Feb. 7, 1950 H. F. ELLIOTT 2,496,455

TUNING CONTROL APPARATUS

Original Filed Dec. 16, 1943 4 Sheets-Sheet 1

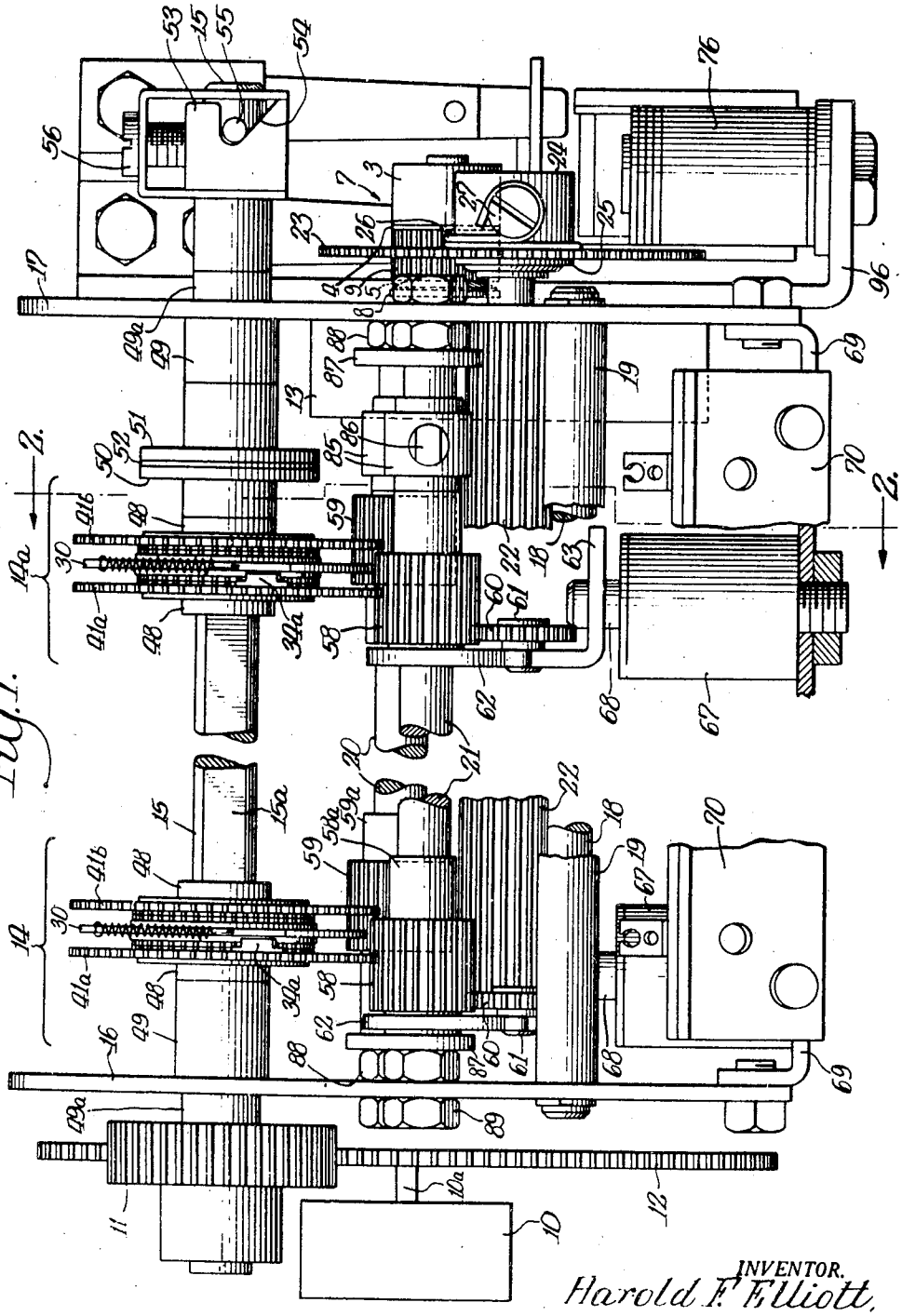


Fig. 1.

