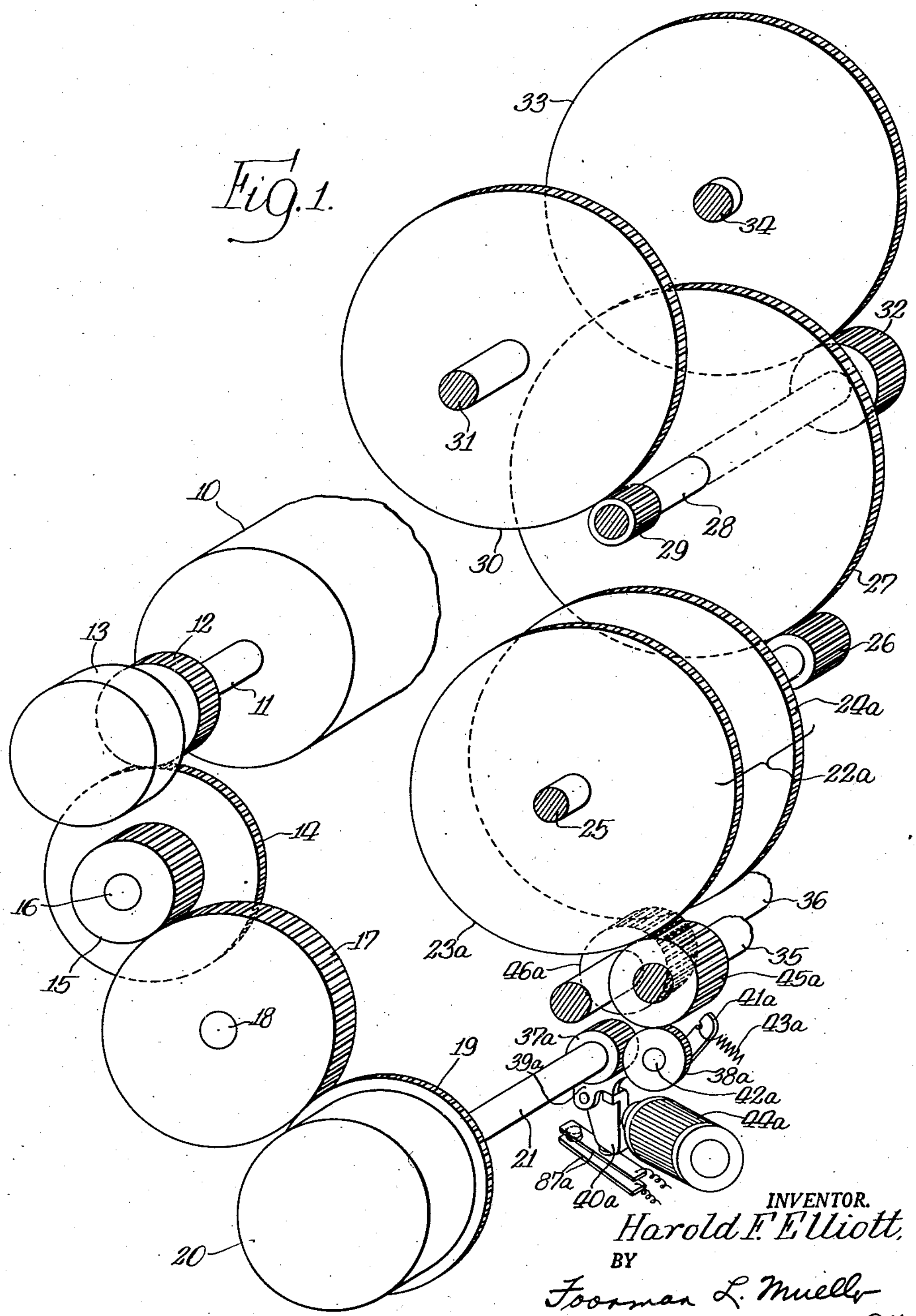
Nov. 26, 1946. H. F. ELLIOTT 2,411,618

CONTROL APPARATUS

Filed Dec. 16, 1943 4 Sheets-Sheet 1

Fig. 1.



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CONTROL APPARATUS

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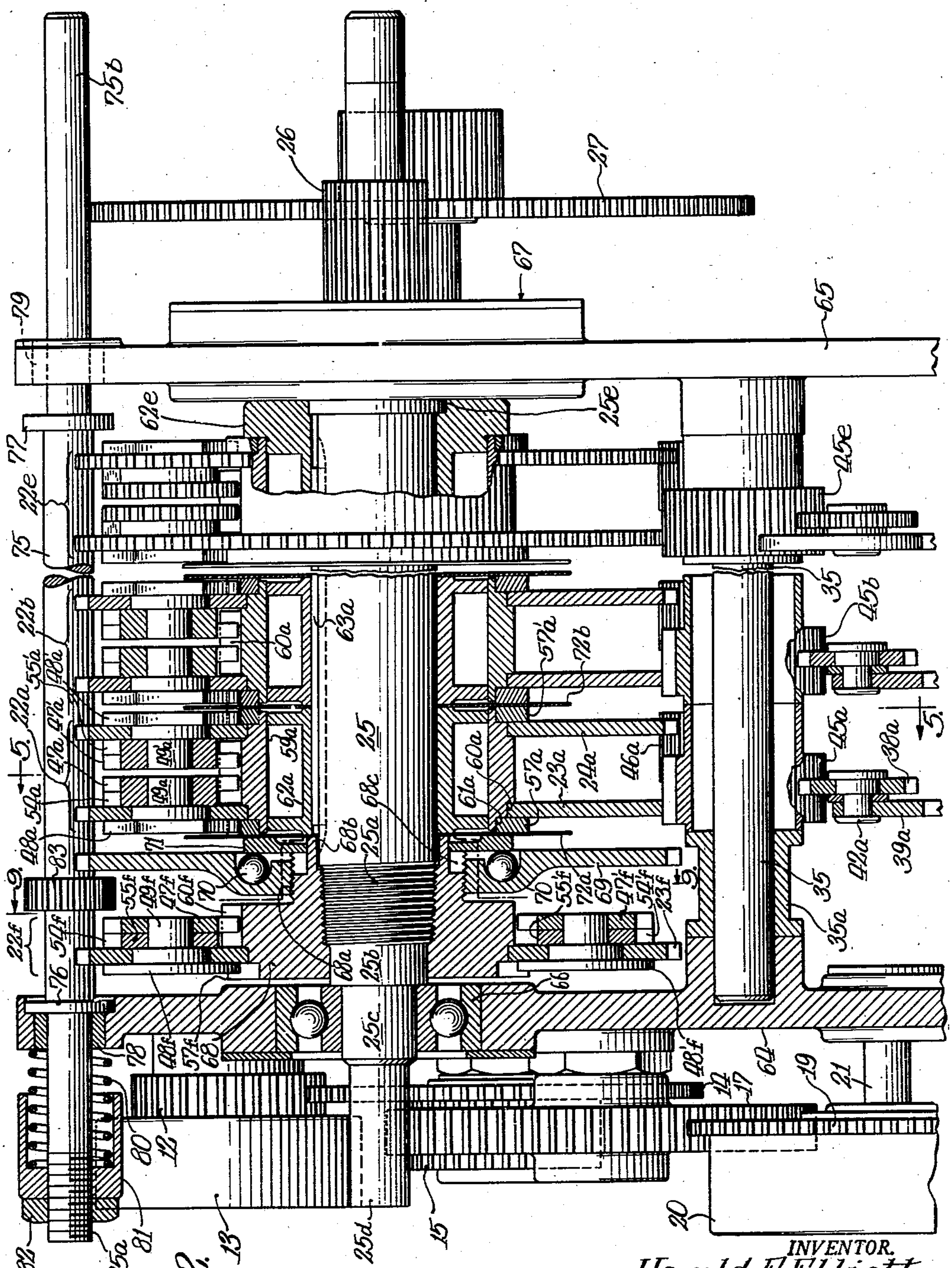

Fig. 2.

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CONTROL APPARATUS

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Fig. 3.

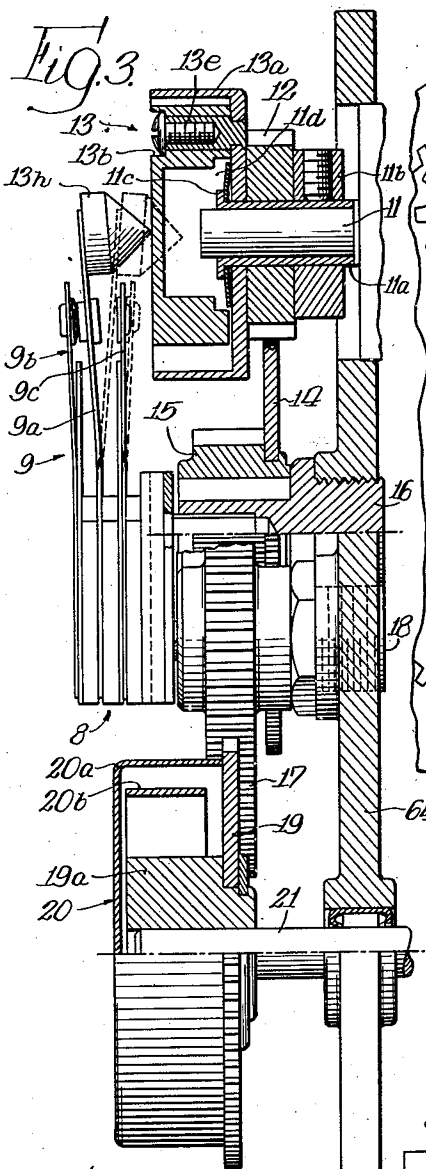


Fig. 9.

