of the different frequencies produced. In view of this objection, resort is often had to the use of a relatively large number of different crystals in association with the electron tube of an oscillator, thereby to enable a different frequency to be attained for each such crystal, and through the provision of suitable switching means the user has been able to change selectively from one frequency to another with relative ease. Such use of a plurality of selectively operative control crystals may serve, of course, to afford a plurality of different frequencies having a relatively close band spacing, but the added cost and difficulties of upkeep are in many instances considered to render such an expedient objectionable.

With the foregoing arrangements, however, it has been found that there are many practical objections, for where frequency doublers are employed there is an undue multiplication of relatively large elements of the apparatus, while in the use of a plurality of crystals in connection with the oscillator, the relatively high cost of such crystals and the difficulty of obtaining, grinding and mounting such crystals has been considered to be objectionable. Moreover, with respect to use of crystals, it has been found that the relatively delicate character of the crystals had made the upkeep of such oscillators extremely difficult, particularly in those instances where the equipment was subjected to rough handling or to extreme variations in temperature or weather conditions.

In the construction of most types of crystal oscillators it is customary to utilize an electron tube which produces the desired fundamental wave with but few harmonics, but in certain instances crystal oscillators have been constructed so as to embody an electron tube having a relatively high harmonic output in at least certain of the harmonics of the fundamental frequency determined by the control crystal of the oscillator. In harmonic-generating crystal oscillators as heretofore used it has been possible to obtain a sufficiently high power output at least certain of the lower harmonics to enable this output to be utilized as a control frequency. In such harmonic generating crystal oscillators, however, it has been recognized that the power output in the even harmonics has been relatively low, and in fact, has been so low that it has been customary to uti-

lize only the odd harmonics. Such harmonic-generating crystal oscillators have in most instances been considered impractical for use where a plurality of different and readily available frequencies were to be afforded for with such oscillating systems the change from one harmonic to another has required accurate readjustment of the grid tank circuit as well as adjustment of the characteristics of the plate circuit.

Thus, in view of the foregoing, it will be evident that the possibility of selectively utilizing different harmonics of a complex fundamental wave has been recognized, and another instance where such use has been attempted is found in studies and development which have heretofore been carried out with respect to the use of magnetostrictive vibrators for the control of an electrical oscillating circuit. It has heretofore been recognized that magnetostrictive vibrators, when used to stabilize an electrical oscillator have produced a complex wave, but heretofore there has been no practical application or use of harmonics of such a complex wave to afford a readily available source of a plurality of different electrical frequencies. Efforts have been made to filter out and amplify one or more selected harmonics of a complex wave such as that produced by a magnetostrictively controlled oscillating system, but such efforts have involved undue multiplication of the relatively large elements of the apparatus so that such expedients have been objectionable in the same respect as those devices which employed frequency doublers.

In my aforesaid copending application I have disclosed means whereby relatively high frequency electrical oscillations may be produced and accurately controlled in a new and improved manner such that the intensity of such high frequency electrical oscillations is sufficiently high to enable effective use thereof in commercial apparatus such as radio transmitters and receivers, and in accordance with the disclosure of such copending application the even as well as the odd harmonics of a fundamental wave may be utilized, and other highly desirable objectives may be attained such as the production of a plurality of stable frequencies by simple means particularly suited to the attainment of a close band spacing between such frequencies, and the production of a relatively large number of stable high frequency electrical oscillations through the use of but a single control element rather than through the use of a plurality of such control elements as has been necessary where resort was had to an individual crystal for each desired frequency.

The present invention is related particularly to a magnetostrictive vibrator element or unit adapted for use in oscillator systems such as those disclosed in my aforesaid copending application, and the primary object of the present invention is to afford a new and improved magnetostrictive vibrator unit.

