Nov. 26, 1946. H. F. ELLIOTT 2,411,619

CONTROL APPARATUS

Filed Dec. 16, 1943 4 Sheets-Sheet 1

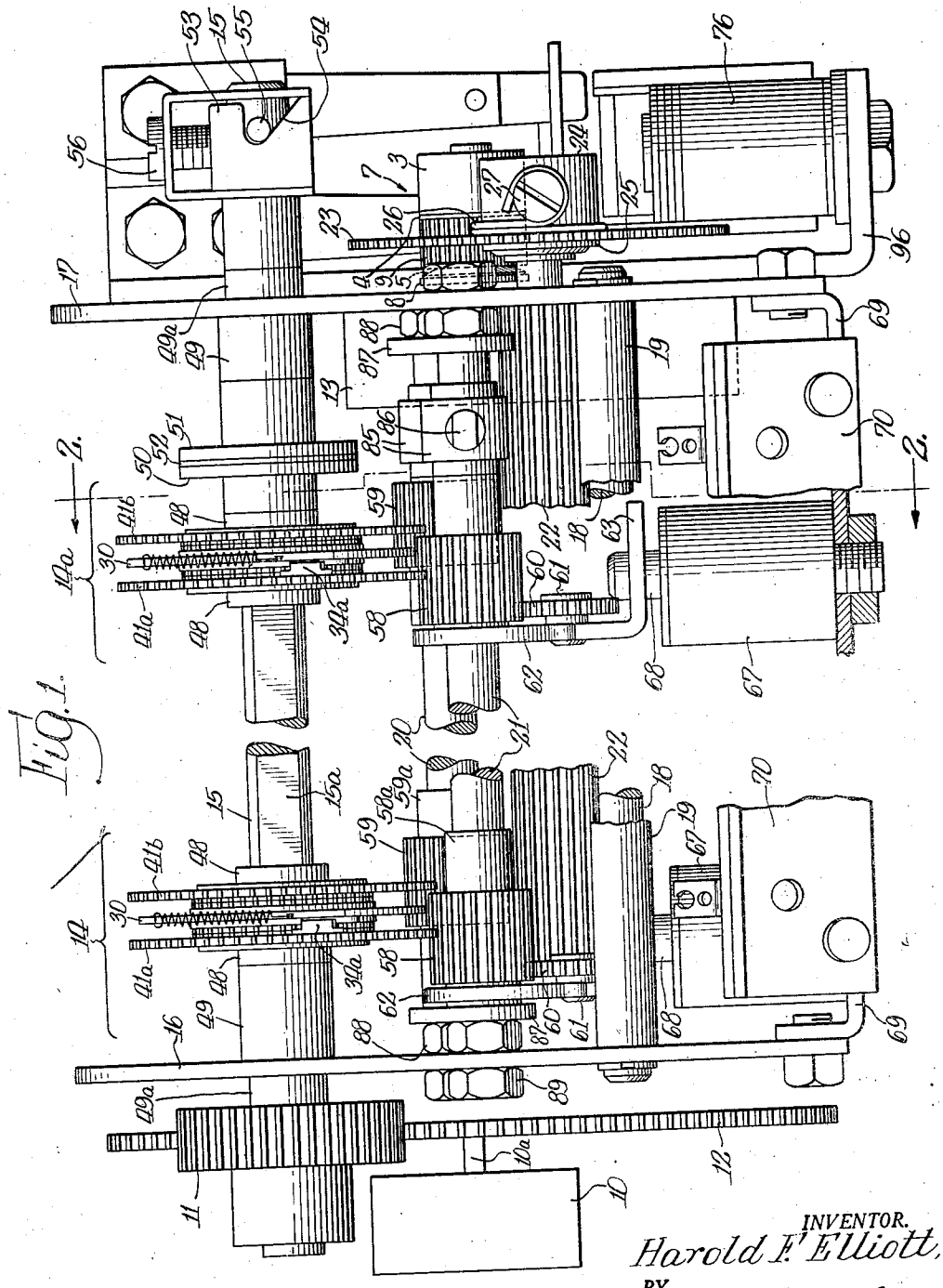


Fig. 1.

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Fig. 2.

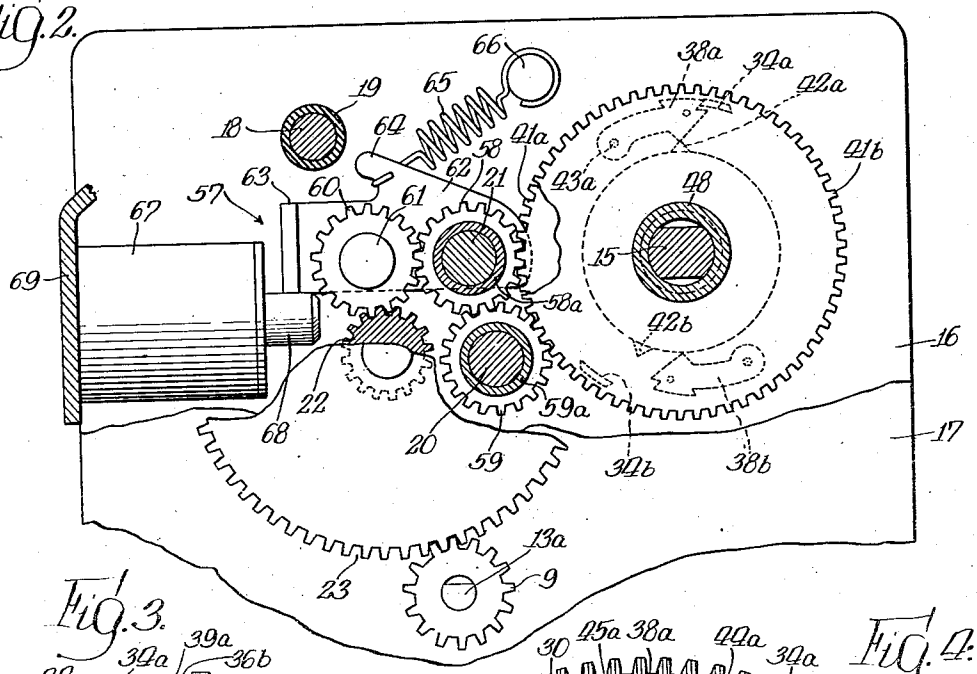


Fig. 3.