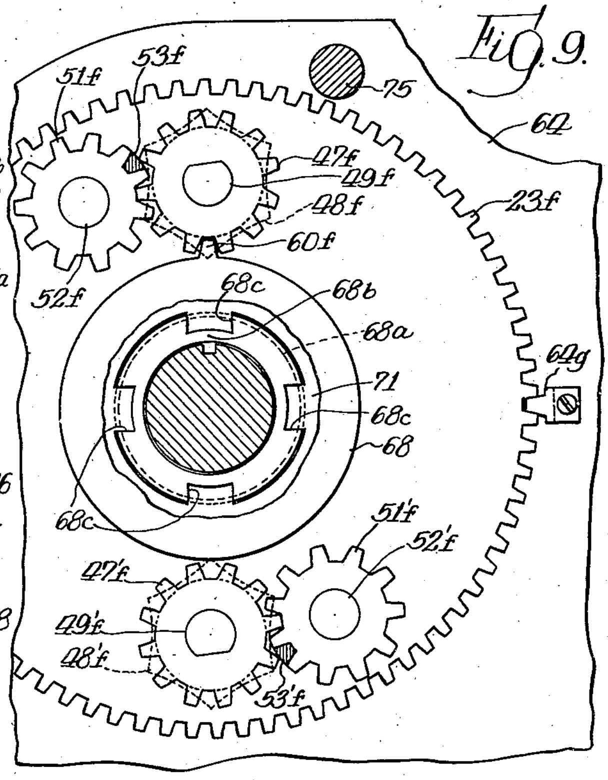


Fig. 8.

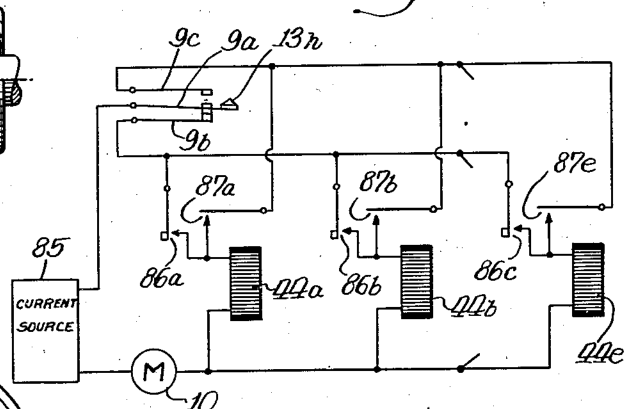
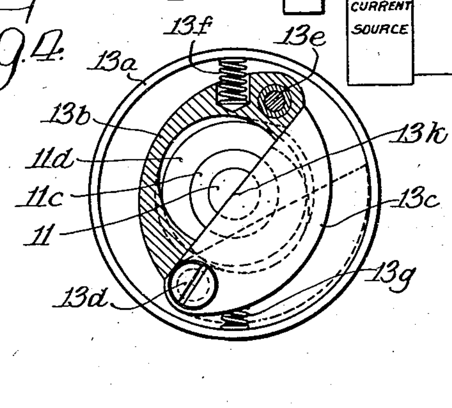


Fig. 4.



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CONTROL APPARATUS

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Fig. 5.

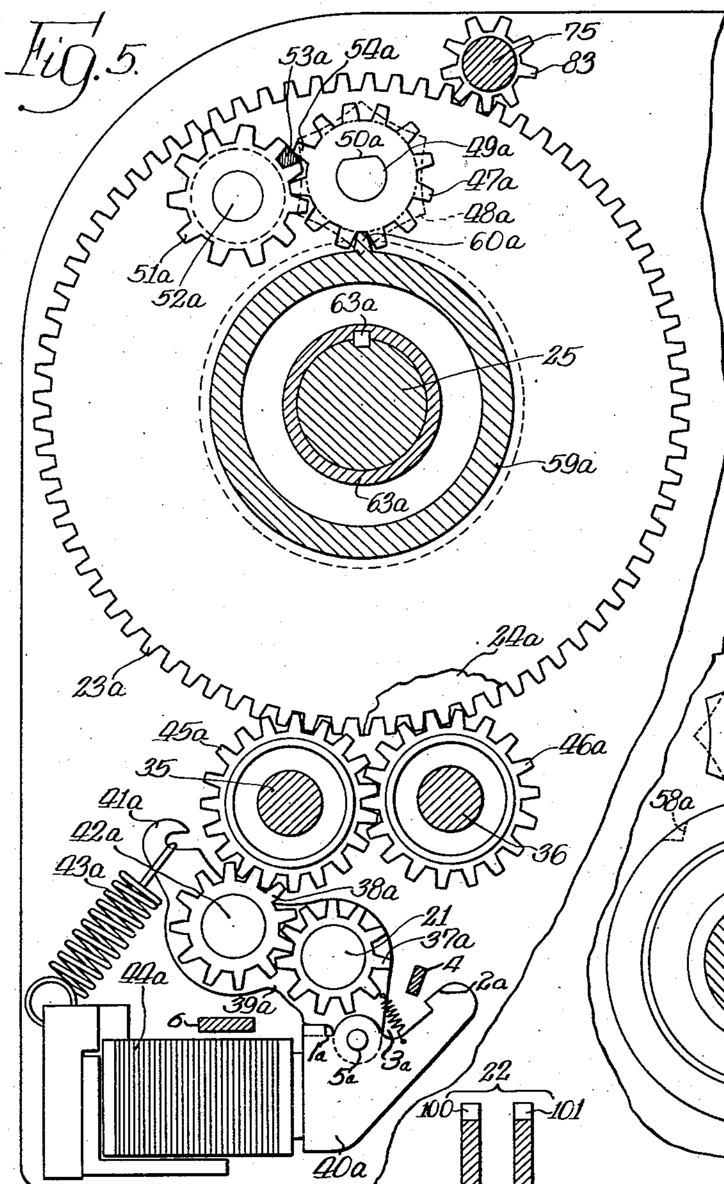


Fig. 7.

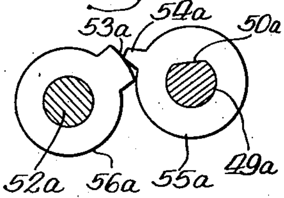
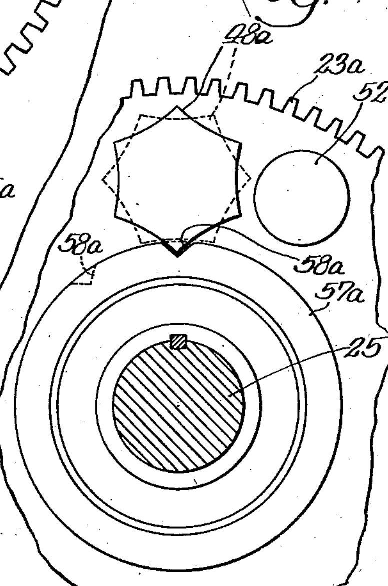


Fig. 6.



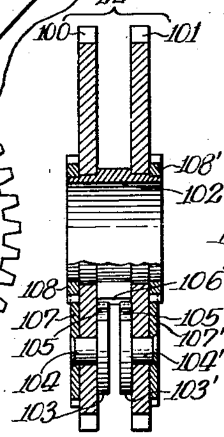
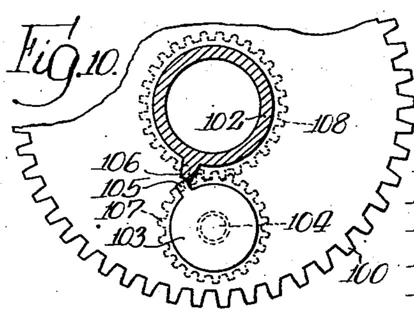


Fig. 11.

Fig. 10.



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2,411,618

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CONTROL APPARATUS

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Application December 16, 1943, Serial No. 514,462

21 Claims. (Cl. 74—10)

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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, the settable element of the tuning means is driven by a rotary control shaft and 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 rotary control shaft to the desired setting and then stop the same with precision accuracy, and also for permitting a wide range of adjustment of this shaft when actuated through others of the control units.

According to another object of the invention, a lost-motion mechanism of extremely rugged and compact construction, and yet permitting a large amount of relative movement between two of the parts thereof, is employed to establish a mechanical drive or locking connection between the two parts, thereby to enhance the accuracy with which a settable element operated through the mechanism may be moved to a predetermined setting.

In accordance with still another object of the invention, the space occupied by each lost-motion mechanism of each control unit is minimized by arranging parts thereof upon each of the two sides of the actuating element or member of the mechanism.

According to a still further object of the invention, a lost-motion mechanism of exceedingly

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small size is provided which includes improved facilities for supplying a powerful locking connection between the relatively movable parts of the mechanism when they are moved into predetermined relative positions.

In accordance with yet another object of the invention, all parts of the lost-motion mechanism are positively operated in order to prevent inadvertent relative movement therebetween and thus eliminate any possibility of the desired free travel range of the mechanism being reduced or exceeded during actuation of the mechanism.

According to still another object of the invention, the control units are arranged for selective operation by driving means common to the units, and improved connector facilities are provided for positively preventing the non-selected units from being inadvertently connected to the driving means.

It is a still further object of the invention to provide an improved and exceedingly rugged mechanism for limiting rotary movement of the rotary control shaft to a predetermined rotational range and for releasably locking the control units in different adjusted settings to provide for operation of the rotary control shaft to the particular predetermined settings which may be desired.

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 partially diagrammatic view illustrating the general arrangement of improved control apparatus characterized by the features of the present invention;

Fig. 2 is a fragmentary view, partially in section, illustrating the structural arrangement of those portions of the apparatus shown in Fig. 1 which are essential to an understanding of the present invention;

Fig. 3 is a side sectional view further illustrating the left end portion of the apparatus shown in Fig. 2;

Fig. 4 is an end view partially in section, illustrating the construction of the centrifugal switch provided in the apparatus;

Fig. 5 is a fragmentary end sectional view of the apparatus shown in Fig. 2 illustrating the construction of one of the control units provided in this apparatus;

Fig. 6 is a fragmentary end view of the control unit shown in Fig. 5, as viewed from the reverse side thereof;

Fig. 7 is a detail view illustrating the mode of coaction of two of the stop parts embodied in the control unit shown in Figs. 5 and 6;

Fig. 8 is a diagrammatic view illustrating the arrangement of the circuit provided to control the apparatus shown in Figs. 1 and 2;

Fig. 9 is a sectional view taken transversely through the apparatus shown in Fig. 2 to illustrate the details of the stop assembly provided in this apparatus;

Fig. 10 is an end elevation view of a modified control unit structure; and

Fig. 11 is a side sectional view of the modified control unit structure shown in Fig. 10.

