

March 19, 1946.

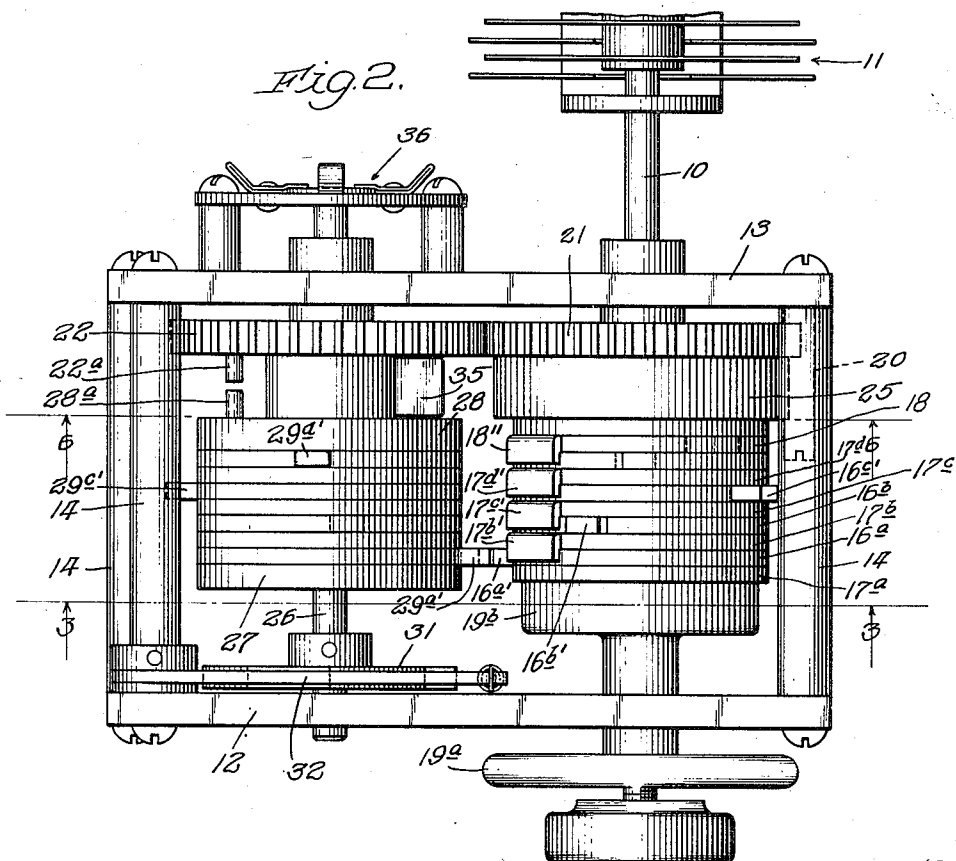
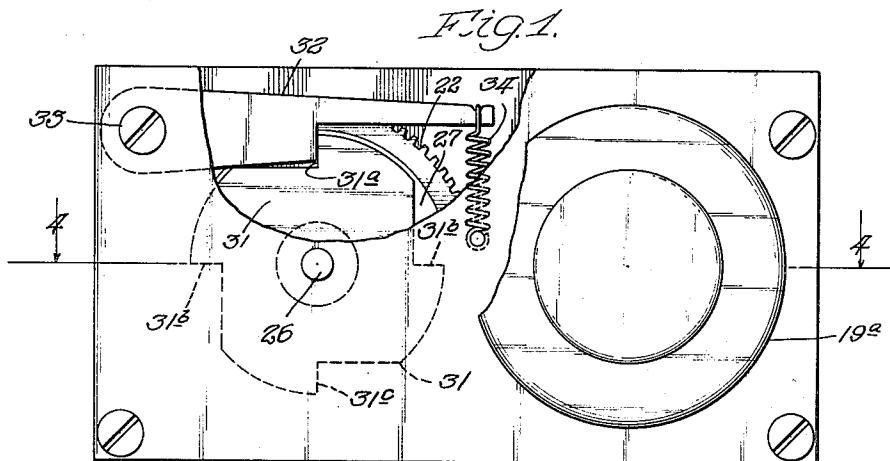
R. W. MAY

2,396,714

SHAFT POSITIONING APPARATUS

Filed July 8, 1944

3 Sheets-Sheet 1



Inventor:
Richard W. May,
By *Clinton, Wiley, Schroder & Henning,*
Attorneys.

March 19, 1946.