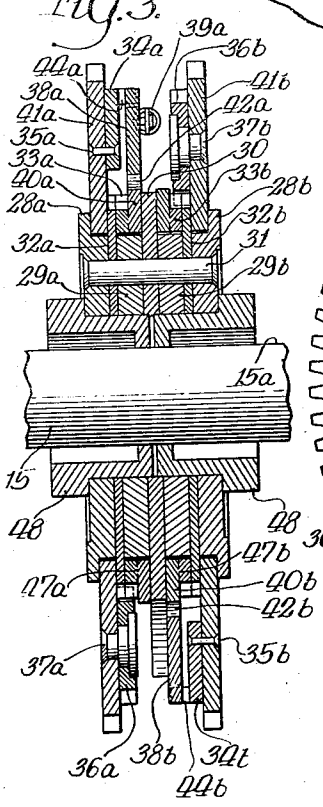
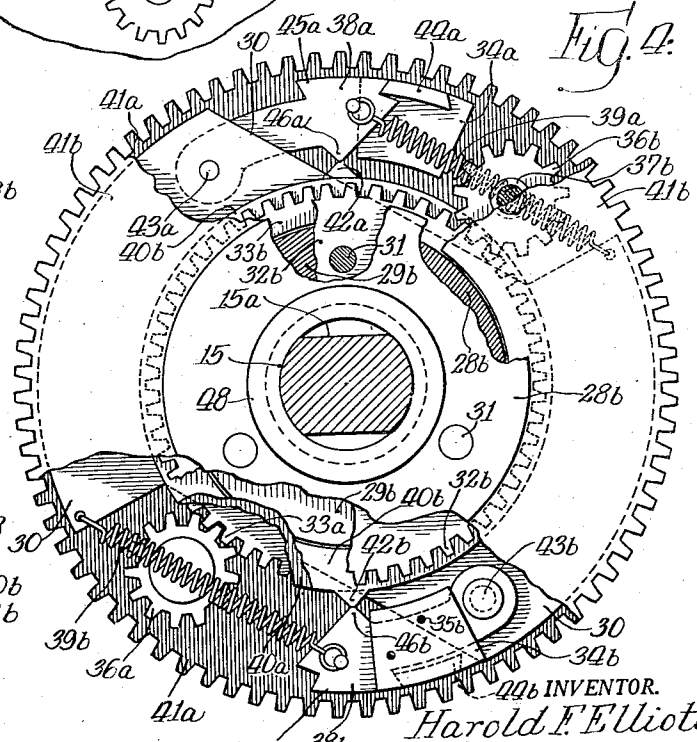


Fig. 4.



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CONTROL APPARATUS

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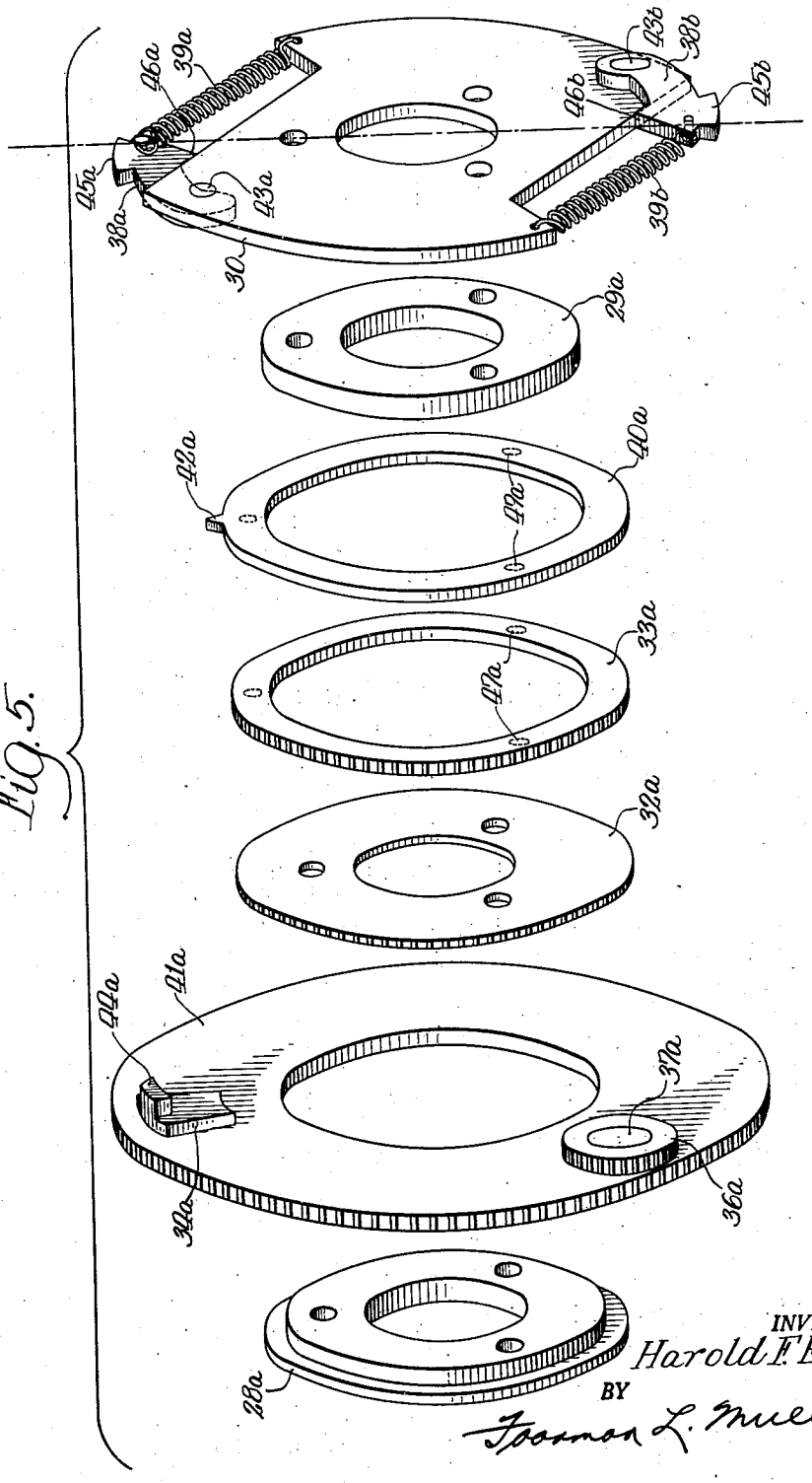


Fig. 5.