Referring now to the drawings, and more particularly to Fig. 1 thereof, the control apparatus there illustrated is particularly adapted to be embodied in a radio receiving system for the purpose of selectively and automatically operating the frequency changing means of the system to different predetermined settings respectively corresponding to different predetermined signal channels. More specifically, the rotor plates of the tuning condensers provided in a radio receiving system may be mounted upon the rotor shaft **31** for rotation between predetermined limits defining the tuning range of the system. The identified shaft is adapted to be actuated to any one of a plurality of different settings, respectively corresponding to different signal channels or stations, by a single driving motor **10**. This motor is arranged to rotate the rotor shaft **31** through any one of a plurality of driving connections which commonly include the gears **12**, **14**, **15**, **17**, **19**, **26**, **27**, **29** and **30**, and also commonly include the three shafts **11**, **21** and **28**. Individually, the driving connections include different ones of a plurality of control units **22***a*, **22***b*, etc. One of these control units, i. e. the unit **22***a*, is illustrated in Fig. 1 of the drawings as comprising two enlarged driving gears or actuating members **23***a* and **24***a*, two pinions **46***a* and **45***a* which mesh with each other and respectively mesh with the gears **24***a* and **23***a*, and a connector mechanism which includes the two meshing pinions **38***a* and **37***a*, the first of which is adapted to be moved into meshing engagement with the pinion **45***a* and the second of which is mounted for rotation with the shaft **21**. Each control unit further comprises a pair of lost-motion mechanisms of the character shown in Figs. 2, 5, 6 and 7 of the drawings, through which driving and locking connections may be provided between the gears **23***a* and **24***a* and the shaft **25**. For the purpose of visually indicating the different settings to which the rotor shaft **31** may be actuated, an indicating gear **33** is provided which meshes with a gear **32** carried by the shaft **28** so that it will be rotated concurrently with rotation of the shaft **31**. At the front side thereof, the gear **33** may be provided with suitable scale markings which when indexed with a viewing window or line, identify the different predetermined settings of the rotor shaft **31**.

More specifically considered and as best shown in Fig. 2 of the drawings, all parts of the control apparatus illustrated in Fig. 1 are supported between or upon two spaced-apart parallel extending frame members **64** and **65**. These members have suitable tie rods extending therebetween for the purpose of providing an entirely rigid and rugged supporting structure. The motor **10** is mounted upon the frame member **64** at the rear side thereof and is provided with a rotor shaft **11** which extends through an opening in this frame member and carries the driving gear **12**.

As clearly shown in Fig. 3 of the drawings, the drive gear **12** is slip clutch connected to the projecting end of the motor shaft **11** by means of a slip clutch assembly which comprises a friction collar **11***b*, a sleeve **11***a* and a dish-shaped spring washer **11***d*. At its extreme left end, the shaft **11** also supports the movable parts of a centrifugal switch indicated generally at **13**. More in detail, the parts **11***b* and **11***d* of the slip clutch assembly, together with the housing cup **13***a* of the centrifugal switch **13**, are supported upon the sleeve **11***a* which is keyed or otherwise rigidly secured to the end of the shaft **11** for rotation therewith. The friction collar **11***b* is in turn set screw mounted upon the sleeve **11***a* so that the gear **12** and the bottom of the cup **13***a* are confined between this collar and the flange **11***c* of the sleeve **11***a* by means of the spring washer **11***d*. With this arrangement, the two parts **13***a* and **12** are mounted for rotation relative to the shaft **11** but are normally restrained against such relative movement by means of the spring washer **11***d* which is held under tension between the sleeve flange **11***c* and the adjacent inner surface of the bottom of the cup **13***a*. Within the rim of the cup **13***a* there are provided two centrifugally actuated parts **13***b* and **13***c* which, as shown in Fig. 4 of the drawings, are pivotally supported upon the bottom wall of the cup **13***a* at the opposed ends thereof by means of pivot assemblies **13***d* and **13***e*. These parts are hollowed out, as shown in Fig. 3, to provide a recess within which the end of the shaft **11**, the flange **11***c* and the friction washer **11***d* are received, and are provided with faces which meet on a line and are held in engagement by means of two small biasing springs **13***f* and **13***g*. The line of meeting engagement between the faces of the two centrifugal parts **13***b* and **13***c* is intersected by the axis of rotation of the shaft **11** and at this point of intersection, a prick punch recess **13***k* is provided to seat the point of a conical contact actuating element **13***h*. This element is carried by the free end of a movable contact spring **9***a* which is included in a contact spring assembly **9**, and is utilized to govern the operation of the motor **10** and the various control units **22** in the manner more fully pointed out below. This assembly includes three contact springs **9***a*, **9***b* and **9***c* which are insulated from each other and are mounted upon the supporting member **64** by means of a supporting assembly **8** of conventional arrangement. The center spring **9***a* is, through engagement of the actuating element **13***h* with the two centrifugal parts **13***b* and **13***c*, normally held under tension in a position such that the contact carried thereby engages the contact provided at the free end of the outer contact spring **9***b*. During rotation of the shaft, however, when the parts **13***b* and **13***c* of the centrifugal switch are pivoted radially outward from the axis of rotation of the shaft **11** against the biasing forces of the two springs **13***f* and **13***g*, the conical end of the element **13***h* enters the gap between the two parts permitting the contact carried by the spring **9***a* to engage the inner contact spring **9***c* and then move away from the engaged contact of the outer spring **9***b*.

The two gears **14** and **15** are rigidly connected for rotation together and are supported upon a bearing shaft **16** which is threaded into an opening provided in the supporting member **64**. Similarly, the gear 17 which meshes with the two gears 15 and 19 is rotatably supported by a stub shaft 18 which is threaded into the supporting member 64. A yielding connection indicated generally at 20 is utilized to transmit rotary movement from the gear 19 to the shaft 21, this connection comprising a spring member 20b which partially surrounds the hub 19a upon which the gear 19 is rotatably mounted, is anchored to this hub at one end and at the opposite end is anchored to a pin, not shown, extending outwardly from the face of the gear 19. The hub 19a is keyed or otherwise rigidly mounted for rotation with the shaft 21 and a housing cup 20a is utilized to enclose this hub and the spring member 20b which partially surrounds the same.

The six shafts 21, 35, 36, 25, 28 and 31 are also supported by the two frame members 64 and 65. Thus, and as shown in Fig. 3 of the drawings, roller bearings respectively carried by the two supporting members 64 and 65 are utilized as bearing supports for the shaft 21. The two idler pinion shafts 35 and 36 are each supported at the ends thereof within opposed openings provided with hubs formed integrally with the two supporting members and extending toward each other from the inner faces of these two members. Ball bearings 66 and 67 are utilized to support the rotary control shaft 25 at points inwardly of the opposed ends of this shaft. Similar bearing structures are utilized for the purpose of rotatably supporting the two shafts 28 and 31 upon the two supporting members 64 and 65. The bearing supports for these shafts are not shown in the interests of limiting the disclosure to those parts which are essential to an understanding of the present invention.

As shown in Fig. 2 of the drawings, the several control units are axially disposed along the rotary control shaft 25 and are of identical construction and arrangement. Accordingly, the arrangement of these units will be readily understood from a consideration of the control unit 22a, the parts of which are detailed in Figs. 2, 5, 6 and 7 of the drawings. This control unit is divided into two halves which are operative to rotate the shaft 25 to a predetermined setting from either direction and to provide a connection for locking this shaft against further rotation when the predetermined setting is reached. All parts of the unit are commonly supported upon a hub 59a which is spaced from the shaft 25 by means of a bushing 62a. The first half of the unit comprises an actuating member in the form of a gear 23a which is rotatably supported upon the stepped portion 60a of the hub 59a and meshes with the idler pinion 45a. At the outer side of the actuating member 23a, a detent collar 57a is provided which is seated upon the stepped portion 61a of the hub 59a and at its inner edge is rigidly secured to this hub. At the inner side of the actuating member 23a and spaced radially from the axis of the shaft 25, a pinion set is provided which comprises two meshing pinions 51a and 47a having different numbers of teeth. The first of these pinions is rotatably supported upon an axis pin 52a and the second pinion is mounted for rotation with an axis pin 49a journaled in an opening through the actuating member 23a. Upon the opposite or outer side of the actuating member 23a the pin 49a carries a star wheel 48a having six points which are connected by edge surfaces of concave arcuate configuration. Each of these surfaces has a radius which slightly exceeds the outer radius of the detent ring 57a, so that when any one thereof is riding over the periphery of the ring the angular position of the star wheel 48a relative to the actuating member 23a cannot be altered. At a predetermined point around the periphery thereof, the ring 57a is provided with a recess 58a into which the points of the star wheel may be successively rotated during succeeding revolutions of the actuating member 23a about the hub 59a.

For the purpose of rotating the meshing pinions 47a and 51a through a predetermined angle in response to rotation of the actuating member through one revolution about the hub 59a, this hub is provided at a predetermined point around its periphery with an axially extending rib or single gear tooth 60a which extends normal to the face of the actuating member 23a. This single gear tooth is arranged to mesh with different ones of the teeth of the pinion 47a during succeeding revolutions of the actuating member 23a about the hub 59a, whereby the meshing pinions 52a and 47a, the shaft 49a and the star wheel 48a are rotated through a predetermined angle relative to the actuating member 23a during each revolution of this member. In this regard it is noted that the angular settings of the star wheel 48a and the pinion 47a are so related to each other and to the relative angular positions of the detent 58a and the single tooth 60a that one of the points of the star wheel is brought into registry with the center of the detent 58a each time the tooth 60a engages one of the teeth of the pinion 47a. Assembly of the parts to provide this desired predetermined angular relationship therebetween is facilitated by making the star wheel 48a and the pin 49a of one-piece construction and by flatting the end of this pin as indicated at 50a to coact with a flatted portion of the opening in the pinion 47a through which the pin 49a extends. The two pinions 47a and 51a are provided with unlike numbers of teeth, the pinion 47a having a greater number of teeth than the pinion 51a such that the latter is rotated through more than one revolution for each revolution of the pinion 47a. Between these pinions and the inner side of the actuating member 23a there are provided two coacting stop parts 55a and 56a which are respectively carried by the pin 49a and the axis pin 52a. The part 55a is in the form of an annular ring having a single tooth 54a at the outer periphery thereof, and may be formed integrally with the pinion 47a. Alternatively, this part may be pinned or otherwise rigidly connected to the pinion 41a. The coacting part 56a is likewise in the form of an annular ring 56a having a blank double tooth 53a provided at a predetermined point around the peripheral surface thereof, and may either be formed integral with the pinion 51a or may be fixedly connected to this pinion.