In prior electrical oscillators it is recognized that undesired variations in the circuit components, whether introduced in the initial construction by poor workmanship or excessive manufacturing tolerances, by weather conditions encountered in use, or by other causes, often result in undue and objectionable variation or instability in the output frequency or frequencies, and it is therefore a further object to minimize the effect of such variations of the circuit components of an oscillator upon the stability of the output thereof. More specifically, it is an object of this invention to afford a magnetostrictive

vibrator for use as the control element of an oscillator that the magnetostrictive vibrator will dominate the oscillating action despite wide variations in the circuit components of the oscillator; and a related object is to afford such a magnetostrictive vibrator that will effectually increase the tolerances permissible in manufacture and upkeep of the oscillator and the various circuit components thereof.

A further object is to reduce the cost and complexity of multi-band or multi-frequency oscillating systems as well as of other electrical systems; and an object related to the foregoing is to enable the frequency in such multi-band or multi-frequency oscillating systems to be stabilized by a single control element which is adapted to be made with ordinary production tools and to be formed with such tools with a degree of accuracy such that the variations in size within normal working tolerances will produce frequency stability within the permissible range of variations thereof.

Another object of this invention is to enable multifrequency oscillating systems to produce properly stabilized electrical frequencies despite ordinary commercial variations in the elements thereof such as electron tubes, resistors, condensers, battery voltage and the like; and an object related to the foregoing is to enable multifrequency oscillating systems to function in such a manner that dynamic instability caused by weather or temperature variations is minimized.

Another object is to enable a magnetostrictive vibrator or rod to be so supported in the chassis of an electrical system that the operating characteristics of the magnetostrictive vibrator will not be disturbed by the shocks to which it may be subjected in the transportation of the equipment; and a further object is to enable the magnetostrictive control unit to be included in a single housing in such a manner that the magnetostrictive member is maintained in the proper relation to the mounting means and the inductive devices at all times. A further object is to enable a magnetostrictive vibrator to be mounted in a fixed or rigid mounting so that the magnetostrictive member will operate properly in any position, and a related object is to simplify the manner of incorporating the vibrator in the electrical apparatus with which it is to be used.

Other and further objects of the present invention will be apparent from the following description and claims and are illustrated in the accompanying drawings which, by way of illustration, show preferred embodiments and the principle thereof and what I now consider to be the best mode in which I have contemplated applying that principle. Other embodiments of the invention embodying the same or equivalent principle may be used and structural changes may be made as desired by those skilled in the art without departing from the present invention and the purview of the appended claims.

In the drawings:

Fig. 1 is a longitudinal sectional view of one embodiment of my invention;

Fig. 2 is an elevational view showing the base of the control element as viewed from the right in Fig. 1;

Fig. 3 is a transverse sectional view taken along the line 3—3 of Fig. 1;

Fig. 4 is a transverse sectional view taken along the line 4—4 of Fig. 1;

Fig. 5 is a perspective view of the control device of Fig. 1 with one-half of the casing removed and

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one of the inner elements removed to show details of internal construction;

Fig. 6 is a longitudinal sectional view taken through a modified form of control device;

Fig. 7 is a fragmental view taken along the line 7—7 in Fig. 6;

Fig. 8 is a view illustrating the base of the control device of Fig. 6, the view being taken from the right as viewed in Fig. 6;

Fig. 9 is a transverse sectional view taken along the line 9—9 in Fig. 6;

Fig. 10 is a longitudinal sectional view illustrating another embodiment of the control device;

Fig. 11 is a view taken along the line 11—11 in Fig. 10 and showing the base of the control device; and

Fig. 12 is a transverse sectional view taken substantially along the line 12—12 of Fig. 10.