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CONTROL APPARATUS

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Fig. 6.

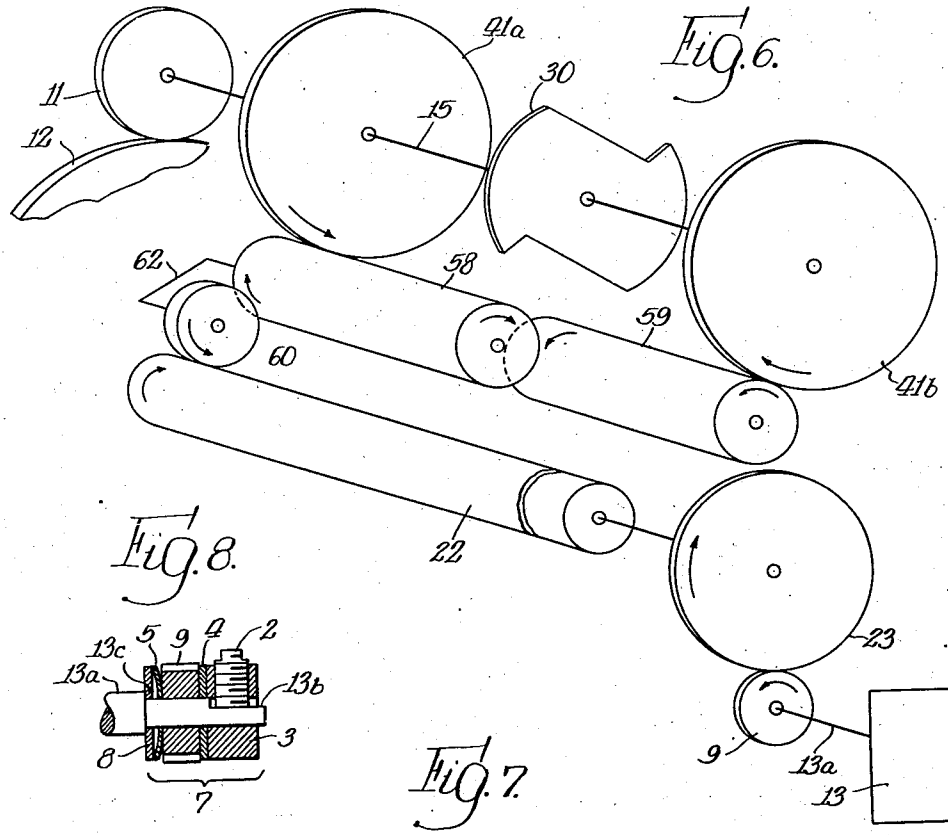
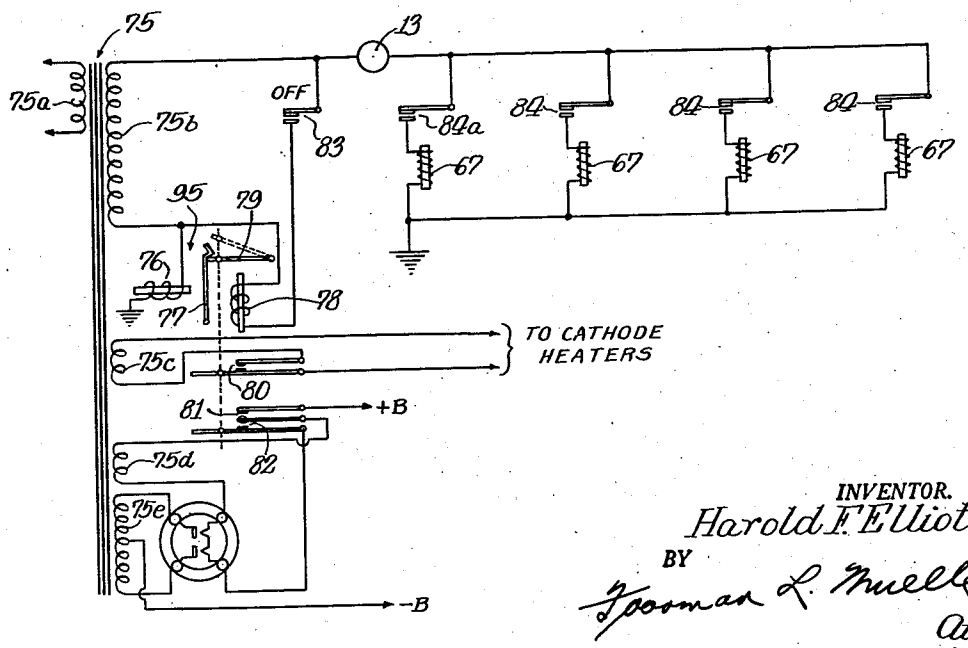


Fig. 8.

Fig. 7.



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Patented Nov. 26, 1946

2,411,619

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2,411,619

CONTROL APPARATUS

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Application December 16, 1943, Serial No. 514,463

6 Claims. (Cl. 192—31)

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The present invention relates to improvements in control mechanisms and more particularly to improved control apparatus for automatically and accurately tuning a radio receiving system to any desired one of a plurality of signal channels.

It is an object of the present invention to provide automatic tuning apparatus for a radio receiver, which is extremely accurate and positive in its operation to move the frequency changing means to any setting corresponding to a desired station, is compact in arrangement, and is of simple and inexpensive construction.

It is another object of the invention to provide control apparatus of the character described, wherein a control unit of improved rugged construction is provided for moving the settable element of the frequency changing means into each predetermined setting and for locking the element in the established setting, while at the same time permitting the settable element to be moved in either direction away from the established setting when actuated through a second control unit corresponding to a different predetermined setting.

According to a further object of the invention, each control unit is provided with two positively acting lost-motion mechanisms of small size and an improved rugged structure for establishing the driving and locking connections required to actuate the settable element to the desired setting and then stop the same with precision accuracy, and also for permitting a wide range of adjustment of the settable element when actuated through others of the control unit.

It is another object of the invention to provide a lost-motion device wherein an improved speed reducing mechanism employing a differential gear assembly having an exceedingly high drive ratio, is employed to actuate one of the relatively movable lost-motion parts of the device, thereby to enhance the accuracy with which another of the parts is actuated after the parts have been moved into predetermined relative positions.

In accordance with still another object of the invention, an improved cam and cam follower assembly occupying a minimum of space is utilized to provide the required lost motion in each device.