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Fig. 2.

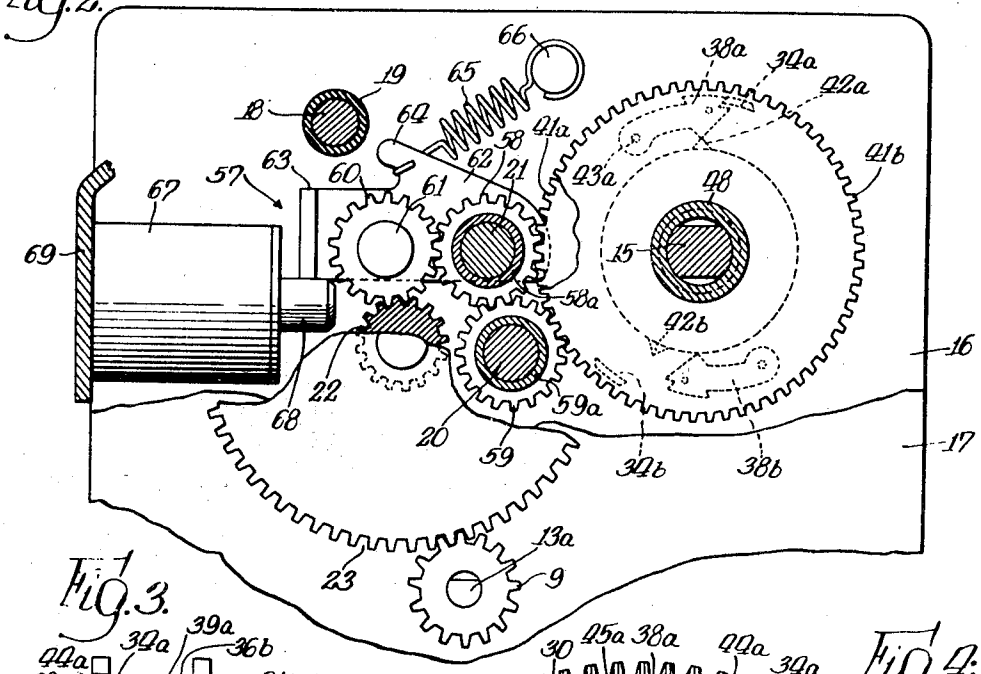


Fig. 3.