In my aforesaid copending application, I have disclosed the general circuit characteristics of several oscillator systems in which the magnetostrictive vibrators of the present invention may be employed, and in each instance a magnetostrictive element is arranged in operative association with inductive devices which are in turn included as circuit elements of the oscillator system. In accordance with the present invention, the magnetostrictive element or vibrator and the associated inductive devices are combined to afford a unitary construction, and in Figs. 1 to 4 I have illustrated a vibrator unit 140 which is so constructed. The vibrator unit 140 comprises an elongated cylindrical housing 141 formed from insulating material to provide end walls 142 and 143, and the end wall 143 has a plurality of pins 144 and 145 extended therefrom so as to afford a pin base mounting for the unit. The housing 141 is sectional in character in that it is formed in two longitudinal sections separable along a longitudinal extending division line or plane indicated at 146 in Fig. 2. The housing 141 is hollow so as to afford a mounting chamber 147 therein, and a magnetostrictive vibrator in the form of a rod 150 of square cross section is mounted therein with inductive units 151 and 152 in surrounding relation to the opposite ends thereof. The magnetostrictive vibrator or rod 150 is in this embodiment of the invention supported in position by a sectional mounting disc 155 which has the edge portions thereof snugly embraced and supported in an annular groove 156 formed in the wall of the housing 141. The sectional supporting disc 155 has a central opening therein which is formed with a knife-edge 157 which is arranged to engage an annular knife-edge groove 158 formed in the rod 150 at substantially the midpoint thereof.

The inductive devices 151 and 152 are substantially similar in construction and each inductive device includes a coil supporting spool 160 formed from insulating material and having an induction coil 161 wound thereon. The spools 160 are disposed in surrounding relation to the opposite ends of the magnetostrictive rod 150, and in order that the inductive action of the coils 161 may be effectively utilized, the spools 160 are supported in the desired relation to the rod 150 by sectional enclosures 163 formed from highly permeable material such as powdered iron. Each sectional enclosure 163 is separable in a longitudinally extending plane of separation indicated at 164 in Figs. 3, 4 and 5, and the sections of the enclosure are so formed as to extend across the outer edge of the enclosed spool 160 and inwardly

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along the ends of the spool so as to terminate in spaced relation to the magnetostrictive rod and thereby afford an accurately determined clearance space about the rod. The enclosures 163 therefore accomplish the function of the iron cores described in my aforesaid copending application, and for purposes of this disclosure will hereinafter be termed the cores of the inductive devices 151 and 152. As mentioned in said copending application, the construction of the cores of powdered iron enables them to have low eddy current losses, low magnetic losses, and high electrical resistance, thus assuring a high output of the higher harmonics.

The casing 141 is formed from moulded insulating material having openings 166 therein which are counterbored at 167 to receive fastening bolts and nuts 168 for securing the two sections of the housing together. In the assembly of the magnetostrictive unit 140 the lead wires from the ends of the coils of the two inductive devices 151 and 152 must first be connected to the mounting pins 144 and 145, and to facilitate such connection these pins are moulded into the sections of the housing 141 with wires connected to the respective pins and moulded into and extending through the housing to points within the mounting chamber 147 at which leads from the coils may be conveniently soldered thereto.

This connecting operation is facilitated by moulding one of the sections of each powdered iron core 163 with longitudinal openings 170 therethrough, and the lead wires of the coil which is to be enclosed are projected through the openings 170 so as to extend beyond the end of the core section. The appropriate wires from the mounting pins are extended into clearance spaces 171 and 172 at opposite ends of the mounting chamber, and before the coils and the cores are put in place, the coil leads may be soldered to the appropriate wires in these clearance spaces.

Thus after the parts have been put in place and the fastening screw and nut devices 168 have been tightened, the magnetostrictive rod 150 is firmly and accurately supported by the sectional supporting disc, and the cores and the coils which make up the inductive devices 151 and 152 are maintained in an accurately predetermined relation to the magnetostrictive rod. The unit which is thus provided may be readily and easily associated with the other elements of an oscillating circuit or other electrical systems merely by plugging the pins 144 and 145 into the appropriate pin socket of the oscillator or other appropriate chassis.