It is a still further object of the invention to provide an improved mechanism for operating a controlled element with precision accuracy when an associated actuating element is operated to a predetermined setting.

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The invention, both as to its organization and method of operation, together with further objects and advantages thereof, will best be understood by reference to the following specification taken in connection with the accompanying drawings, in which:

Fig. 1 is a fragmentary plan view illustrating improved control apparatus characterized by the features of the present invention;

Fig. 2 is a fragmentary end view partially in section of the apparatus shown in Fig. 1;

Fig. 3 is an edge sectional view illustrating the parts of one of the control units provided in the control apparatus shown in Fig. 1;

Fig. 4 is a side view of the control unit shown in Fig. 3 with parts thereof broken away to show the driving relationship between certain of the elements of the mechanism;

Fig. 5 is an exploded perspective view of the parts making up one-half of the control unit shown in Fig. 3;

Fig. 6 is a diagrammatic view illustrating the manner in which the rotary control shaft of the control apparatus may be actuated through a driving connection provided by the parts of one of the control units;

Fig. 7 is a circuit diagram illustrating the manner of electrically energizing the electromagnets and driving motor of the apparatus shown in Fig. 1; and

Fig. 8 is a sectional detailed view of certain of the parts included in the apparatus shown in Fig. 1.

Referring now to the drawings, and more particularly to Figs. 1 and 2 thereof, the improved control apparatus there illustrated is adapted to be embodied in a radio receiving system for the purpose of selectively and automatically operating the frequency changing means 10 of the system to different predetermined settings respectively corresponding to different desired signal channels. More specifically, the tuning or frequency changing means 10 of the receiver is adapted to be actuated to any one of a plurality of different settings, respectively corresponding to different stations, by a single driving motor 13. This motor is arranged to rotate the settable shaft 10a of the tuning means 10 through any one of a plurality of driving connections which commonly include the gears 11 and 12, a rotary control shaft 15, an elongated driving gear 22, and the two meshing motor driven gears 9 and 23. These driving connections also individually include control units 14 which are axially disposed along the rotary control shaft 15 and are

arranged to be selectively clutched to the elongated driving gear 22 by means of clutching units 57 individually associated therewith.

More specifically considered, all parts of the control apparatus are supported between or upon two spaced-apart parallel extending frame members 16 and 17. These members have suitable tie rods 18 and 66 extending therebetween and anchored thereto at the end portions thereof for the purpose of enhancing the rigidity of the structure. The motor 13 is mounted upon the frame member 17 at the inner side thereof and is provided with a rotor shaft 9a which extends through an opening in the frame member 17 and carries the driving gear 9. As clearly shown in Fig. 8 of the drawings, the projecting end of the shaft 13a is of reduced section and is formed with a flat 13b near the outer extremity thereof. The shoulder portion 13c of the shaft serves as a stop or abutment for a washer 8 of a clutch assembly 7 through which the shaft 13a and gear 9 are slip connected. More specifically, this assembly comprises a stressed dish-shaped spring washer 5, the gear 9, a friction washer 4 and a collar 3. The parts of this assembly are maintained upon the shaft end, with the washer 5 pressing the gear 9 against the friction washer 6, by means of a set screw 2 which is threaded through the collar 3 to engage the flat portion 13c of the shaft end.

The gear 23 which meshes with the driving gear 9 is preferably formed of fiber or other like composition material, and is arranged to drive the elongated gear 22 through a spring connection which includes the coil spring 26. More specifically, the gear 23 is rotatably supported by a retaining bushing 24 which is rigidly mounted upon the shaft end of the elongated gear 22. A steel washer 25 abutting against a shouldered portion of the bushing 24 holds the gear 23 loosely upon the hub or bushing 24 so that it is free to rotate relative to the hub within the limits imposed by the spring 26. One end of this spring is looped about a friction screw 27 which holds the bushing 24 in a fixed position upon the shaft end of the gear 22. The opposite end of the spring 26 is hooked into an aperture formed in the face of the gear 23. Thus, a flexible drive between the motor shaft 13a and the elongated gear 22 is provided which serves to prevent any possible locking of the clutch units to the driving gear 22 in the manner more fully explained below.

As best shown in Fig. 1 of the drawings, the several control units 14 are arranged between the two frame members 16 and 17 and each includes parts carried by three parallel extending shafts 15, 20 and 21. The two shafts 20 and 21 are fixedly supported by the members 16 and 17 at the respective ends thereof in the manner pointed out below. The third shaft 15, as indicated above, constitutes the rotary control shaft and carries stepped spacing sleeves 49 which are journaled in the frame members 16 and 17 in an obvious manner. This shaft has the gear 11 set screw mounted thereon at the end thereof which is adjacent the settable element 10a of the tuning means 10. The several control units, which are axially disposed along the three shafts 15, 20 and 21, are of identical construction and arrangement. Accordingly, the arrangement of these units will be readily understood from a consideration of the control unit 14a, the parts of which are detailed in Figs. 3, 4 and 5 of the drawings.

In brief, this control unit comprises an actuating element 30 which is mounted for rotation with the rotary control shaft 15 and to which rotation may be imparted in different directions through two driving connections which respectively include the driving elements 41a and 41b and two combination speed reducing and lost-motion mechanisms. Each combination speed reducing and lost-motion mechanism comprises a pair of relatively movable pinion gears 32 and 33, the first of which is mounted for rotation with the shaft 15 and the second of which is rotatable relative to this shaft and the other gear 32; an orbital or planetary gear 36 which is pivotally mounted by means of an axis pin 37 upon the associated driving element 41 for meshing engagement with the associated gears 32 and 33; a camming element in the form of a ring 40 which is welded or pinned to the associated gear 33 for rotation therewith about the shaft 15 and is provided around its outer periphery with a cam lobe 42; a cam follower 38 which is pivotally supported by means of a pin 43 at the outer periphery and to one side of the actuating element 30 for engagement by the associated cam lobe 42 when predetermined relative positions of the two associated gears 32 and 33 are established through operation of the associated driving element 41; and a stop or projection 34 which is pinned by means of pins 35 to the associated driving element 41 and is provided with a projecting portion 44 adapted to be engaged by the associated cam follower 38 when this cam follower is actuated by the associated cam lobe 42. Each gear 33 of the control unit is provided with a different number of teeth than the associated gear 32 so that during operation of the associated driving element 41, it is rotated relative to the associated driving element but at a much slower speed. For example, if the gear 33a is provided with sixty-one teeth and the gear 32a is provided with sixty teeth, a 60:1 drive ratio is provided between the driving element 41a and the gear 33a, such that the latter element and the cam ring 40a connected thereto are rotated one revolution for each sixty revolutions of the driving element 41a. Thus, the four elements 41a, 36a, 32a and 33a combine to form an exceedingly compact differential gear assembly through which the cam ring 40a may be rotated at slow speed in response to high speed rotation of the driving element 41a. The other differential mechanism of the control unit, i. e., that comprising the four elements 41b, 36b, 32b and 33b, is an exact duplicate of that described and utilizes the same drive ratio between the driving element 41b and the gear 33b thereof.