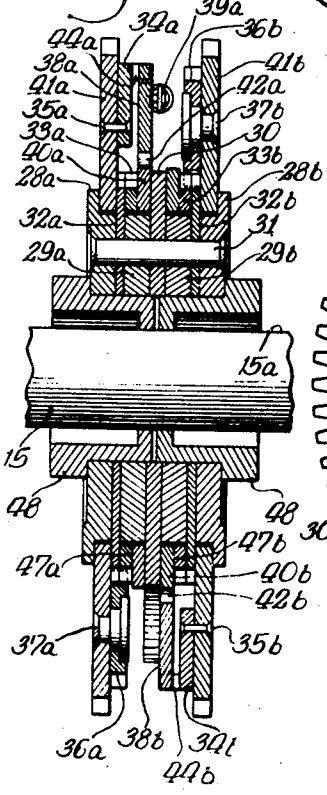
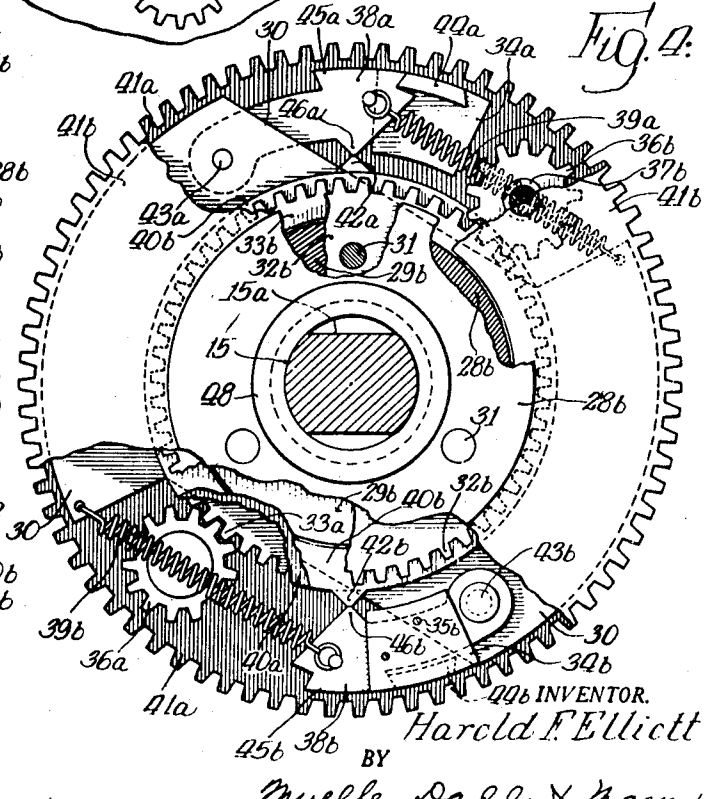


Fig. 4.