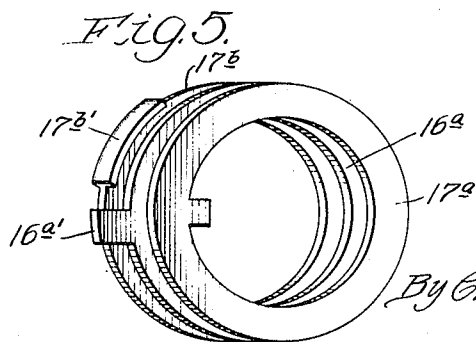
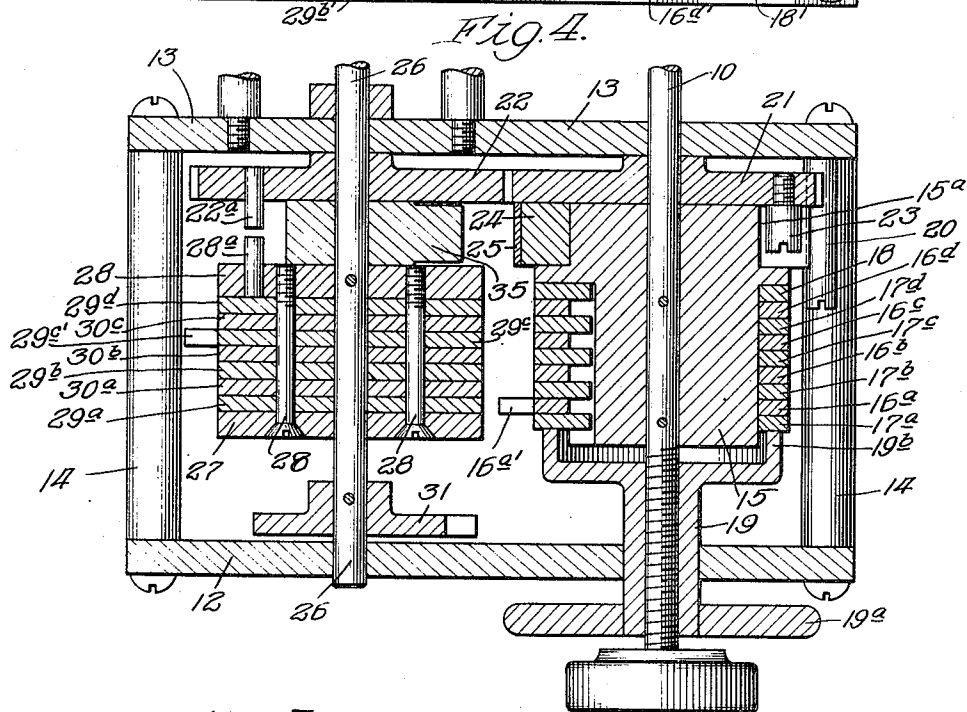
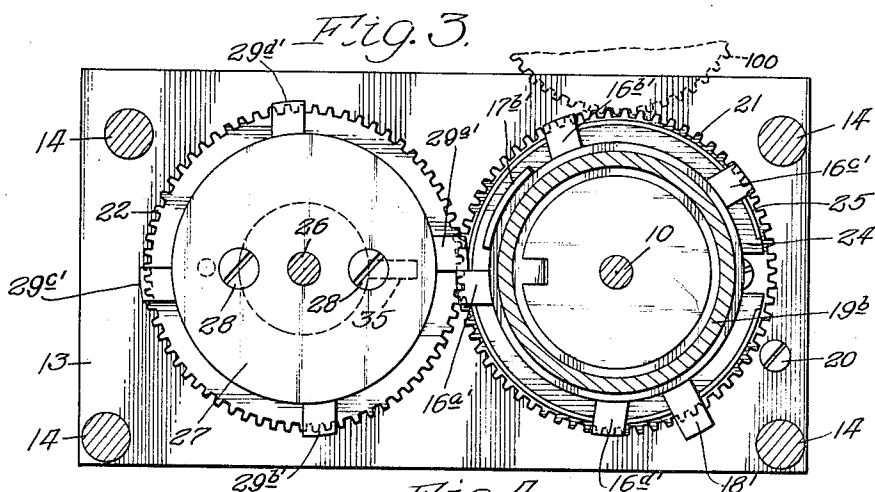
R. W. MAY

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SHAFT POSITIONING APPARATUS

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3 Sheets-Sheet 2



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Inventor:
Richard W. May,
By Chas. W. Mills, Schroeder & Merriam,
Attys.

March 19, 1946.