In the assembly of the control unit 14a, two shouldered bushings 28a and 28b and two inner spacing rings 29a and 29b are utilized to provide the required bearing surfaces for those elements 41, 33 and 40 which are rotatable relative to the control shaft 15. The four identified supporting members, together with the actuating element 30 and the two gears 32, are arranged in a stack, with the elements 41, 33 and 40 assembled thereon, in the manner just illustrated in Fig. 3 of the drawings. Assembly pins 31 extending through the stack at several positions about the axis of the stack are utilized to provide clamping engagement between the parts 28, 29, 30 and 32, thereby to maintain the enumerated parts of the control unit in their assembled relationship. In this regard, it is pointed out that each bearing ring 29 has a thickness which is slightly greater than the combined thicknesses of the two elements 33 and 40 which it supports, whereby these two elements are permitted to rotate freely about the bearing ring 29 without binding engagement

with the adjacent elements 30 and 32. Springs 39 are utilized to bias the lobes 46 of the cam followers 38 into engagement with the peripheral surfaces of their respective associated camming elements 40. More specifically and as best shown in Fig. 5 of the drawings, that peripheral portion of the actuating element 30 which is disposed adjacent the free end of the camming element 38a is cut away to provide a space within which the coil spring 39a may be connected at opposite ends to the free end of the cam follower 38a and the actuating element 30. This spring connection serves at all times to bias the lobe 46a of the cam follower 38a into engagement with the outer peripheral surface of the camming ring 40a. An identical arrangement is utilized to bias the lobe 46b of the cam follower 38b into engagement with the outer peripheral surfaces of the camming ring 40b, it being noted in this regard that the two cam followers are disposed upon opposite sides of the actuating element 30.

From the above explanation it will be clearly apparent that each control unit is exceedingly compact in arrangement and is entirely self-contained, such that it may be removed from the rotary control shaft 15 without disassembly of the parts thereof. As best shown in Figs. 1 and 3 of the drawings, bushings 48 are utilized fixedly to support each control unit 14 upon the rotary control shaft 15 and to maintain the required axial spacing between each adjacent pair of control units. More specifically, the inner peripheral portion of the supporting stack of each control unit is clamped between the oppositely arranged shoulders of two shouldered bushings 48, these bushings being provided with inner flatted surfaces which are adapted to engage the flat 15a of the shaft 15 to provide a fixed mechanical connection between the shaft and the control unit which the bushings support. At the ends of the control shaft 15, the stepped spacing sleeves 49 are provided, each of which includes a portion 49a of reduced diameter which is journaled within an opening provided in the adjacent one of the two frame members 16 and 17.

In order frictionally to clamp the control units 14 between the shouldered portions of the bushings 48 upon which they are respectively supported, a spring washer assembly comprising the two bushings 50 and 51 and the spring washer 52, and a clamping assembly comprising the three parts 53, 55 and 56 are provided. More specifically, the dish-shaped spring washer 52 is disposed between the two bushings 50 and 51 to retain a slight clamping pressure against the assembly stack of each control unit regardless of the setting of the clamping assembly. This assembly comprises a camming member 53 having camming sides 54 which engage a pin 55 extending through the shaft 15, and is provided with a cross bar which is threaded to receive a screw 56. In its engagement with the shaft 15, this screw may be utilized to move the member 53 radially of the shaft for the purpose of exerting an axial clamping pressure upon the parts 49, 48, 50, 51 and 49b, in the manner more fully explained below.

The driving elements 41a and 41b of each control unit 14 are in meshing engagement with pinions 58 and 59 respectively carried by the two stationary shafts 21 and 20. More specifically and as best shown in Fig. 1 of the drawings, the pinions 58 and 59 through their meshing engagement with each other, are so arranged that they rotate the driving elements 41a and 41b in opposite directions. The pinions 58 are axially aligned and freely rotatable on the shaft 21, each thereof being formed with a toothed portion and a spacing portion 58a for positioning the next adjacent pinion so that the toothed portion thereof is directly opposite the driving element 41a of the associated control unit. The pinions 59 are of similar construction, each thereof being provided with a spacing portion 59a for properly positioning the toothed portion of the next adjacent pinion. Assembly of the pinions 58 and 59 upon the respective associated shafts 21 and 20 is maintained by bushings 85 which are frictionally engageable with their respective associated shafts by means of friction screws 86. The threaded ends of the two shafts 20 and 21 are held by nuts 88 to tie plates 87, and extend through the frame members 16 and 17, the nuts 88 serving to hold the tie plates against the pinion assembly and to space the pinions from the frame members 16 and 17. Nuts 89 located upon the outside of the frame members 16 and 17 are utilized fixedly to mount the shafts 20 and 21 thereon.

For the purpose of selectively connecting the elongated gear 22 in driving relationship with any one of the control units 14, clutching units 57 are provided individual to the control units. Each clutching unit comprises an idler pinion 60 pivotally supported by means of a pivot pin 61 upon an L-shaped rocker arm 62 which is loosely mounted upon the shaft 21. Each idler pinion 60 is in meshing engagement with its associated pinion 58. At its projecting end, each rocker arm 62 carries an armature piece 63 which is adapted to be attracted into engagement with the projecting core end 68 of an electromagnet 67, thereby to move the idler pinion 60 into meshing engagement with the elongated drive gear 22 in response to energization of this magnet. In order normally to bias the rocker arm 62 of each clutch assembly 57 to a position wherein the idler pinion 60 is disengaged from the gear 22, each rocker arm is spring connected through a coil spring 65 to the tie rod 66. Movement of the rocker arms 62 under the influence of their respective associated retracting springs 65 is limited by the tie rod 18 which is positioned in the paths of movement of the rocker arms and is provided with a cushioning sleeve 19 formed of rubber or other soft flexible material. The electromagnets 67 are all bolted to a crossbar 69 which extends transversely between the two frame members 16 and 17, and is anchored to these members at the ends thereof. This crossbar also supports a terminal strip 70 formed of Bakelite or other suitable insulating material having terminal elements suitably mounted thereon for connection with the winding terminals of the electromagnets 67.