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TUNING CONTROL APPARATUS

Original Filed Dec. 16, 1943 4 Sheets-Sheet 3

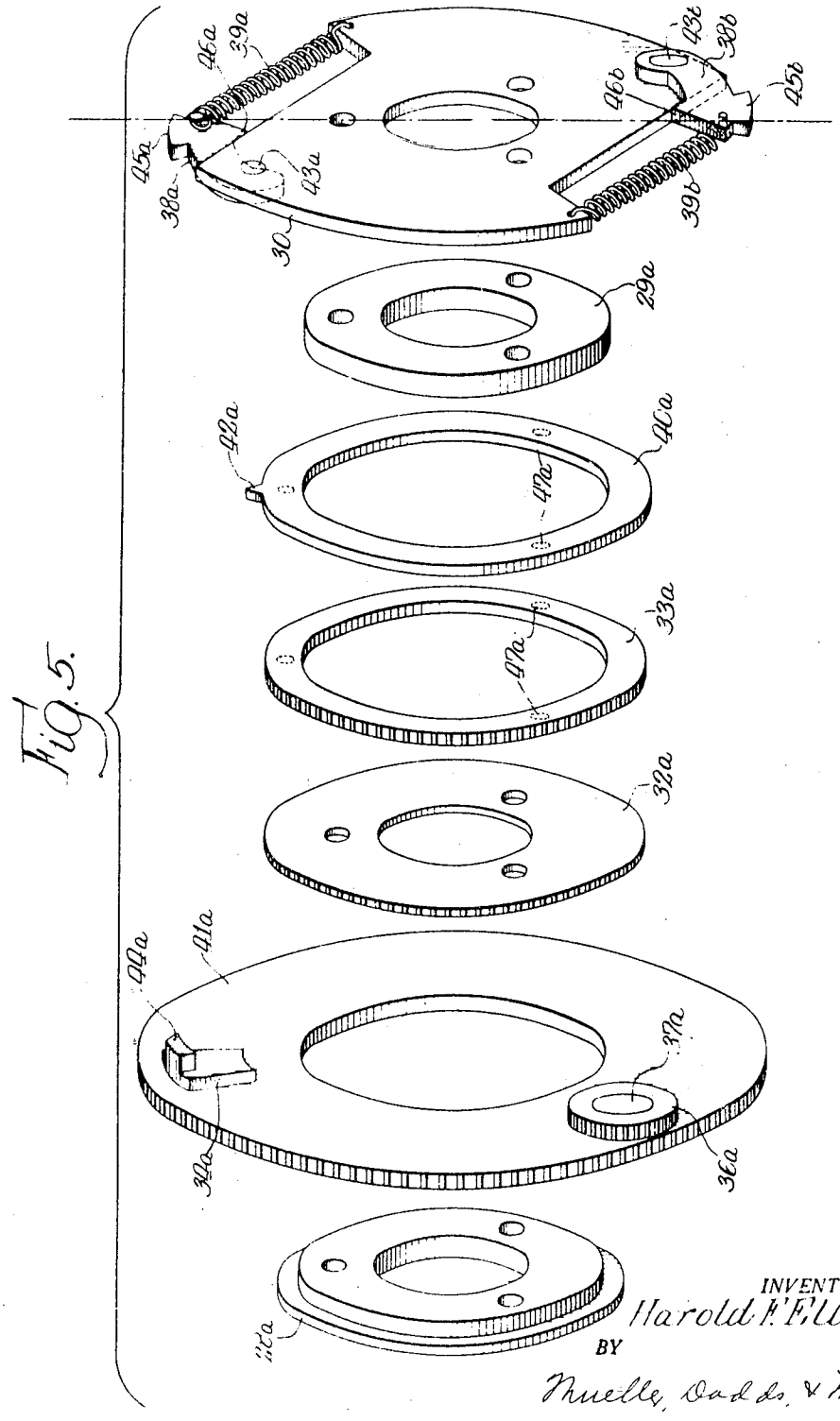


Fig. 5.