In Figs. 6 to 9 of the drawings another form of magnetostrictive vibrator unit 140a is illustrated, and in this form the separable housing 141a has connecting flanges 175 and 176 formed along the sides of the two sections so that fastening bolts 177 may be passed therethrough to secure the two sections of the housing together. The housing 141a has end walls 142a and 143a, and mounting pins 144a and 145a are moulded therein to afford a pin base mounting for the unit. In this embodiment of the invention, a magnetostrictive rod 150a of round cross section is formed so as to afford an integral mounting flange 178 substantially midway between its ends, and to support the flange 178 a supporting ring 179 of insulating material is moulded thereabout so as to embrace the peripheral border portion of the flange.

In this embodiment of the invention the magnetostrictive rod 150a is supported by the cores which embrace the inductive coils 161a formed on

the insulating spools 160a, and to this end the cores are formed so as to enable convenient engagement thereof with the supporting ring 179. Thus the cores are formed by a pair of annular members 180 and a pair of cup shaped members 181, all formed from powdered iron, each annular member being of T-shaped cross section to afford a web and oppositely extending flanges at the outer edge of the web. In the assembly of the unit, the core members 180 are placed in position on opposite sides of the mounting ring 179 so as to be firmly engaged therewith, and when thus positioned, the adjacent flanges of the two members 180 are in firm abutment with each other and with the outer periphery of the mounting ring, and hence the rod 150a is supported by the two members 180. The two coils 161a are then placed in position within the other flanges of the two core members 180, after which the cup-shaped core members 181 may be placed in surrounding relation to the other or end portions of the two spools or coils.

In the mounting of one of the cup shaped members 181 in place as aforesaid the leads from the adjacent coil 160a may be extended through openings, as 182 in the member 181, and prior to the mounting of the housing sections about the cores these lead wires may be soldered to the pins 144a, which in this embodiment are disposed adjacent to the plane of separation of the two housing sections. The leads from the other coil are positioned so as to extend outwardly through registered notches 183, Fig. 7, in the adjacent flanges of the other core member 181 and the adjacent core member 180, and these leads are extended along the outer sides of the cores as shown in Figs. 6 and 9 in clearance passages 185 formed in the inner face of the housing, as for example, along the line of juncture of the housing sections. At the opposite end of the housing the end wall 143a is formed with clearance grooves 186 therein along which these leads may be extended for connection as by soldering to the respective pins 145a.

In Figs. 10 to 12, the magnetostrictive vibrator is embodied in a unit 140b wherein a casing comprises a cylindrical side wall section 141b and separately formed end walls 142b and 143b. The magnetostrictive rod 150b is round in cross section and has an integral flange 178b intermediate its ends, and in this form of the invention the rod 150b is permanently mounted in the side wall section 141b by an integral internal flange 179b which is moulded so as to embrace the peripheral border portion of the flange 178b. The iron cores in this embodiment of the invention are in the form of cups 190, two of which are arranged to embrace each spool 160b, and the cups 190 have opening 191 in the ends thereof so that an assembly comprising a spool and the two surrounding cups may be inserted into each end of the side wall section into abutment with the flange 179b. Before such insertion of the inductive devices, the leads from the coils 160b are connected to wires which are led through or moulded into the side wall section 141b. The end wall 142b may then be placed in its closing position as by threading the end wall into one end of the side wall section.

The other end wall 143b has a plurality of mounting pins 144b and 145b moulded therein, and after these pins have been connected, as by soldering, to the wires from the respective coils 161b, the end wall 143b is inserted into the other end of the side wall section 141b and is secured

in place by radial screws 193 which extend through the side wall 141b and are threaded into the end wall 143b. When the end wall 143b is in this position it abuts the end of the adjacent core member 190 so as to hold the same firmly against the internal flange 179b, and clearance slots or grooves 196 are formed in the inner face of the end wall 143b in order that the coil leads may be extended to the mounting pins 144b and 145b. Where it is desired to utilize a permanent magnet to supplant the magnetizing action of one of the inductive devices, such a magnet may be moulded in the side and end walls of the housing 141 or 141a with the ends of the magnet extended into the end walls of the housing so as to be disposed in the desired relation to the ends of the magnetostrictive rod. In such an arrangement the end of the adjusting screw may be disposed so as to be accessible exteriorly of the housing.