The motor 13 is of the unidirectional type and may be so arranged that its rotor is rotated in a counterclockwise direction as viewed in Fig. 6 of the drawings. With the driving gear 22 thus rotating in a clockwise direction, the idler pinions are adapted for counterclockwise rotation when engaged with the driving pinion 22. Accordingly, when any selected idler pinion 60 is actuated into meshing engagement with the driving gear 22, the meshing engagement of the gear 60 with its associated pinion 58 produces a force which acts to pull the pinion 60 into meshing engagement with the driving gear 22, thereby to lock the pinion and driving gear in mesh during the tuning operation. Since this meshing engagement holds the armature piece 63 in its attracted position against

the magnet core 68, a mechanical pressure urging the armature piece 63 toward the magnet core occurs concurrently with the electrical attraction of this piece by the core, whereby the magnet is aided in operating the movable parts of the clutch assembly. The magnets 67, therefore, need only be large enough to attract their associated armature pieces into engagement with the magnet cores. This utilization of the mechanical reaction between any one of the pinions 60 and its engaged pinion 58 provides for the use of relatively small magnets 67, since each magnet merely functions to initially engage the idler pinion with the driving gear; the pulling of the pinion into meshing engagement with the gear being sufficient to maintain the geared or interlocked engagement between the two elements so long as the driving gear is rotating. The coil spring 26 through which the gear 22 is driven by the motor 13 insures positive disengagement of the idler pinion 60 embodied in any actuated clutch unit when the electromagnet 67 of the unit is deenergized upon completion of a tuning operation.

For the purpose of energizing the motor 13 and selectively controlling the energization of the clutch magnets 67 individual to the several control units 14, the control circuit illustrated in Fig. 7 of the drawings may be employed. Briefly considered, this circuit comprises a transformer 75 having a primary winding 75*a* adapted to be connected to a suitable commercial frequency source of alternating current and a secondary winding 75*b* from which current is delivered for energizing the motor 13 and selectively energizing the magnets 67. The transformer 75 also includes a low voltage winding 75*c* for supplying cathode heating current to the heaters of the tubes provided in the radio receiver equipped with the illustrated control apparatus. Two additional secondary windings 75*d* and 75*e* are provided, which are included in the illustrated full wave rectifying circuit, this circuit being utilized to supply the screen and anode potentials required for operation of the various tubes provided in the receiver. In order selectively to control the energization of the motor 13, the magnets 67, the cathode heating circuit, and the rectifying circuit, switching equipment is provided which includes an off switch 83, push button switches 84 individual to the various magnets 67, and a relay switching unit indicated generally at 95. This unit includes two mechanically interlocked magnets 76 and 78, the second of which includes an armature 79 interlocked with the armature 77 of the magnet 76 and arranged to control three sets of contacts 80, 81 and 82. The magnet 76, together with the armature and contact spring assemblies thereof, are shown in Fig. 1 of the drawings as being mounted upon an assembly plate 96 which is rigidly secured to the frame member 17.

In considering the operation of the control apparatus as described above, it may be assumed that this apparatus is to be utilized to actuate the tuning means 10 of the receiver to the particular setting corresponding to the control unit 14*a*, thereby to tune the receiver for the reception of signals radiated at the particular carrier frequency to which the control unit 14*a* corresponds. In order to initiate the operation of this control unit, the push button switch 84*a* associated with this control unit is actuated to its closed circuit position, thereby to complete a circuit for energizing the clutch magnet 67 individual to the

control unit 14*a* in series with the driving motor 13 and the winding of the magnet 76. When energized in this circuit, the magnet 76 attracts its associated latching armature 77, thereby to release the spring biased armature 79 of the magnet 78. The armature 79 in moving to its retracted position, closes the contacts 80 to complete the cathode heater circuit, and at the contacts 81 and 82, completes the high voltage rectifying circuit in an obvious manner.

When the electromagnet 67 individual to the control unit 14*a* is thus energized, the armature piece 63 of the clutch unit 57 associated with this control unit is attracted, whereby the rocker arm 62 of the clutch unit is pivoted about the shaft 21 against the bias of its retracting spring 65 to move the idler pinion 60 into engagement with the driving gear 22. Thus, a driving connection is established between the motor 13 and the driving elements 41*a* and 41*b* of the control unit 14*a*. As will be seen from Fig. 6 of the drawings, when the motor 13 is energized in the manner just explained, it rotates the gear 9 in a counterclockwise direction through the slip clutch connection provided between this gear and the motor shaft 13*a*. Accordingly, the gear 23 is actuated to rotate the elongated drive gear 22 in a clockwise direction through the resilient connection provided by the spring 26. As a result, the two pinions 58 and 59 are respectively rotated in clockwise and counterclockwise directions through the driving connection afforded by the idler pinion 60 in its engagement with the driving gear 22. Thus, driving connections are provided, whereby the driving element 41*a* is rotated in a counterclockwise direction and the driving element 41*b* in a clockwise direction relative to the rotary control shaft 15.

During rotation of the driving element 41*a*, the planetary gear 36*a* is rotated about the two gears 32*a* and 33*a* and, due to the tooth differential between these two gears, the gear 33*a* and the camming element 40*a* connected thereto are rotated in the same direction as the driving element 41*a*, i. e., in a counterclockwise direction about the rotary control shaft 15. The driving element 41*b* similarly functions to drive the camming elements 40*b* in a clockwise direction relative to the rotary control shaft 15 through the driving connection provided by the differential gears 32*b*, 33*b* and 36*b*. During such rotation of the two camming elements 40*a* and 40*b* the actuating element 30 for the rotary control shaft 15 remains stationary until the cam lobe 42 carried by one of the two camming elements is positioned to actuate its associated cam follower 38 into engagement with the associated stop 34 carried by the associated driving element 41. With the camming element 40*b* rotating in the direction indicated, i. e., in a clockwise direction, the cam lobe 42*b* thereof will engage one of the camming surfaces of the lobe 46*b* when it is moved to the proper position relative to the actuating element 30. After such engagement, and during continued rotation of the camming element 40*b*, the two engaged lobes 42*b* and 46*b* coact to pivot the cam follower 38*b* in a counterclockwise direction about its pivot pin 43*b* so that the stop engaging head 45*b* thereof is moved radially outward from the shaft 15. Approximately when the lower knife edge of the lobe 46*b* is moved to bear against the upper knife edge of the lobe 42*b*, the locking head 45*b* of the cam follower 38*b* is positioned to be engaged by the projection 44*b* of the stop element 34*b*. The engaged surfaces

of the two engaged elements **34b** and **44b** are cut on a bias so that the continued movement of the driving element **41b**, following engagement of the two elements, provides a solid mechanical interlock therebetween.