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TUNING CONTROL APPARATUS

Original Filed Dec. 16, 1943 4 Sheets-Sheet 4

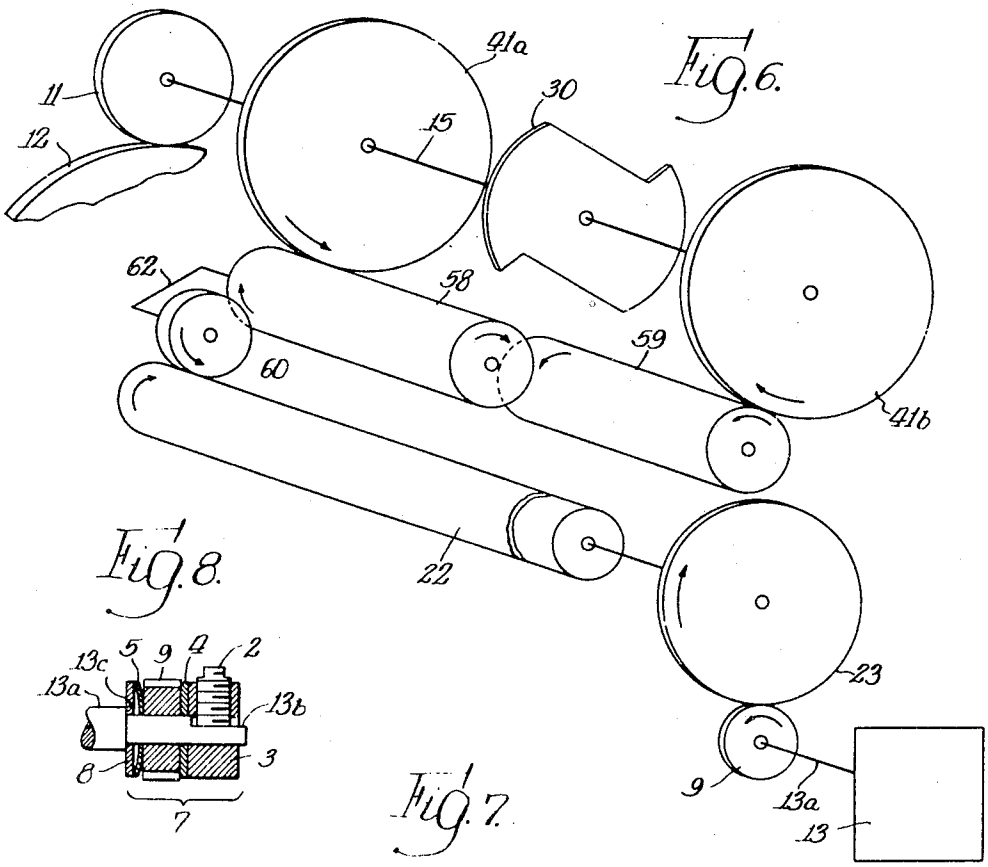


Fig. 6.

Fig. 8.

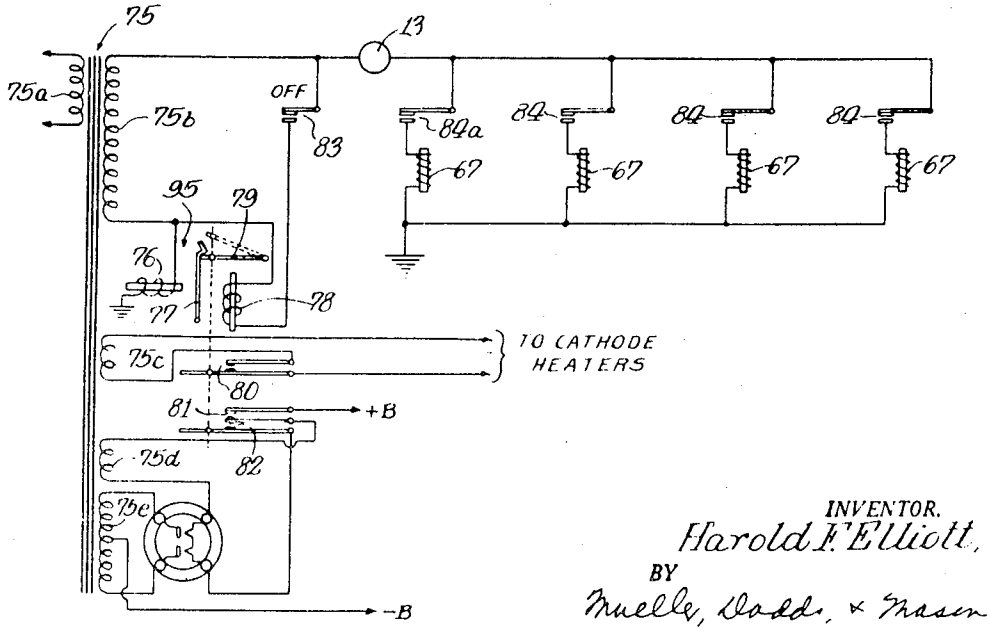


Fig. 7.

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UNITED STATES PATENT OFFICE

2,496,455

TUNING CONTROL APPARATUS

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Original application December 16, 1943, Serial No. 514,463. Divided and this application August 17, 1945, Serial No. 611,051

21 Claims. (Cl. 74—10.2)

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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. This application is a division of copending application Serial No. 514,463, filed December 16, 1943, and issued as Patent 2,411,619, on November 26, 1946.

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 units.

It is another object of the invention to provide a lost-motion device wherein an improved speed reducing mechanism employing a planetary reduction 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..

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

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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 10*a* 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 connected to the elongated driving gear 22 by means of connector 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 4, by means of a set screw 2 which is threaded through the collar 3 to engage the flat portion 13b 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 butting 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 member 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 speed-reducing planetary 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 speed-reducing 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, connector units 57 are provided individual to the control units. Each connector 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 connector 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 motor is rotated in a counter-clockwise 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 counter-clockwise 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 connector 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 be-

tween 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 connector 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 connector 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. To 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, is 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 botton switch 84*a* associated with this control unit is actuated to its closed circuit position, thereby to complete a circuit for energizing the connector magnet 67 individual to the control unit 14*a* in series with the driving motor 13 and the winding of the magnet 76. When energizing 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 connector unit 57 associated with this control unit is attracted, whereby the rocker arm 62 of the connector 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 speed-reducing 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 34*b* and 44*b* are cut on a bias so that the continued movement of the driving element 41*b*, following engagement of the two elements, provides a solid mechanical interlock therebetween.