From the foregoing it will be evident that the electromechanical control units which are thus provided under the present invention are rugged in character, and since the parts thereof are rigidly held in a predetermined relation, these units will withstand shocks, blows, and external vibration without objectionable variations in the frequency of the oscillations of the system. Moreover, these units, by reason of the rigid mounting of the magnetostrictive rod, may be utilized in different and even continuously varying angular positions.

Hence, while I have illustrated and described preferred embodiments of my invention, it is to be understood that these are capable of variation and modification and I therefore do not wish to be limited to the precise details set forth, but desire to avail myself of such changes and alterations as fall within the purview of the following claims.

I claim:

1. In an electro-mechanical control unit, an elongated sectional housing embodying side and end walls separable along a longitudinal plane of separation and affording an internal mounting chamber, an elongated rod made from magnetostrictive material and disposed within said housing, a pair of inductive devices surrounding opposite end portions of said rod and disposed within said housing, and supporting means for said magnetostrictive rod operatively associated therewith substantially midway between the ends of the rod, and means acting between said supporting means and said housing to support said rod in predetermined relation to said inductive devices.

2. In an electro-mechanical control unit, an elongated sectional hollow housing having side and end walls, an elongated bar formed from magnetostrictive material, means connected to said bar substantially midway between its ends and supporting said bar within said housing, a pair of inductive devices each comprising a coil supporting spool having an inductive coil wound thereon and a powdered iron core surrounding said spool and having an opening therein aligned with the central opening of its spool, said inductive devices being disposed within said housing in surrounding relation to opposite ends of said bar, and means on said casing exteriorly thereof affording terminals for said coils.

3. In an electro-mechanical control unit, an elongated rigid housing, an elongated rod made from magnetostrictive material and disposed within said housing, a pair of inductive devices surrounding opposite end portions of said rod and disposed in a stationary relation within said

housing, and supporting means for said magnetostrictive rod operatively associated therewith substantially midway between the ends of said rod and acting between said rod and said housing to rigidly support said rod within said housing.

4. In an electro-mechanical control unit, an elongated rigid housing, an elongated rod made from magnetostrictive material and disposed within said housing, a pair of inductive devices surrounding opposite end portions of said rod and disposed in a stationary relation within said housing, supporting means for said magnetostrictive rod operatively associated therewith substantially midway between the ends of said rod and acting between said rod and said housing to rigidly support said rod within said housing, mounting pins stationarily mounted on and projecting from said housing to afford a pin base mounting therefor, and electrical connections from said inductive devices to respective ones of said pins to afford individual circuits for said inductive devices.

5. In an electro-mechanical control unit, an elongated sectional housing embodying side and end walls separable along a longitudinal plane of separation and affording an internal mounting chamber, an elongated rod of square cross-section having an annular knife-edge groove formed in the rod at substantially the midpoint thereof and made from magnetostrictive material and disposed within said housing, a pair of inductive devices surrounding opposite end portions of said rod and disposed within said housing, and supporting means for said magnetostrictive rod operatively associated therewith substantially midway between the ends of the rod, and means acting between said supporting means and said housing to support said rod in predetermined relation to said inductive devices.

6. In an electro-mechanical control unit, an elongated sectional housing embodying side and end walls separable along a longitudinal plane of separation and affording an internal mounting chamber, an elongated rod of square cross-section having an annular knife-edge groove formed in the rod at substantially the midpoint thereof and made from magnetostrictive material and disposed within said housing, a pair of inductive devices surrounding opposite end portions of said rod and disposed within said housing, and a sectional mounting disc having the edge portions thereof snugly embraced and supported in an angular groove formed in the inner wall of the said housing and having a central opening therein formed with a knife-edge which is arranged to engage said annular knife-edge groove in said bar.