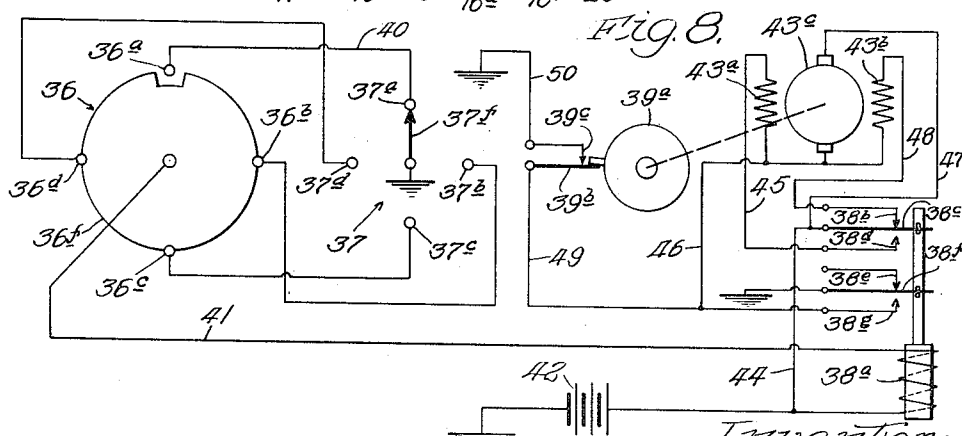
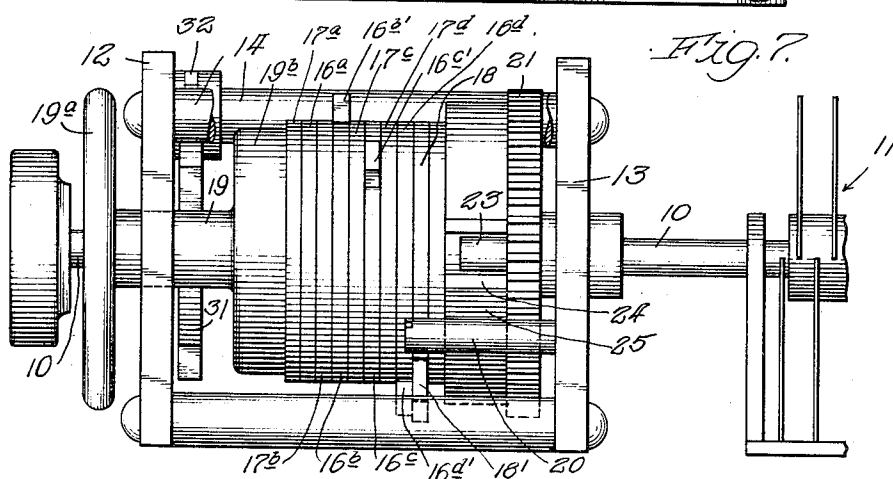
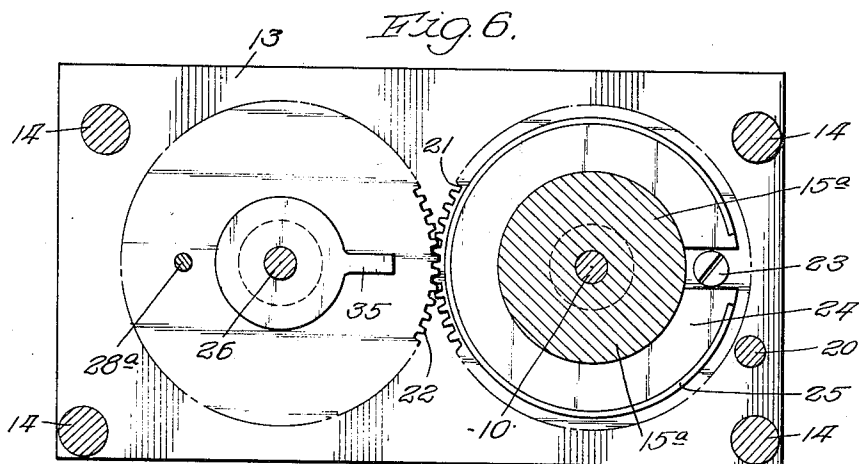
R. W. MAY

2,396,714

SHAFT POSITIONING APPARATUS

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3 Sheets-Sheet 3



Inventor:
Richard W. May,
By *Charles W. May, Attorney*
St. Louis, Mo.

UNITED STATES PATENT OFFICE

2,396,714

SHAFT POSITIONING APPARATUS

Richard W. May, Cedar Rapids, Iowa, assignor to
Collins Radio Company, a corporation of Iowa

Application July 8, 1944, Serial No. 544,076

9 Claims. (Cl. 74—10)

This invention relates to shaft positioning apparatus, and more especially to apparatus designed and adapted for automatically positioning a tuning shaft in radio apparatus.