In a manner entirely similar to that just described, the camming element 40*a* is rotated until the cam lobe 42*a* thereof is moved into engage-

ment with the lobe 46a of the cam follower 38a. Here again, when the two lobes 42a and 46a are relatively so positioned that 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 15a 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 connector 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 predeterminted 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 14*a*, the actuating element 30 and driving element 41*b* of this unit are rotated in the same direction due to the engagement between the cam follower 38*b* and stop 34*b* respectively carried thereby. The gear 32*a* is also rotated in a counterclockwise direction with the two elements 30 and 41*b*. Also, and due to the driving connection afforded by the pinions 58 and 58, the driving element 41*a* is rotated in a clockwise direction relative to the shaft 15. With the two elements 41*a* and 32*a* thus rotating in opposite directions and with the element 41*a* rotating in a direction opposite the direction of rotation of the actuating element 30, the planetary gear 36*a* functions to rotate the gear 33*a* and camming element 46*a* in a clockwise direction relative to the actuating element 30. Thus, the cam lobe 42*a* is withdrawn from beneath the lobe 46*a* of the cam follower 38*a* to prevent reengagement of the stop 34*a* with the cam follower 38*a* after the two elements 41*a* and 30 have been relatively rotated through one revolution. As relative movement between the two elements 41*a* and 30 continues, the cam lobe 42*a* is gradually backed away from the lobe 46*a* 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 10*a* 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 10*a* 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 64 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 connector 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 a radio receiver, a tuning system comprising: means for operating the tuning element of the receiver to a predetermined setting from a particular direction, and means including a speed-reducing planetary gear assembly responsive to the operation of said element to said predetermined setting from said direction for arresting the same.

2. In control apparatus for operating a settable element to a predetermined setting, a speed-reducing planetary gear asembly, means including said assembly for operating said element to said predetermined setting, and means coacting with said assembly and responsive to operation of said element to said predetermined setting for locking the same against further operation.

3. In control apparatus which includes means for driving a rotatable control shaft to different predetermined settings through different driving connections, means including a speed-reducing planetary gear assembly for locking said shaft against rotation when it is rotated to one of said predetermined settings through one of said driving connections, and means including said assembly for permitting said shaft to be rotated away from said one predetermined setting when driven through a second of said driving connections.

4. In control apparatus which includes means for operating a rotary control shaft to a prede-

termined setting, a pair of relatively rotatable gears having different numbers of teeth, a rotatable driving element, a planetary gear rotatably supported upon said driving element and meshing with said pair of gears, whereby relative movement between said pair of gears is produced in response to rotation of said planetary gear thereabout by said driving element, and means controlled by the relative movement between said pair of gears for locking said rotary control shaft against continued rotation when it is rotated to said predetermined setting.

5. In control apparatus which includes means for operating a rotary control shaft to a predetermined setting, a pair of relatively rotatable gears having different numbers of teeth, a rotatable driving element, a planetary gear rotatably supported upon said driving element and meshing with said pair of gears, whereby relative movement between said pair of gears is produced in response to rotation of said planetary gear thereabout by said driving element, a cam actuated in response to relative movement between said pair of gears, a cam follower actuated by said cam after said pair of gears are moved into predetermined relative positions, and means including a stop adapted to be engaged by said cam follower for locking said rotary control shaft against continued rotation when it is rotated to said predetermined setting.