With this arrangement, the single tooth 54a may be operated to engage the blanked out portion of the double tooth 53a when the two pinions 47a and 51a occupy predetermined relative positions. When these two parts are thus lockingly engaged, relative rotation between the two pinions 47a and 51a in one direction is prevented, where by upon rotation of the actuating member 23a to bring one of the teeth of the pinion 47a into engagement with the single tooth 60a of the hub 59a, a direct mechanical connection is provided between the actuating member 23a and the hub 59a. Relative rotation of the pinions 47a and 51a in the reverse direction, i. e. in a direction to move the engaged teeth 54a and 53a out of engagement, is permitted however. Because of the different numbers of teeth with which the two pinions 51a and 47a are respectively provided, no further engagement between the two locking teeth 54a and 53a can occur until after the pinion 47a has been reversely rotated a predetermined number of revolutions relative to the actuating member 23a. After a predetermined number of revolutions of the pinion 47a in the reverse direction, the two locking teeth 53a and 54a are of course moved back into engagement to establish a new locking connection between the actuating member 23a and the hub 59a.

From the above explanation it will be apparent that since the pinion 47a is rotated through only a fraction of a revolution in response to each revolution of the actuating member 23a about the hub 59a, a large number of revolutions of the actuating member are required in order to rotate the two stop parts 55a and 56a from one position in which the locking teeth 53a and 54a are engaged to a new position of engagement between these teeth. Thus, if the pinion 47a is provided with twelve teeth and the smaller pinion 51a is provided with eleven teeth, and the pinion 47a is rotated through a sixty degree angle defining two complete tooth points during each revolution of the actuating member 23a about the hub 59a, sixty-five revolutions of the acutating member 23a about the hub 59a are required in order to rotate the parts 56a and 55a from one point at which the teeth thereof are lockingly engaged to a second point at which these teeth are again moved into engagement. This lost motion between the two parts 59a and 23a of the control unit constitutes the range of free travel within which may be embraced all of the several predetermined settings which may be imparted to the rotor shaft 31 by the respective control units. As indicated above, the star wheel 48a, through its coaction with the detent ring 57a, functions to limit rotation of the two pinions 47a and 51a precisely to predetermined fractions of a revolution during each revolution of the actuating member 23a about the hub 59a. The arrangement is such that when the single tooth 60a of the hub is out of engagement with the teeth of the pinion 47a, one of the six concave peripheral surfaces of the star wheel rides over the periphery of the ring 57a to lock the shaft 50a and the two meshing pinions 47a and 51a against rotation relative to the actuating member 23a. When, however, the member 23a is rotated to engage one of the teeth of the pinion 47a with the tooth 60a, a point of the star wheel 48a is simultaneously brought into coincidence with the depression 58a permitting the connected parts 47a, 49a, 55a and 48a to be rotated relative to the member 23a. The extent of this rotation is of course limited to that required to bring the next succeeding concave surface of the star wheel back into sliding engagement with the periphery of the ring 57a. With a six point star wheel, the extent of rotation of the identified parts relative to the actuating member 23a is of course limited to an angle of sixty degrees, representing a tooth displacement of two teeth on the twelve tooth pinion 47a.

The structural arrangement of the second half of the control unit 22a exactly duplicates that just described. Thus, it will be noted that the actuating member 24a is rotatably supported upon a stepped portion of the hub 59a at the right end of this hub, and at a point radially disposed from the axis of the shaft 25, carries the four con-

nected parts 47a', 48a', 49a' and 55a' which are arranged to be rotated relative to the actuating member 24a by the single tooth 60a of the hub 59a. The star wheel 48a' is arranged to coact with a detent ring 57a' rigidly mounted upon a second stepped portion of the hub 59a to limit rotation of the pinion 47a' and the parts fixedly and pivotally connected therewith to a predetermined fraction of a revolution during each revolution of the actuating member 24a about the hub 59a.

As indicated above, the two actuating members 23a and 24a of the control unit 22a respectively mesh with idler pinions 45a and 46a which mesh with each other and are rotatably supported upon the shafts 35 and 36, respectively. The pinions 45 individual to the various control units are spaced along the shaft 35 and each thereof is provided with a toothed portion and a spacing portion. A sleeve 35a carried by the shaft 35 adjacent the left end thereof is utilized to prevent movement of the idler pinions 45 axially of the shaft and to thus maintain these pinions in meshing engagement with their respective associated actuating members 23. In an entirely similar manner, the pinions 46 carried by the shaft 36 are self-spacing and are rotatably supported by the shaft 36, a sleeve being provided at the left end of this shaft 36 to prevent axial movement of the pinions 46 along the shaft. The sleeve 62e, which supports the parts of the last control unit 22e upon the rotary control shaft 25, is provided with an extended flanged portion against which the hub of this control unit is adapted to be clamped. This portion of the sleeve 62e is also provided with an annular seat at the inner periphery thereof which is adapted to receive a flanged or ring portion 25e of the rotary control shaft. Thus, this shaft portion acts as a stop against which the hubs 59 of the various control units may be clamped to lock the same against rotary movement relative to the shaft 25. The bushings 62 are clamped against the ring portion 25e of the shaft by means of a clamping member 68 which is threaded onto a threaded portion 25a of the control shaft and is provided with an annular portion 68b, the rim of which is adapted to be clamped against the adjacent surface of the bushing 62a through a spring washer 72a. Similar spring washers are interposed between the sleeves and hubs of the respective control units along the shaft 25. These washers, together with the bushings 62, are keyed to the shaft 25 by means of a key 63a which lies within aligned keyways cut at the inner sides of the bushings and a keyway cut axially of the shaft 25. With this arrangement, the bushings 62 and the spring washers 72 may be clamped against the ring portion 25e of the shaft 25 by threading the clamping member 68 upon the threaded portion 25a of this shaft. The clamping pressure thus produced serves to prevent movement of the bushings axially of the shaft, and the key 63a serves to prevent relative rotary movement between the bushings and the shaft. The hubs 59 individual to the various control units are normally clamped to the shaft ring portion 25e for rotation with the bushings 62, but may be released for rotation to new settings relative to the shaft 25 by means of an improved releasable locking assembly.

This assembly comprises a locking washer or ring 71 having fingers received within slots 68c extending axially of the annular portion 68b of the clamping member 68 to prevent relative rotary movement between the two named parts. The assembly further comprises a traveling nut 69 which is threaded on the threaded portion **68a** of the clamping member **68** and is provided with gear teeth around the outer periphery thereof adapted for meshing engagement with a small gear **83** carried by a locking shaft **75**. Balls **70** disposed within a ball race formed in the front side of the traveling nut **69** are interposed between this nut and the locking washer **71** to reduce the frictional engagement between these two parts. The shaft **75** is journaled within sleeve bearings **78** and **79** respectively supported by the two supporting members **64** and **65**. It is slidable within these bearings between limits defined by engagement of the shaft rings **76** and **77** with the supporting members **64** and **65**. Normally this shaft **75** is biased to a position such that the ring **76** engages the supporting member **64** and the gear **83** is out of meshing engagement with the traveling nut **69**. This bias is provided by a coil spring **80** which surrounds the shaft and is tensioned between the supporting member **64** and a cup-shaped nut **81** threaded onto the left end of the shaft. A locking nut **82** also threaded onto the left end of the shaft **25** is utilized to lock the cup-shaped nut **81** against rotation once the position of this nut upon the shaft has been established to properly tension the spring **80**.

For the purpose of limiting rotation of the shaft **25** to a predetermined range which embraces all of the desired predetermined settings of the rotor shaft **31**, a lost-motion, shaft locking assembly **22f** is provided which is substantially similar to each of the two lost-motion mechanisms provided in each of the control units **22**. In brief, this locking assembly comprises a stationary member **23f** within which a stepped portion of the clamping member **68** is journaled so that relative rotary movement may occur between the two parts, and a detent ring **57f** which is rigidly mounted upon a second stepped portion of the clamping member **68** to retain the member **23f** upon the clamping member. The member **23f** rotatably supports two sets of lost-motion pinions which are exact duplicates of that shown in Figs. 5 and 7 of the drawings. As shown in Figs. 2 and 9, the first set of lost-motion pinions comprises a pinion **47f**, a stop part **55f** having a locking tooth **54f** at the periphery thereof, an axis pin **49f** and a star wheel **48f** arranged to coact with the detent ring **57f**. These four connected parts are arranged to be rotated relative to the member **23f** as a unit and are actuated through engagement of the teeth of the pinion **47f** with a single tooth **60f** provided at the periphery of the clamping member **68**. The pinion **47f** meshes with a pinion **51f** having a lesser number of teeth which is pivotally supported by an axis pin **52f**. This pin also rotatably supports a stop part **56f** which is rotatable with the pinion **51f** and carries a blank double tooth **53f** arranged for engagement with the tooth **54f**. The second set of lost-motion pinions, i. e. that comprising the seven parts **47f′**, **48f′**, **49f′**, **51f′**, **52f′**, **55f′** and **56f′** is of identical arrangement, and is also actuated by the tooth **60f** of the clamping member **68**. With the above-described arrangement of the locking assembly **22f**, the shaft **25** can only be rotated in one direction until a locking connection is established between this shaft and the stationary member **23f** through the parts of the pinion set which comprises the pinion **47f**, for example. In an entirely similar manner, the shaft **25** can only be rotated in the reverse direction until a locking connection is established between this shaft and the stationary member **23f** through the parts of the other lost-motion pinion set, i. e. that comprising the pinion **47f′**. In this regard, it is noted that the stationary member **23f** is provided with gear teeth around the periphery thereof, any one of which may be engaged with a bracket **64g** extending outwardly from the supporting member **64f** to prevent rotation of this member. It is noted further, that the two lost-motion pinion sets are provided to limit the rotation of the shaft **25** to a range which is substantially less than the free travel range of either pinion set considered alone. As a result, standard parts may not only be used in the manufacture of the several control units **22a** to **22e** inclusive, but these same parts may be used in making up the locking assembly **22f**. Thus, all parts of this assembly, including the detent ring **57f**, are exact duplicates of the corresponding parts making up the control unit **22a**, for example, with the exception that the member **23f** is provided with two openings instead of one in order to make provisions for supporting the two sets of lost-motion pinions.