In a manner entirely similar to that just described, the camming element **40a** is rotated until the cam lobe **42a** thereof is moved into engagement with the lobe **46a** of the cam follower **38a**. Here again, when the two lobes **42a** and **46a** are relatively so positioned that when their knife edges are engaged, the head **45a** of the cam follower **38a** is positioned for engagement by the projection **44a** of the stop element **34a**. In this case also, the engaged edges of the head **45a** and the stop **34a** are cut at an angle such that the two elements are interlocked by continued operation of the driving element **41b**.

From the above explanation it will be understood that when the cam follower **38a** is engaged by the stop **34a**, a direct mechanical connection is provided between the driving element **41a** and the actuating element **30**. When this connection is established, rotation of the planetary gear **36a** about the two gears **32a** and **33a** is obviously arrested with the result that relative movement between the parts **30**, **40a**, **33a**, **32a**, **36a** and **41a** is entirely discontinued. In a similar manner, relative movement between the parts **41b**, **36b**, **32b**, **33b**, **40b** and **30** is arrested when the cam follower **38b** is moved to a position for engagement by the stop **44b** carried by the driving element **41b**.

From the above explanation it will be apparent that depending upon the initial setting of the control unit **14a**, the rotary control shaft **15** and the actuating element **30** will be rotated in one direction or the other by one of the two driving elements **41a** or **41b**. Thus, if the stop **34a** engages the cam follower **38a** before the stop **34b** engages the cam follower **38b**, the actuating element **30** and control shaft **15** will be rotated in a counterclockwise direction to the predetermined setting to which the control unit **14a** corresponds. Conversely, if the stop **34b** is moved to engage the cam follower **38b** before the stop **34a** engages the cam follower **38a**, the actuating element **30** and the control shaft **15** will be rotated in a clockwise direction to the predetermined setting corresponding to the control unit **14a**. In either case, the actuating element **30** and the shaft **15** are rotated at the speed of the driving element **41** with which they are mechanically connected until the nonengaged stop and cam follower are brought into engagement. When both of the two stop elements **34a** and **34b** are moved into engagement with the cam followers **38a** and **38b**, respectively, a locking connection is obviously established which prevents continued rotation of the parts **15**, **30**, **41**, **58**, **59**, **60**, **22**, **23** and **9**. Thus, the entire gear train extending back to the motor driving gear **9** is locked up when the shaft **15** is rotated to the predetermined setting corresponding to the actuated control unit **14a**. After this train has been locked up, continued rotation of the motor shaft **13a** is permitted through the slip clutch connection between this shaft and the gear **9**.

When the new setting of the settable element **10a** for the tuning means **10** is established in the manner just explained, the operator will be apprised of this fact through reception of the desired station and may release the push button switch **84a** to deenergize the driving motor **13**, the energized electromagnet **67** and the winding

of the magnet **76** in an obvious manner. When the magnet **76** is thus deenergized, its spring biased armature **77** is retracted to a position beneath the armature **79** of the magnet **78**, but this operation is obviously without effect, and the power circuits of the receiver remain energized. When the electromagnet **67** of the clutching unit associated with the control unit **14a** is deenergized, its associated rocker arm **62** is spring actuated by the associated spring **65** to its normal position wherein the idler pinion **60** of the actuated clutching unit **57** is disengaged from the driving gear **22**. In this regard it is noted that upon deenergization of the driving motor **13**, the coil spring **26** connected between the gear **23** and the driving gear **22** provides a kick-back action to insure release of the idler pinion **60** by the driving gear **22**.

The manner in which the remaining control units **14** may, through selective energization of the magnets **67** by the push button switches **84**, be actuated for the purpose of driving the settable element **10a** to its other predetermined settings, will be clearly apparent from the above explanation with reference to the operation of the control unit **14a**. If at any time it is desired to turn off the receiver after a period of operation, the off switch **83** may be momentarily operated to its closed circuit position thereby to complete an obvious circuit for energizing the winding of the magnet **78**. This magnet, in attracting its associated armature **79**, opens the contacts **80** to deenergize the cathode heaters of the tubes provided in the receiver. At the contacts **81** and **82**, the magnet **78** opens the B supply circuits to the tubes and deenergizes the cathode heaters of the full wave rectifying tube provided in the rectifying circuit. As the armature **79** is moved to its attracted position, the free end thereof rides over the locking portion of the armature **77**. After the switch **83** is released to deenergize the winding of the magnet **78**, therefore, the armature **79** is held in its attracted position by the latching armature **77** of the magnet **76**.

During the above described movement of the shaft **15** to the particular setting corresponding to the control unit **14a**, the movable parts of the nonactive control units are also moved to produce unlatching relative movement between the cam and cam follower parts of one of the lost-motion mechanisms provided in each unit. In this regard it will be understood that as the control shaft **15** is rotated, all of the actuating elements **30** individual to the various control units are rotated therewith. The action which occurs in the nonactive units will be more fully apparent from the following explanation relating to the movement of the parts provided in the control unit **14a** when the control shaft **15** is driven to another predetermined setting by another of the control units. Thus it may be assumed that after the rotary control shaft **15** is operated to the setting corresponding to the control unit **14a**, such that the cam followers **38a** and **38b** are respectively in engagement with the stops **34a** and **34b**, the shaft **15** is rotated by a second control unit in a clockwise direction. During such rotation of the shaft **15** the cam follower **38a** remains in engagement with the stop **34a** to prevent relative movement between the parts **41a**, **36a**, **32a**, **33a**, **40a** and **30** of the control unit. Thus, the driving gear **41a** which is rotating in a clockwise direction, is rendered operative to drive the driving element **41b** in a clockwise direction through the driving connection afforded by the meshing pinions **58** and

59. The relative movement thus produced between the driving element 41b and the actuating element 30 by rotating these two elements in opposite directions causes the stop 34b and the cam follower 38b to be disengaged in a manner which will be clearly apparent from the following explanation.