6. In control apparatus which includes driving means for operating a rotary control shaft to a predetermined setting, a control unit comprising a pair of relatively rotatable gears having different numbers of teeth, a rotatable driving element provided with a stop and actuated by said driving means, a planetary gear rotatably supported upon said driving 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 driving element to rotate said planetary gear about said pair of gears, a cam actuated in response to relative movement between said pair of gears, an element mounted for rotation with said rotary control shaft, and a cam follower pivotally supported upon said last-named element and actuated into engagement with said stop to arrest the rotation of said rotary control shaft in response to the actuation of said cam to a predetermined position relative to said cam follower.

7. In control apparatus which includes driving means for operating a rotary control shaft, a control unit comprising a pair of relatively rotatable gears having different numbers of teeth, one of said gears being mounted for rotation with said rotary control shaft and the other gear being rotatable about said shaft, a rotatable driving element freely rotatable about said shaft and actuated by said driving means, a planetary gear rotatably supported upon said driving element for meshing engagement with said pair of gears, whereby said other gear is rotated relative to said shaft in response to operation of said driving element to rotate said planetary gear about said pair of gears, a camming element rotatable with said other gear about said shaft, a second element mounted for rotation with said shaft, a cam follower pivotally supported upon said second element and actuated by said camming element in response to rotation of said camming element relative to said shaft, and a stop carried by said driving element and engaged by said cam follower to arrest the rotation of said shaft in response to the rotation of said camming element to a predetermined position relative to said shaft.

8. In control apparatus which includes a settable element operative to a predetermined setting, a mechanism comprising a speed-reducing planetary gear assembly, means including said mechanism for operating said element to said predetermined setting, and stop means coacting with said assembly and responsive to operation of said element to said predetermined setting for locking the same against further operation.

9. In control apparatus which includes a settable element operative to a predetermined setting, a drive mechanism comprising a speed-reducing planetary gear assembly and a pair of lost-motion parts which are actuated in response to operation of the parts of said assembly, means for establishing a driving connection for said element which includes said gear assembly when said parts are moved into predetermined relative positions, and stop means coacting with said mechanism and responsive to operation of said element to said predetermined setting for locking the same against further operation.

10. In control apparatus which includes driving means and a rotary control shaft, a pair of relatively rotatable gears having different numbers of teeth, a rotatable driving element actuated by said driving means, a planetary gear rotatably supported upon said driving element and meshing with said pair of gears, whereby relative rotation between said pair of gears is produced in response to operation of said driving element to rotate said planetary gear about said pair of gears, and lost-motion means controlled by the relative movement between said pair of gears and operative to establish a driving connection between said driving means and said shaft when said pair of gears are moved into predetermined relative positions.

11. In control apparatus which includes driving means and a rotary control shaft, a pair of relatively rotatable gears having different numbers of teeth, a rotatable driving element actuated by said driving means, a planetary gear rotatably supported upon said driving element and meshing with said pair of gears, whereby relative rotation between said pair of gears is produced in response to operation of said driving element to rotate said planetary gear about said pair of gears, a camming element rotatable about said shaft in response to relative movement between said pair of gears, an actuating element mounted for rotation with said shaft, a cam follower supported upon said actuating element for movement radially of said shaft when engaged by the camming portion of said camming element, and stop means carried by said driving element for engagement by said cam follower to establish a direct drive connection between said driving element and said shaft.

12. In a control unit for operating a settable element to a predetermined setting, driving means, a pair of speed-reducing planetary gear assemblies connected to be rotated in opposite directions by said driving means, means including one of said assemblies for operating said settable element to said predetermined setting, and means including the other of said assemblies for arresting the operation of said element when it is operated to said predetermined setting.

13. In a control unit for operating a settable element to a predetermined setting, a pair of speed-reducing planetary gear assemblies, means including one of said assemblies for operating said

settable element to said predetermined setting from one direction, means including the other of said assemblies for operating said settable element to said predetermined setting from the other direction, and means including both of said assemblies for arresting the operation of said element when it is operated to said predetermined setting from either direction.