For the purpose of selectively connecting the shaft **21** in driving relationship with the actuating members **23** and **24** of any one of the control units **22a** to **22e** inclusive, these units are respectively provided with individual connector assemblies. Thus the control unit **22a** is provided with a connector assembly which comprises a pinion **37a** mounted for rotation with the shaft **21** and meshing with an idler pinion **38a**. This idler pinion is rotatably supported by means of a pivot pin **42a** upon a two piece rocker arm **39a** which is loosely mounted upon the shaft **21**. It is adapted for meshing engagement with the pinion **45a**, but the arm **39a** is normally restrained by a biasing spring **43a** to a position in engagement with a stop bar **6**, such that the two identified pinions are disengaged. More specifically, the spring **43a** is tensioned between one end **41a** of the arm **39a** and a tie bar which extends transversely between the two supporting members **64** and **65**. At its opposite end, the rocker arm **39a** is provided with an armature piece **40a** which is adapted to be attracted into engagement with the projecting core and of an electromagnet **44a**, thereby to move the idler pinion **38a** into meshing engagement with the pinion **45a**. The electromagnets **44**, individual to the various control units, are all bolted or otherwise rigidly secured to a crossbar which extends transversely between and is anchored at its end to the two supporting members **64** and **65**.

More specifically, the armature piece **40a** is pivotally supported by means of an axis pin **5a** upon the lower end of the arm **39a**. It includes a catch portion **2a** which is normally biased to engage a catch bar **4** by means of a coil spring **3a** connected between the two parts **39a** and **40a**. Coacting stop means **1a** are also provided to furnish a force transmitting connection between the two parts **39a** and **40a** when the magnet **44a** is energized. Two stop bars **4** and **6** are common to the several connector assemblies and extend transversely between the two supporting members **64** and **65**.

With the above-described connector arrangement, the catch portion **2a** of the armature piece **40a** normally engages the catch bar **4** to lock the arm **39a** in a position such that the gear **38a** is prevented from engaging the gear **45a**. Thus during rotation of the shaft **21**, the two gears 38a and 45a are positively locked against engagement when the magnet 44a is deenergized. This locking connection is important since the shaft 21 is rotated in a direction to pivot the arm 39a toward the gear 45a and hence if the friction between the identified shaft and arm should become sufficiently great, through an accumulation of dirt between the engaging surfaces thereof, inadvertent engagement of the two gears 38a and 45a could be produced in the absence of the locking connection.

When the magnet 44a is energized, the armature piece 40a is first pivoted about its axis pin 5a to disengage the catch portion 2a thereof from the catch bar 4. During continued rotation of the armature piece, the stops 1a are engaged, following which the arm 39a is pivoted against the bias of the spring 43 to bring the gear 38a into engagement with the gear 45a, thereby to establish a connection for driving the parts of the control unit 22a.

The motor 10 is of the unidirectional type and is arranged so that its rotor is rotated to drive the shaft 21 in a clockwise direction as viewed in Fig. 5 of the drawings. With the shaft 21 rotating in this direction, the idler pinions 38 are rotated in a counterclockwise direction. Accordingly, when any selected idler pinion 38 is actuated into meshing engagement with its associated pinion 45, the meshing engagement between the two named parts produces a force which tends to pull the idler pinion 38 into meshing engagement with the associated pinion 45. Thus the two pinions are locked in mesh during the tuning operation. The mechanical pressure urging the armature piece 40 of the rocker arm in the selected unit toward the magnet core of the magnet in this unit occurs concurrently with the electrical attraction of the armature piece by the core, whereby the magnet is aided in operating the movable parts of the clutch assembled. The magnets 44, therefore, need only be large enough to attract their associated armature pieces into engagement with the cores provided therein. This utilization of the mechanical reaction between any one of the pinions 38 and its associated pinion 45 provides for the use of relatively small magnets 44, since each magnet merely functions to initially engage the two associated pinions 38 and 45; the pull of the pinion 38 into meshing engagement with the associated pinion 45 being sufficient to maintain the geared or interlocked engagement between the two elements so long as the shaft 21 is rotating. The spring member 20b through which the shaft 21 is driven by the motor 10 insures positive disengagement of the idler pinion 38 in any actuated connector assembly when the electromagnet 44 of the assembly is deenergized upon completion of a tuning operation. As best shown in Fig. 1 of the drawings, each magnet structure 44 also includes a pair of contact springs 87a which are normally disengaged, are insulated from each other, and are adapted to be moved into engagement when the associated armature piece 40a is attracted to the core of the associated magnet 44.

For the purpose of energizing the motor 10 and selectively controlling the energization of the magnets 44 individual to the several control units 22a to 22e inclusive, the control circuit illustrated in Fig. 8 of the drawings may be employed. Briefly considered, this circuit comprises a suitable source of current 85 from which current is derived for energizing the motor 10 and for selectively energizing the magnets 44. In order selectively to control the energization of the motor 10 and the magnets 44, switching equipment is provided which includes the three contact springs of the centrifugally actuated spring assembly 9, push button switches 86 individual to the various control units, and the locking contact springs 87 individually controlled by the magnets 44.

In considering the operation of the above-described control apparatus, it may be assumed that this apparatus is to be utilized to rotate the rotor shaft 31 to the particular setting corresponding to the control unit 22a, thereby to tune the receiver for the reception of a signal or signals radiated at the particular carrier frequency to which the control unit 22a corresponds. In order to initiate the operation of this control unit, the push button switch 86a is actuated to its closed circuit position, thereby to complete a circuit for energizing the connector magnet 44a individual to the control unit 22a in series with the driving motor 10. When energized in this circuit, the magnet 44a attracts its associated armature piece 40a, whereby the rocker arm 39a is pivoted about the shaft 21 against the bias of the retracting spring 43a to move the idler pinion 38a into meshing engagement with the pinion 45a. In attracting its armature piece 40a, the magnet 44a also closes the contacts 87a to prepare a circuit for holding the magnet 44a and the motor 10 energized after the nonlocking push button 86a is released. When the two pinions 38a and 45a are engaged, a driving connection is established between the motor 10 and the actuating members 23a and 24a of the control unit 22a. This connection comprises the shaft 11, the slip clutch between this shaft and the gear 12, the gears 12, 14, 15, 17 and 19, and the yielding spring member 20b which connects the gear 19 and the shaft 21 through the hub 19a. Assuming that the shaft 21, as viewed in Fig. 5 of the drawings, is rotated in a clockwise direction through this driving connection, the two pinions 45a and 46a are respectively rotated in clockwise and counterclockwise directions. Accordingly, the actuating member 23a is rotated in a counterclockwise direction, as viewed in Fig. 5 of the drawings. The actuating member 24a on the other hand, is driven in the reverse direction by the pinion 46a, i. e., a clockwise direction, as viewed in Fig. 5 of the drawings. During each revolution of the actuating member 23a about the hub 59a, the two pinions 47a and 51a are pivoted through fractions of a revolution relative to the actuating member. Thus each time the actuating member 23a is rotated to a position wherein one of the teeth of pinion 47a engages a single tooth 60a of the hub 59a a driving connection is established for rotating the pinion 47a, the shaft 49a and the star wheel 48a relative to the actuating member 23a. As previously indicated, such engagement occurs when one of the points of the star wheel 48a coincides with the depression 58a in the ring 57a. Accordingly, the star wheel 48a is prevented from locking the pinion 47a and hence the actuating member 23a against rotation. As the three connected parts, 47a, 49a and 48a are rotated relative to the actuating member 23a, the tooth 60a passes out of engagement with the engaged tooth of the pinion 47a and the star wheel 48a is rotated to a position wherein the concave surface thereof which next follows the star point engaged with the depression 58a is slidably engaged with the periphery of the ring 57a. Incident to the described part revolution of the pinion **47a** relative to the actuating member **23a**, the pinion **51a** is likewise rotated through a corresponding fraction of a revolution relative to this member.

Rotation of the actuating member **23a** about the hub **59a** continues until such time as the parts **47a**, **51a**, **55a**, and **56a** occupy angular positions wherein the tooth **54a** engages the blanked double tooth **53a**. As will be evident from the above explanation, depending upon the initial setting of the lost-motion mechanism associated with the actuating member **23a**, a variable number of revolutions of this member about the hub **59a** will be required before the locking teeth **54a** and **53a** are moved into engagement. When such engagement occurs, a direct mechanical connection, which may be utilized either for locking or driving the shaft **25** in the manner explained below, is provided between the actuating member **23a** and the rotary control shaft **25**. This connection comprises the engaged locking teeth **54a** and **53a**, the two stop parts **55a** and **56a**, the meshing teeth of the two pinions **47a** and **51a**, the single hub tooth **60a** and the tooth of the pinion **47a** engaged thereby, the hub **59a**, the clamping connection between this hub and the bushing **62a**, and the key connection comprising the key **53a** between the bushing **62a** and the shaft **25**.

In a manner entirely similar to that just described, rotation of the actuating member **24a** in the reverse direction about the hub **59a** is utilized to actuate the lost-motion parts associated with this actuating member until the locking teeth **54a'** and **53a'** of the two stop parts provided therein are moved into engagement. The engagement between the identified teeth of these two stop parts likewise provides a direct drive mechanical connection between the actuating member **24** and the shaft **25**.

From the above explanation it will be apparent that depending upon the initial setting of the control unit **22a**, the rotary control shaft **25** will be rotated in one direction or the other by one of the two actuating members **23a** or **24a**. Thus, if the tooth **54a** of the stop part **55** is rotated to engage the blanked double tooth **53a** of the stop part **56a** before the corresponding locking teeth of the two stop parts **55a'** and **56a'** are engaged, the rotary control shaft will be rotated in a counterclockwise direction, as viewed in Fig. 5 of the drawings, to the predetermined setting to which the control unit **22a** corresponds. Conversely, if the locking teeth of the two stop parts **55a'** and **56a'** are moved into engagement before the locking teeth of the two stop parts **55a** and **56a** are engaged, the rotary control shaft **25** will be rotated in a clockwise direction as seen in Fig. 5 of the drawings, to the predetermined setting corresponding to the control unit **22a**. In either case, the rotary control shaft will be rotated at the speed of the actuating member **23a** or **24a** with which it is mechanically connected until the nonengaged locking teeth are brought into engagement. Also, when the shaft **25** is rotated in one direction or the other, the rotor shaft **31** is rotated in a corresponding direction through the driving connection afforded by the gears **26** and **27**, the shaft **28**, and the gears **29** and **30**. The display gear **33** is likewise rotated by the control shaft **25** through the driving connection provided by the gears **26** and **27**, the shaft **28** and the gear **32**.