Assuming now that the rotary control shaft 15 is rotated in a counterclockwise direction away from the predetermined setting corresponding to the control unit 14a, the actuating element 30 and driving element 41b of this unit are rotated in the same direction due to the engagement between the cam follower 38b and stop 34b respectively carried thereby. The gear 32a is also rotated in a counterclockwise direction with the two elements 30 and 41b. Also, and due to the driving connection afforded by the pinions 59 and 58, the driving element 41a is rotated in a clockwise direction relative to the shaft 15. With the two elements 41a and 32a thus rotating in opposite directions and with the element 41a rotating in a direction opposite the direction of rotation of the actuating element 30, the planetary gear 36a functions to rotate the gear 33a and camming element 40a in a clockwise direction relative to the actuating element 30. Thus, the cam lobe 42a is withdrawn from beneath the lobe 46a of the cam follower 38a to prevent reengagement of the stop 34a with the cam follower 38a after the two elements 41a and 30 have been relatively rotated through one revolution. As relative movement between the two elements 41a and 30 continues, the cam lobe 42a is gradually backed away from the lobe 46a until these two lobes are separated by a distance which is determined by the amount of movement required to actuate the shaft 15 to its new setting.

From the above explanation it will be clearly apparent that the rotary control shaft 15 and the settable element 10a actuated thereby may be moved to any desired setting through operation of a particular control unit without any interference whatever from the nonactive control units. This is due to the fact that during operation of any one of the control units to establish the desired setting for the shaft 15, the parts of the nonactive units are so moved relative to each other as to prevent a locking connection from being established through any one of these units. Thus, the two combination speed reducing and lost-motion mechanisms as provided in each control unit, permit the rotary control shaft 15 to be freely, accurately and positively driven in either direction to any one of the predetermined settings respectively corresponding to the several control units.

In order individually to adjust the various control units relative to the rotary control shaft 15, thereby to provide for operation of this shaft by the various control units to the desired predetermined settings, the screw 56 in the clamping mechanism is withdrawn until the control units are freed for rotation relative to their respective associated supporting bushings 48. The shaft 15 is then adjusted to a desired control position or setting by a suitable manual control knob (not shown) provided for manually actuating the settable element 10a of the frequency changing means 10. During such rotation of the shaft 15 the spring washer 52 serves to maintain sufficient clamping pressure against the elements 28 of the respective control units to prevent the shaft from being moved relative to the control units, the movement of the rotary control shaft being taken up within each control unit in a manner which will be clearly apparent from the above explanation. While the shaft 15 is held in the position to which it is adjusted, by manually gripping the control knob of the manual actuating means, the switch 84 associated with the particular control unit which is to be utilized in operating the rotary control shaft to the manually established setting, is operated to energize the driving motor 13 and to engage the idler pinion 60 of the clutching unit individual to the control unit with the driving gear 22. The motor 13 is thus rendered operative to drive the movable parts of the selected control unit until these parts are lockingly engaged in the manner explained above. During the final portion of the operation of the selected control unit and more particularly after one of the cam followers 38 is engaged by its associated stop 34, all parts of the control unit are rotated relative to the shaft 15 and the bushings 48 upon which the control unit is supported. Thus, the selected control unit is actuated to a position relative to the rotary control shaft 15, such that when the shaft and control unit are subsequently locked together, the control unit can thereafter only operate the rotary control shaft to the particular setting which it occupies when the locking operation is completed. The above described procedure may be repeated for each of the other control units 14, in order to establish the other predetermined settings desired for the rotary control shaft 15. During each setting operation, the control units which are not being adjusted are maintained in adjustment because of the fact that their frictional engagement with the bushings 48 is sufficient to maintain their established positions relative to the shaft 15. When all of the control units 14 have been adjusted, the screw 56 may be tightened to frictionally lock all of the control units 14 in fixed positions relative to the shaft 15, in a manner which will be clearly apparent from the foregoing explanation.

While one embodiment of the invention has been disclosed, it will be understood that various modifications may be made therein, which are within the true spirit and scope of the invention.

I claim:

1. In combination, a rotatable actuating element, a second element movable in a path extending radially of the axis of rotation of said actuating element, lost-motion means operative to actuate said second element along said path, and a differential gear mechanism operated by said actuating element and operative to take up the free travel in said lost-motion means and to then operate said second element through said lost-motion means.

2. In combination, a rotatable actuating element, a camming element rotatable about the same axis as said actuating element, speed reducing means connecting said actuating element in driving relationship with said camming element, and an additional element actuated by said camming element when said camming element is operated to a predetermined angular position.

3. In combination, a rotatable actuating element, a second element movable in a path extending radially of the axis of rotation of said actuating element, a camming element operative to actuate said second element when moved into a predetermined position, and a speed reducing gear mechanism connecting said actuating means in driving relationship with said camming element.

4. In combination, a pair of relatively rotatable gears having different numbers of teeth, a rotatable actuating element, a planetary gear rotatably supported upon said actuating element for meshing engagement with said pair of gears, whereby relative rotation between said pair of gears is produced in response to operation of said actuating element to rotate said planetary gear about said pair of gears, a controlled element, and means responsive to the operation of said pair of gears into predetermined relative positions for actuating said controlled element from one position to a different position.

5. In combination, a pair of relatively rotatable gears having different numbers of teeth, a rotatable actuating element, a planetary gear rotatably supported upon said actuating element for meshing engagement with said pair of gears, whereby relative rotation between said pair of gears is produced in response to operation of said actuating element to rotate said planetary gear about said pair of gears, a controlled element, and means comprising a camming element rotatable with one of said pair of gears for actuating said controlled element from one position to a different position in response to the operation of said pair of gears into predetermined relative positions.

6. In combination, a pair of relatively rotatable gears having different numbers of teeth, a rotatable actuating element, a planetary gear rotatably supported upon said actuating element for meshing engagement with said pair of gears, whereby relative rotation between said pair of gears is produced in response to operation of said actuating element to rotate said planetary gear about said pair of gears, said actuating element and pair of gears having a common axis, a controlled element movable in a path extending radially of said axis, and means comprising a camming element rotatable with one of said pair of gears about said axis for moving said controlled element along said path in response to the operation of said pair of gears into predetermined relative positions.

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