14. In control apparatus which includes means for driving a rotatable control shaft in either of two directions to different predetermined settings through different driving connections, means including a pair of speed-reducing planetary gear assemblies for locking said shaft against rotation when it is rotated to one of said predetermined settings through one of said driving connections, and means including said assemblies for permitting said shaft to be rotated in either direction away from said one predetermined setting when driven through a second of said driving connections.

15. In control apparatus which includes means for driving a rotatable shaft in either of two directions to different predetermined settings; a pair of speed-reducing planetary gear assemblies each actuated by said driving means, means including one of said assemblies for rotating said shaft to one of said predetermined settings from one direction and for locking said shaft against continued movement when moved to said one predetermined setting by the other assembly, means including said other assembly for moving said shaft to said one predetermined setting from the other direction and for locking said shaft against continued movement when moved to said one predetermined setting by said one assembly, an independent mechanism for completing a mechanical engagement between said driving means and said shaft, and lost-motion means included in the driving connections between said assemblies and said shaft for permitting said shaft to be rotated in either direction away from said predetermined setting when actuated through said independent mechanism.

16. In combination, a rotatable shaft, a driving element freely rotatable about said shaft, a ring rotatable about said shaft and provided with a cam lobe, speed-reducing means driven by said driving element for rotating said ring about said shaft, a member supported by said shaft, a cam follower carried by said member and adapted for actuation by said cam lobe, and means coacting with said cam follower to establish a direct mechanical connection between said driving element and said member when said cam follower is actuated by said cam lobe.

17. In combination, a rotatable shaft, a driving element freely rotatable about said shaft, a ring rotatable about said shaft and provided with a cam lobe, means including a speed-reducing planetary gear assembly rotatably supported by said shaft and actuated by said driving element for rotating said ring about said shaft at a fraction of the speed of rotation of said driving element, a member supported by said shaft, a cam follower movably supported upon said member for actuation by said cam lobe, and means coacting with said cam follower to establish a direct mechanical connection between said driving element and said member when said cam follower is actuated by said cam lobe.

18. A control apparatus for a controlled element comprising: a fast rotatable member operable over a multi-revolution range; a slow rotatable member operable over a range not exceeding one revolution; driving means for simultaneously rotating said members at a preselected speed ratio; a normally disengaged driving connection between said driving means and the controlled element and including said members; a follower mechanism for engaging one of said members to engage said driving connection between said driving means and the controlled element; and means controlled by the other of said members for conditioning said follower mechanism to engage said one member.

19. A control apparatus for a controlled element comprising: a fast rotatable member operable over a multi-revolution range; a slow rotatable member operable over a range not exceeding one revolution; driving means for simultaneously rotating said members at a preselected speed ratio; a normally disengaged driving connection between said driving means and the controlled element and including said members a follower mechanism for engaging said fast member to engage said driving connection between said driving means and the controlled element; and means controlled by said slow member for conditioning said follower mechanism to engage said fast member.

20. A control apparatus for a controlled element comprising: a fast rotatable member operable over a multi-revolution range; a slow rotatable member operable over a range not exceeding one revolution; driving means for simultaneously rotating said members at a preselected speed ratio; a normally disengaged driving connection between said driving means and the controlled element and including said members; a follower mechanism for engaging one of said members to engage said driving connection between said driving means and the controlled element; and means responsive to a predetermined angular setting of the other of said members for conditioning said follower mechanism to engage said one member.

21. A control apparatus for operating a settable element to a predetermined setting comprising: a driving mechanism for said element including a speed-reducing planetary gear assembly normally operatively disconnected from said element; means for establishing a driving connection between said mechanism and said element through said planetary gear assembly when the parts of said mechanism are operated to predetermined relative positions; and stop means coacting with said mechanism and responsive to operation of said element to said predetermined setting for arresting all of the elements of the apparatus.

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