When both of the teeth **54a** and **54a'** are moved into engagement with their respective associated teeth **53a** and **53a'**, a locking connection is obviously established which prevents continued rotation of the actuating members **23a** and **24a**, the lost-motion parts associated with these two actuating members, the pinions **45a**, **46a**, **38a** and **37a**, and the shaft **21**. Thus the entire gear train extending back to the motor drive shaft **11** is locked up when the rotary control shaft **25** is rotated to the predetermined setting corresponding to the actuated control unit **22a**. After this train has been locked up, continued rotation of the motor shaft **11** is permitted through the described slip clutch connection between this shaft and the motor drive gear **12**. Rotation of the rotor shaft **31** and the display gear **33** is also obviously arrested when rotation of the control shaft **25** is stopped. The shaft **25** is stopped in the particular angular setting to which the control unit **22a** corresponds and this setting is identified by the indication displayed by the gear **33**.

As indicated above, energization of the electromagnet **44a** and the driving motor **10** is initially produced in response to actuation of the push button switch **86a**, this circuit being completed through the engaged contact springs **9a** and **9b** of the assembly **9**. It is also explained above that when the magnet **44a** attracts its armature piece **40a** to initiate operation of the control unit **22a**, the contact springs **87a** are engaged to prepare a locking circuit for the magnet **44a** and the motor **10**. As the shaft **11**, the gear **12** and the parts of the centrifugal switch **13** are brought up to speed following energization of the motor **10**, the centrifugally actuated elements **13b** and **13c** of the switch **13** are pivoted away from the axis of rotation of the shaft **11** to provide a gap between the normally engaged faces thereof. As the width of this gap increases with increasing speed of rotation of the shaft **11**, the conical point of the element **13a** enters this gap with the result that the center contact spring **9a** is moved to the right to the dash line position illustrated in Fig. 3 of the drawings. During such movement of the contact spring **9a**, one of the contacts carried thereby is moved into engagement with the contact carried by the spring **9c**. Thereafter the engaged contacts carried by the contact springs **9a** and **9b** are moved out of engagement. When the contact springs **9a** and **9c** are thus electrically engaged, a locking circuit is completed through the engaged contacts **87a** for sustaining the energization of the magnet **44a** and the motor **10**, independently of the position of the push button switch **86a**. Thereafter and when the element **13h** is moved to a position such that the contact springs **9a** and **9b** are electrically disengaged, the initial operating circuit for the magnet **44a** and the motor **10** is opened.

After the shafts **25** and **31** have been operated to the predetermined settings to which the control unit **22a** corresponds, such that the entire gear train extending back to the motor shaft **11** is locked up, rotation of the centrifugal switch **13** is arrested. When this occurs, the centrifugally actuated parts **13b** and **13c** are pivoted back into engagement under the influence of the springs **13f** and **13g**. As these parts are moved back to normal, the conical point of the element **13h** is squeezed from between the two parts **13b** and **13c** with the result that it is moved back to its normal position. Incident to this movement of the element **13h**, the contact springs **9a** and **9c** are electrically disengaged to interrupt the locking circuit for the magnet **44***a* and the motor **10**. Thus, these two circuit elements are deenergized. Also incident to the return movement of the contact actuating element **13***h*, the contact springs **9***a* and **9***b* are again electrically engaged, thereby to reprepare the parallel circuits for energizing any selected one of the magnets **44** in series with the motor **10**. From the above explanation it will be understood that only momentary operation of the nonlocking push button switch **86***a* is required in order to initiate operation of the control unit **22***a* and to insure that this unit will continue to operate until the rotary control shaft **25** and the rotor shaft **31** are rotated to the respective predetermined settings corresponding to the control unit **22***a*. It will also be understood that when these settings are established, the circuit elements **44***a* and **10** are automatically deenergized.

The manner in which the remaining control units **22***b* to **22***e* inclusive, may, through selective actuation of the push button switches **86***b*, **86***e*, etc., be actuated for the purpose of driving the rotor shaft **31** to its other predetermined settings, will be clearly apparent from the above explanation with reference to the operation of the control unit **22***a*. During the above-described rotation of the shaft **25** to drive the rotor shaft **31** to the particular setting corresponding to the control unit **22***a*, certain of the movable parts of the nonactive control units are also moved to produce unlocking relative movement between the locking teeth of the stop parts of one of the lost-motion mechanisms provided in each unit. In this regard it will be understood that as the shaft **25** is rotated, all of the hubs **59** 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 **22***a* when the shaft **25** is driven to another predetermined setting by another of the control units. Thus, it may be assumed that after the shaft **25** is operated to the setting corresponding to the control unit **22***a*, such that the locking teeth **54***a* and **54***a'* respectively engage the locking teeth **53***a* and **53***a'*, the shaft **25** is rotated in a counterclockwise direction, as viewed in Fig. 5 of the drawings, by a second control unit to a new setting. During such rotation of the shaft **25**, the locking teeth **54***a'* and **53***a'* remain in engagement to prevent relative movement between the hub **59***a*, the actuating member **24***a* and the parts of the lost-motion mechanism carried by this actuating member. Thus, the actuating member **24***a* is rotated in a counterclockwise direction, and is rendered operative to drive the actuating member **23***a* in a clockwise direction through the driving connection afforded by the meshing pinions **46***a* and **45***a*. The relative movement thus produced between the actuating member **23***a* and the hub **59***a* by rotating these two elements in opposite directions causes the pinions **47***a* and **51***a* and the stop parts **55***a* and **56***a* to be rotated in directions such that the locking teeth **54***a* and **53***a* are disengaged. Thus, during each revolution of relative movement between the two parts **59***a* and **23***a*, the pinion **47***a* is rotated through an angle of 60 degrees in a clockwise direction relative to the actuating member **23***a* and the pinion **51***a* is rotated through a corresponding angle in the reverse direction. The teeth **53***a* and **54***a* are progressively disengaged as the two pinions are intermittently rotated relative to the actuating member **23***a* in the directions indicated.

Assuming now that the shaft **25** is rotated in a clockwise direction away from the predetermined setting corresponding to the control unit **22***a*, the actuating member **23***a* of this unit is rotated in the same direction due to the engagement of the locking teeth **53***a* and **54***a*. Through the driving connection afforded by the pinions **46***a* and **45***a*, this actuating member rotates the actuating member **24***a* in a counterclockwise direction relative to the shaft **25**. With the two elements **59***a* and **24***a* thus rotating in opposite directions, the pinions **47***a'* and **51***a'* are intermittently rotated relative to the actuating member **24***a* to produce progressive disengagement of the locking teeth carried by the stop parts **55***a'* and **56***a'*. The extent to which these two stop parts are moved along the free travel range between the locking limits therebetween is of course determined by the amount of movement required to actuate the shaft **25** to its new setting.

From the above explanation it will be clearly apparent that the shaft **25** and the rotor shaft **31** 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 **31**, 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 lost-motion mechanisms as provided in each control unit, permit the shaft **25** to be freely, accurately and positively driven in either direction to any one of the predetermined settings respectively corresponding to the several control units.

As indicated above, the locking assembly **22***f* is provided to define the rotational range of the rotary control shaft **25** and hence the range of rotation of the rotor shaft **31**. Thus, as the shaft **25** is continuously rotated in one direction, the pinions **47***f* and **51***f* supported by the stationary member **23***f* are intermittently rotated to actuate the stop parts **55***f* and **56***f* until they occupy relative positions such that the locking teeth **54***f* and **53***f* are engaged. When this occurs, the shaft **25** is obviously locked against further rotation in the direction of rotation utilized to effect engagement of the two identified locking teeth. Also during the described rotation of the shaft **25**, the parts **47***f'*, **51***f'*, **55***f'* and **56***f'* are likewise intermittently rotated relative to the stationary member **23***f* through engagement of the single tooth **60***f* with different ones of the teeth carried by the pinion **47***f*. Before the locking teeth **54***f'* and **53***f'* can be moved into engagement, however, the locking teeth carried by the stop parts **55***f* and **56***f* are engaged to stop rotation of the shaft. In a similar manner, when the shaft **25** is rotated in the reverse direction, the stop parts as actuated in response to alternate engagement of the pinions **47***f* and **47***f'* by the tooth **60***f*, are concurrently actuated toward locking positions. In this case, the locking teeth **54***f'* and **53***f'* are engaged to arrest the rotation of the shaft **25** before the locking teeth of the two other stop parts are engaged. Thus it will be apparent that the two pinion sets as provided in the control unit **22***f*, function to limit rotation of the shaft **25** to a predetermined rotational range. Obviously, this range may be shifted at will by unlocking the member **23***f*, rotating this member, the clamping member 60h and the shaft 25 in unison, and then reestablishing the locking connection between the member 23f and the supporting member 64.

In order to adjust the various control units relative to the rotary control shaft 25, thereby to provide for operation of this shaft and the shaft 31 to the desired predetermined settings by these units, the shaft 75b is pulled out against the force exerted by the spring 80 until the pinion 83 carried thereby engages the toothed periphery of the traveling nut 69. The shaft 75b is now rotated to drive the traveling nut in a direction which would back this nut away from the clamping washer 71 but for the freedom of movement of the shaft 25 and the clamping member 68. Rotation of the identified parts is continued until one limit of the rotational range of the shaft 25 as defined through the action of the locking assembly 22f is reached in the manner just explained. When this occurs, the clamping member 68 and the shaft 25 are locked against further rotation. Accordingly, if rotation of the shaft 75 is continued in the same direction, the traveling nut 69 is backed away from the locking washer 71 to remove the clamping pressure applied axially of the shaft 25 against the hubs 59 of the several control units. Rotation of the traveling nut 69 relative to the clamping member 68 is continued until the left side surface thereof is brought into tight clamping engagement with the opposed surface of the clamping member, thereby to provide a friction drive between these two parts which may be utilized in rotating the parts 69, 68 and 25 in the reverse direction. At this point it is noted that the amount of movement of the traveling nut 69 required to effect the described clamping engagement between this nut and the clamping member 68 is insufficient to permit the antifriction balls 70 from dropping out of the ball race in which they are disposed. Also, the spring washers 72 engage the stepped hubs 59 with sufficient pressure to prevent the hubs from being rotated relative to their supporting bushings 62 during rotation of the shaft 75 to drive the rotary control shaft 25.