7. In an electro-mechanical control unit, an elongated sectional housing embodying side and end walls separable along a longitudinal plane of separation and affording an internal mounting chamber and said end walls being formed with openings therein to receive fastening bolts and nuts for securing the two sections of the said housing, an elongated rod made from magnetostrictive material and disposed within said housing, a pair of inductive devices surrounding opposite end portions of said rod and disposed within said housing, and supporting means for said magnetostrictive rod operatively associated therewith substantially midway between the ends of the rod, and means acting between said supporting means and said housing to support said rod in predetermined relation to said inductive devices.

8. In an electro-mechanical control unit, an elongated sectional housing embodying side and end walls separable along a longitudinal plane of separation and affording an internal mounting chamber and said housing being formed with connecting flanges along the sides of the two sections of said housing so that fastening bolts may be passed therethrough to secure the said two sections of the housing together, an elongated rod made from magnetostrictive material and disposed within said housing, a pair of inductive devices surrounding opposite end portions of said rod and disposed within said housing, and supporting means for said magnetostrictive rod operatively associated therewith substantially midway between the ends of the rod, and means acting between said supporting means and said housing to support said rod in predetermined relation to said inductive devices.

9. In an electro-mechanical control unit, an elongated sectional hollow housing having side and end walls, an elongated bar of round cross section formed from magnetostrictive material so as to afford an integral mounting flange substantially midway between its ends, a pair of inductive devices surrounding opposite end portions of said rod and disposed within said housing, and a supporting ring of insulating material molded about said flange so as to embrace its peripheral border portion and disposed within said housing.

10. In an electro-mechanical control unit, an elongated sectional hollow housing having side and end walls, an elongated bar of round cross section formed from magnetostrictive material so as to afford an integral mounting flange substantially midway between its ends, a supporting ring of insulating material molded about said flange so as to embrace its peripheral border portion, a pair of inductive devices each comprising a coil supporting spool having an inductive coil wound thereon and a powdered iron core in turn comprising a cup shaped member and an annular member of T-shaped cross section disposed within said housing in surrounding relation to opposite ends of said bar and in firm abutment with the outer periphery of the mounting ring, and means on said casing exteriorly thereof affording terminals for said coils.

11. In an electro-mechanical control unit, a casing comprising a cylindrical side wall section and separately formed end wall sections, one of said end walls being threadedly disposed into one end of said side wall sections and the other end wall being inserted into the other end of the side wall section and secured in place by radial screws, an elongated rod made from magnetostrictive material and disposed within said housing, a pair of inductive devices surrounding opposite end portions of said rod and disposed in a stationary relation within said housing, and supporting means for said magnetostrictive rod operatively associated therewith substantially midway between the ends of said rod and acting between said rod and said housing to rigidly support said rod within said housing.

12. In an electro-mechanical control unit, a casing comprising a cylindrical side wall section and separately formed end wall sections, one of said end walls being threadedly disposed into one end of said side wall sections and the other end wall being inserted into the other end of the side wall section and secured in place by radial screws, a magnetostrictive rod of round cross section formed with an integral flange intermediate its ends and permanently mounted in said sidewall

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section by an integral internal flange molded to embrace the peripheral border portion of said magnetostrictive rod flange, a pair of inductive devices surrounding opposite end portions of said rod and disposed in a stationary relation within said housing, and supporting means for said magnetostrictive rod operatively associated therewith substantially midway between the ends of said rod and acting between said rod and said housing to rigidly support said rod within said housing.

13. In an electro-mechanical control unit, an elongated sectional hollow housing having side and end walls, an elongated bar formed from magnetostrictive material, means connected to

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said bar substantially midway between its ends and supporting said bar within said housing, a pair of inductive devices each comprising a coil supporting spool having an inductive coil wound thereon and a powdered iron core comprising two cup-shaped members arranged to embrace each spool and having an opening therein aligned with the central opening of its spool, said inductive devices being disposed within said housing in surrounding relation to opposite ends of said bar, and means on said casing exteriorly thereof affording terminals for said coil.

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