After the shaft 75 has been rotated to release the hubs 59 for movement relative to their respective supporting bushings 62 and to produce clamping engagement between the two parts 68 and 69, this shaft may be reversely rotated for the purpose of driving the rotary control shaft 25 and the connected rotor shaft 31 of the tuning means to the particular settings at which the desired station or signal channel is tuned in by the associated receiver. While the shafts 31 and 25 are held in these settings by manually restraining the shaft 75 against rotation, the switch 86 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 10 and the electromagnet 44 of the selected control unit. The motor 10 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 the locking fingers 54 and 53 of one of the two lost-motion mechanisms provided in the unit are engaged, the hub 59 is rotated relative to the shaft 25 and the bushing 62 upon which the control unit is supported. Thus the selected control unit is actuated to a position relative to the rotary control shaft 25, such that when the shaft and the hub 59 of the unit are subsequently locked together, the control unit can thereafter only rotate the rotary control shaft to the particular setting which it occupies when the locking operation is completed. The above-described procedure, i. e. that of utilizing the shaft 75 manually to rotate the rotary control shaft 25 and the rotor shaft 31 to different desired settings, may be repeated for each of the other control units 22 in order to establish the other desired predetermined settings for the two named shafts. During each setting operation, the control units which are not being adjusted are maintained in adjustment because of the fact that the frictional engagement of their hubs 59 with the spring washers 72 is sufficient to maintain the established positions of these hubs relative to the shaft 25. When all of the control units 22 have been adjusted, the shaft 75 is rotated to drive the traveling nut 69 in a direction which would bring the balls 70 back into clamping engagement with the clamping washer 71 but for the frictional engagement between this nut and the clamping member 68, and the consequent rotation of the shaft 25 and the clamping member 68 with the traveling nut. Rotation of the three identified parts continues until arrested through the action of the stop assembly 22f in the manner explained above. When the shaft 25 and the clamping member 68 are thus locked against further rotation, continued rotation of the shaft 75 serves to rotate the traveling nut 69 relative to the clamping member 68 in a direction such that the threaded engagement between the parts causes the traveling nut and the clamping washer 71 to be moved axially of the shaft 25 until a clamping pressure is again exerted against the stacked hubs 59. When this clamping pressure is restored, the hubs 59 are positively locked to the shaft 25 to prevent relative rotation therebetween. Thus, the adjusting operations are completed.

Referring now more particularly to Figs. 10 and 11 of the drawings, the modified embodiment of the control unit 22 there illustrated may be directly substituted for the control units described above and utilized in the apparatus shown in Figs. 1 and 2 of the drawings. In brief, this modified control unit comprises a hub 102 having stepped surfaces upon which the two actuating members 100 and 101 are rotatably supported. At the outer sides of the actuating members 100 and 101 and at the extreme ends of the hub 102, gears 108 and 108′ are seated upon additional stepped portions of the hub 102. These gears are rigidly connected to the hub 102 and serve to retain the actuating members 100 and 101 upon the bearing surfaces of this hub. They respectively mesh with gears 107 and 107′ disposed upon the outer sides of the two actuating members 100 and 101 and mounted for rotation with pins 104 and 104′ which are journaled within openings through the respective associated actuating members. At the inner sides of the two actuating members, the pins 104 and 104′ are respectively provided with stop parts in the form of rings 103 and 103′ having teeth 105 and 105′ around the respective peripheries thereof which are adapted to be moved into locking engagement with a single locking tooth 106 formed integral with the hub 102 intermediate the two actuating members 100 and 101. More specifically, the three connected parts 103, 104 and 107 are rotated as a unit relative to the actuating member 100 in response to rotation of this member about the hub 102. Similarly, the three connected parts 103', 104' and 107' are rotated as a unit relative to the actuating member 101 in response to rotation of this member about the hub 102. It will be understood, therefore, that by providing the gear 107 with a different number of teeth than the gear 108 such that the first mentioned gear is rotated through more than one revolution relative to the actuating member 100 during each revolution of this member about the hub 102, several revolutions of the actuating member 100 about the hub 102 will be required in order to rotate the stop part 103 from one position wherein the locking teeth 105 and 106 are engaged, to a position wherein these teeth are reengaged. Thus, if the gear 108 is provided with thirty-five teeth and the smaller gear 107 is provided with twenty-six teeth, twenty-five and a fraction turns of the actuating member 100 about the hub 102 are required in order to rotate the stop part 103 from one setting wherein the teeth 105 and 106 are engaged to a second setting wherein the teeth are reengaged. This represents the free travel range of the actuating member 100 relative to the hub 102 and a rotary control shaft upon which this hub may be fixedly mounted. In a similar manner, the difference between the number of teeth with which the gear 108' is provided and the number of teeth of the gear 107' determines the free travel range of the actuating member 101 relative to the hub 102. Also, and as will be apparent from the foregoing description of the apparatus shown in Fig. 2 of the drawings, the actuating members 100 and 101 are arranged for rotation in opposite directions during operation of the control unit to move a rotary control shaft upon which the hub 102 is mounted to a predetermined setting. It will be understood, therefore, that in utilizing this unit to rotate the control shaft in one direction to the predetermined setting, a direct drive connection is provided between the actuating member 100 and the shaft when the stop part 103 is rotated to a position wherein the locking tooth 105 thereof engages the locking tooth 106 of the hub 102. It will also be apparent that when thereafter the stop part 103' is rotated to a setting wherein the locking tooth 105' also engages the tooth 106, the entire control unit will be locked up to prevent further rotation of the rotary control shaft. If it is necessary to rotate this shaft in the reverse direction to the predetermined setting to which the control unit 22 corresponds, the drive connection will first be established through engagement of the tooth 105' with the tooth 106, following which the locking connection will be established through engagement of the locking tooth 105 with the tooth 106. Aside from the differences just pointed out, the control unit 22 as shown in Figs. 10 and 11 of the drawings, functions in exactly the same manner as the control unit 22a illustrated in Figs. 2, 5, 6 and 7 of the drawings.

From the preceding explanation it will be understood that the overall arrangement of the disclosed control apparatus is such that extremely accurate positioning of the settable rotor shaft 31 in any one of a number of predetermined settings may be automatically obtained in a thoroughly reliable manner without the use of expensive or delicate parts and without an undue amount of bulk and weight. Thus accuracy of the setting operations is insured by the wide range of free travel which is provided in the lost-motion mechanisms of the control units to permit

a low drive ratio to be used between the rotary control shaft 25 and the settable rotor shaft 31. More specifically, the accuracy with which the tuning shaft 31 may be set and reset to the different predetermined settings depends upon two factors, viz.: the precision of the control units and the ratio of the reduction gearing between the shaft 25 and the shaft 31. In the illustrated arrangements, the control units, with their many revolutions of free travel, provide for great precision in the setting of the shaft 25. Any minor errors present in setting the shaft 25 to the desired angular settings are proportionately reduced by the reduction gearing between this shaft and the shaft 31. Further, the provision of the detent rings and star wheel assembly in each lost-motion mechanism insures a positive and accurately controlled drive of the locking teeth of the mechanism. Also, by arranging different parts of each lost-motion mechanism upon the two sides of the associated actuating member the size and particularly the thickness, of each control unit is minimized. The ruggedness of each control unit structure is apparent when it is noted that all of the engaged teeth through which a locking or driving connection is established between one of the actuating members and the rotary control shaft are short and heavy, such that the established connection is exceedingly powerful.

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 which includes a rotary control shaft operative to drive the tuning element of the receiver in either of two directions; a pair of members rotatably supported upon said shaft, a pair of lost-motion mechanisms, one of said mechanisms including parts rotatably supported upon one of said members and disposed upon opposite sides of said one member, the other of said mechanisms including parts rotatably supported upon the other of said members and including parts disposed upon opposite sides of said other member, actuating means including one of said mechanisms for operating said shaft to a predetermined setting from one direction, actuating means including the other of said mechanisms for operating said shaft to said predetermined setting from the opposite direction, and means responsive to the conjoint operation of both of said actuating means for arresting the movement of said shaft when it is operated to said predetermined setting from either direction.

2. In control apparatus which includes a rotary control shaft operative to drive a settable element in either of two directions; a disk-like member rotatably supported upon said shaft, a lost-motion mechanism including parts rotatably supported upon said member and disposed upon either side of said member, means including said mechanism for operating said shaft to drive said settable element to a predetermined setting from one direction, means for operating said shaft to drive said settable element to said predetermined setting from the other direction, and means including said mechanism for arresting the operation of said shaft when it is operated to said predetermined setting from said other direction.

3. In control apparatus which includes a rotary control shaft operative to drive a settable element in either of two directions; a disk-like member rotatably supported upon said shaft, a

lost-motion mechanism including parts rotatably supported upon said member and disposed upon either side thereof, said mechanism also including parts rotatable with said shaft and disposed upon either side of said member to coact with said first-named parts, means including said mechanism for operating said shaft to drive said settable element to a predetermined setting from one direction, means for operating said shaft to drive said settable element to said predetermined setting from the other direction, and means including said mechanism for arresting the operation of said shaft when it is operated to said predetermined setting from said other direction.

4. In control apparatus which includes a rotary control shaft operative to drive a settable element in either of two directions; a control unit including a disk-like member rotatably supported upon said shaft and a lost-motion mechanism including parts rotatably supported upon said member and disposed upon either side of said member, means including said mechanism for operating said shaft to a predetermined setting from one direction and for permitting said shaft to be moved away from said predetermined setting by other means, means for operating said shaft to said predetermined setting from the opposite direction, and means including said mechanism for arresting the operation of said shaft when it is operated to said predetermined setting from said other direction by said last-named means.

5. In control apparatus which includes a rotary control shaft operative to drive a settable element in either of two directions; a control unit including a disk-like member rotatably supported upon said shaft and a lost-motion mechanism including parts rotatably supported upon said member and disposed upon either side thereof, said mechanism including additional parts rotatable with said shaft and disposed upon opposite sides of said member to coact with said first-named parts, means including at least a portion of said parts for operating said shaft to a predetermined setting from one direction and for permitting said shaft to be moved away from said predetermined setting by other means, means for operating said shaft to said predetermined setting from the opposite direction, and means including said mechanism for arresting the operation of said shaft when it is operated to said predetermined setting by said last-named means.

6. In control apparatus which includes a rotary control shaft and a disk-like actuating member rotatably supported upon said shaft; lost-motion means for establishing a locking or driving connection between said member and said shaft which comprises axis means rotatably supported within an opening through said member, parts mounted for rotation with said axis means and disposed upon opposite sides of said member, means carried by said shaft and coacting with at least one of said parts for rotating said axis means relative to said member in response to rotation of said member about said shaft, and coacting stop means operative to establish a direct mechanical connection between said member and said shaft when moved to predetermined relative positions in response to rotation of said axis means relative to said member.

7. In control apparatus which includes a pair of relatively rotatable members; means for establishing a force transmitting connection between said members which comprises parts rotatably supported upon one of said members and disposed upon either side of said one member, and means fixedly mounted upon the other of said members on either side of said one member for actuating said parts in response to relative rotary movement between said members, and means controlled by at least a portion of said parts for establishing a force transmitting connection between said members after said parts have been actuated to predetermined relative positions.

8. In control apparatus which includes a rotary control shaft and a disk-like actuating member rotatably supported upon said shaft; lost-motion means for establishing a locking or driving connection between said member and said shaft which comprises a stop element rotatably supported within an opening through said actuating member and provided with parts disposed upon either side of said actuating member, means carried by said shaft to one side of said actuating member for coacting with the adjacent one of said parts to rotate said stop element relative to said actuating member in response to rotation of said actuating member about said shaft, and locking means engaged in response to rotation of said stop element to a predetermined position for establishing a direct mechanical connection between said actuating member and said shaft.

9. In control apparatus which includes a pair of relatively rotatable members; means for establishing a force transmitting connection between said members which comprises a pair of meshing pinions supported upon one of said members for rotary movement relative thereto and having unlike numbers of teeth, means carried by the other of said members for rotating one of said pinions through a predetermined fraction of a revolution relative to said one member during each revolution of relative movement between said members, and coacting stop means rotated with said pinions for locking said pinions against relative rotation after said one pinion has been rotated to a predetermined position relative to the other of said pinions.

10. In a control unit which is operative to drive a rotary control shaft to a predetermined setting from either of two directions and to permit other means to rotate said shaft away from said predetermined setting in either direction; lost-motion means for rotating said shaft in one direction and for stopping said shaft when it is rotated to said predetermined setting from the opposite direction which comprises a rotatable actuating member, a pair of meshing pinions supported upon said member for rotary movement relative thereto and having unlike numbers of teeth, means for rotating one of said pinions through a predetermined fraction of a revolution relative to said member during each revolution of said member, and coacting stop means controlled by said pinions to establish a direct drive or locking connection between said member and said shaft after said one pinion has been rotated to a predetermined position relative to the other of said pinions.

11. In a control unit which is operative to drive a rotary control shaft to a predetermined setting from either of two directions and to permit other means to rotate said shaft away from said predetermined setting in either direction; the lost-motion means for rotating said shaft in one direction and for stopping said shaft when it is rotated to said predetermined setting from the opposite direction which comprises an actuating member rotatably supported upon said shaft, a pair of

meshing pinions supported upon said member for rotary movement relative thereto and having unlike numbers of teeth, a member mounted for rotation with said shaft and provided with a tooth which engages different teeth of one of said pinions during successive revolutions of said actuating member about said shaft, whereby said one pinion is rotated through a predetermined fraction of a revolution relative to said actuating member during each revolution of said actuating member about said shaft, and coacting stops carried by said pinions to establish a direct drive or locking connection between said actuating member and said shaft after said one pinion has been rotated to a predetermined position relative to the other of said pinions.

12. In a control unit which is operative to drive a rotary control shaft to a predetermined setting from either of two directions and to permit other means to rotate said shaft away from said predetermined setting in either direction; lost-motion means for rotating said shaft in one direction and for stopping said shaft when it is rotated to said predetermined setting from the opposite direction which comprises a rotatable disk-like actuating member, an element rotatably supported upon said member to one side thereof, means for rotating said element relative to said member in response to each revolution of said actuating member, means disposed upon the opposite side of said member for positively limiting the relative rotary movement between said element and said member to a fraction of a revolution for each revolution of said member, and stop means controlled by said element for establishing a direct drive or locking connection between said member and said shaft after said element has been rotated to a predetermined locking position relative to said member.

13. In a control unit which is operative to drive a rotary control shaft to a predetermined setting from either of two directions and to permit other means to rotate said shaft away from said predetermined setting in either direction; lost-motion means for rotating said shaft in one direction and for stopping said shaft when it is rotated to said predetermined setting from the opposite direction which comprises a rotatable disk-like actuating member, an element rotatably supported upon said member, means for rotating said element relative to said member in response to each revolution of said actuating member, a star wheel rotatable with said element, means coacting with said star wheel for positively limiting the relative rotary movement between said element and said member to a predetermined fraction of a revolution for each revolution of said member, and stop means controlled by said element for establishing a direct drive or locking connection between said member and said shaft after said element has been rotated to a predetermined locking position relative to said member.

14. In a control unit, a pair of relatively rotatable members, a pinion rotatably supported upon one of said members, means carried by the other of said members for rotating said pinion relative to said one member in response to relative rotation between said members, a star wheel rotatable with said pinion, means carried by said other member and coacting with said star wheel for positively limiting the relative rotary movement between said pinion and said one member to a fraction of a revolution of said pinion for each revolution of relative movement between said members, and stop means controlled by said pinion for establishing a force transmitting connection between said members after said pinion has been rotated to a predetermined locking position relative to said one member.

15. In a control unit, a rotary control element, a disk-like actuating member rotatably supported upon said element, a pinion rotatably supported upon said member to one side thereof, means carried by said element for rotating said pinion relative to said member in response to rotation of said member about said element, a star wheel rotatable with said pinion and disposed upon the opposite side of said member, means carried by said element and coacting with said star wheel for positively limiting the relative rotary movement between said pinion and said member to a fraction of a revolution of said pinion for each revolution of said member about said element, and stop means controlled by said pinion for establishing a direct drive or locking connection between said member and said element after said pinion has been rotated to a predetermined locking position relative to said member.

16. In a control unit, a rotary control element, an actuating member rotatably supported upon said element, a pair of meshing pinions rotatably supported upon said member and having unlike numbers of teeth, means carried by said element for rotating one of said pinions in response to rotation of said member about said element, a star wheel rotated in response to rotation of said one pinion, means carried by said element and coacting with said star wheel for positively limiting the relative rotary movement between said one pinion and said member to a predetermined fraction of a revolution of said one pinion for each revolution of said member, and coacting stops carried by said pinions to establish a direct drive or locking connection between said member and said element after said one pinion has been rotated to a predetermined position relative to the other of said pinions.

17. In control apparatus which includes a rotary control shaft and a disk-like actuating element rotatably supported upon said shaft; lost-motion means for establishing a locking or driving connection between said element and said shaft which comprises axis means rotatably supported within an opening through said element, a first gear supported for rotation with said shaft to one side of said element, a second gear meshing with said first gear and carried by said axis means to rotate said axis means relative to said element in response to rotation of said element about said shaft, and coacting stop means disposed upon the other side of said element and respectively mounted for rotation with said axis means and said shaft, said stop means being effective to provide a force transmitting connection between said element and said shaft after stop means have been rotated to predetermined relative positions.

18. In a control unit which is operative to drive a rotary control shaft to a predetermined setting from either of two directions and to permit other means to rotate said shaft away from said predetermined setting in either direction; lost-motion means for rotating said shaft in one direction and for stopping said shaft when it is rotated to said predetermined setting from the opposite direction which comprises an actuating member roatably supported upon said shaft, a first stop element rotatably supported upon one side of said member, a second stop element rotatable with said shaft, and means disposed upon the opposite

side of said member and responsive to rotation of said member about said shaft for rotating said first stop relative to said member and to said second stop element to provide a force transmitting connection between said member and said shaft after said stop elements are moved into predetermined relative positions.

19. In a control unit which is operative to drive a rotary control shaft to a predetermined setting from either of two directions and to permit other means to rotate said shaft away from said predetermined setting in either direction; lost-motion means for rotating said shaft in one direction and for stopping said shaft when it is rotated to said predetermined setting from the opposite direction which comprises an actuating member rotatably supported upon said shaft, a pair of meshing gears disposed upon one side of said member and having unlike numbers of teeth, one of said gears being fixedly mounted upon said shaft and the other being rotatably supported upon said member for rotation relative to said member in response to rotation of said member about said shaft, a first stop element disposed upon the opposite side of said member and rotatable with said other gear, and a second stop element carried by said shaft for engagement by said first stop element to establish a force transmitting connection between said member and said shaft after said first stop element is moved into a predetermined locking position by said pair of gears.

20. In a control unit, a rotary control element, a disk-like actuating member rotatably supported upon said element, a pair of meshing gears disposed upon one side of said member and having unlike numbers of teeth, one of said gears being mounted for rotation with said shaft and the other being rotatably supported upon said member for rotation relative to said member in response to rotation of said member about said shaft, a first stop tooth disposed upon the opposite side of said member and rotatable with said other gear, and a second stop tooth carried by said shaft for engagement by said first stop tooth to establish a force transmitting connection between said member and said shaft after said first stop tooth is moved into a predetermined locking position by said pair of gears.

21. In combination with rotatable driven means, rotatable driving means, a lost-motion mechanism including input and output elements and means for defining a predetermined free travel range between said elements and for establishing a driving connection between said output element and said driven means when one limit of said free travel range is reached, a connector for establishing a driving connection between said driving means and said input element, a magnet for actuating said connector, and means for locking said connector against inadvertent operation by said driving means when said magnet is deenergized, said locking means being released in response to energization of said magnet.

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