One feature of this invention is that it provides an improved and simplified shaft positioning apparatus; another feature of this invention is that it provides automatic tuning means of a high degree of accuracy with the use of only two main members, as a stop ring drum and a cooperating drum combining selecting and stopping functions; still another feature of this invention is that, without the use of intermediate pawls, positioning of one rotatable element in a selected one of equally angularly spaced positions enables automatic stopping or positioning of a rotatable shaft at a selected one of variously angularly spaced positions; and yet another feature of this invention is the provision of means preventing undesired stop coaction between the two main rotatable elements during rotation of the element having the selecting function to a selected position. Other features and advantages of this invention will be apparent from the following specification and the drawings, in which:

Figure 1 is a front elevational view of a shaft positioning unit embodying this invention; Figure 2 is a plan view of such unit; Figure 3 is a transverse sectional view along the line 3—3 of Figure 2; Figure 4 is a sectional view perpendicular to that of Figure 3, along the line 4—4 of Figure 1; Figure 5 is a perspective view of representative stop and spacer rings mounted on the tuning shaft; Figure 6 is another sectional view in a plane parallel to that of Figure 3, along the line 6—6 of Figure 2; Figure 7 is an end elevational view, looking from the right of the unit as shown in Figure 1; and Figure 8 is a schematic circuit diagram of one circuit arrangement for effecting automatic operation of the unit.

The present invention is concerned with automatic shaft positioning devices of the kind wherein there is positive mechanical stop engagement between a stop shoulder rotatable with the tuned shaft and a stop element adapted to be mechanically moved into stopping position. Such devices are the subject matter of various issued patents making use of pawls as the stopping elements, a representative patent in this regard being Arthur A. Collins Patent No. 2,285,414, which issued June 9, 1942. In automatic tuning devices of this prior type, the tuning element shaft carries or is connected to a drum carrying a plurality of stop rings, the arrangement being such that the stop shoulders of these rings can be set

at any desired predetermined point. A plurality of pawls are provided adjacent the stop ring drum, one being adapted to cooperate with each stop ring to provide a plurality of stop assemblies, each being adapted to stop the shaft by engagement of the stop shoulder with the cooperating pawl. In operation, a drive motor operates through a drive shaft to rotate the stop ring drum until the drum has reached a terminal position, the drive shaft then rotating further until a selector cam drum and a selector switch, also driven by it, reach a position corresponding to an electrical circuit selected at some remote point, as by a manually operable switch. Thereupon the drive motor reverses and the drum and tuning shaft are driven in the other direction until the operative pawl (the one selected and rendered operative by the position in which the selector cam drum stopped) engages the stop shoulder of its cooperating ring, whereupon the tuning shaft is stopped at the desired position. The drive motor and drive shaft again continue operation until they have completed a cycle which is controlled by a limit switch, this overrunning action of the driving arrangement at each end of the limits of movement of the tuning shaft being permitted by a torque limiting device, as a slip-clutch.

In mechanical shaft positioning arrangements of this type, as heretofore used in the art, the stopping function has been accomplished by a group of stopping pawls; and the position selecting function has been accomplished by an independent selector cam arrangement. I have devised an arrangement wherein the stopping and selecting functions can both be combined in a single element, as a drum having angularly and axially spaced projecting stop portions, each such stop portion being adapted to cooperate with one of a group of similarly axially spaced but variously angularly spaced stop shoulders on the tuning shaft, the angular spacing of the latter being adjustable to enable selection of a desired shaft position. Selecting rotation of this first drum element is effected in one direction only, rotation in the other direction being prevented by a ratchet arrangement; and rotation of the tuning shaft in the tuning direction is such that engagement of the stop shoulder on this shaft with the projecting stop portion on the other element would tend to rotate it in the direction in which its rotation is prevented by the ratchet. This arrangement preserves all of the advantages of positiveness of operation and accuracy of shaft positioning which are inherent in mechanical shaft positioning apparatus; but provides a much simplified unit,

and one which can be made smaller and lighter by elimination of the pawls.

The particular unit illustrated herewith is adapted to automatically position a tuning shaft at any of four predetermined positions within a single revolution. It will be understood, however, that the concept here disclosed may be embodied in other mechanical forms, with a greater or lesser number of stop positions. Also, while only a single unit is illustrated, it will be understood that, in practice, there would be a plurality of shaft positioning units actuated by a single control circuit and driving means. A commercial transmitter, for example, might be provided with one or more line shafts driven by a reversible motor, each shaft in turn driving, through appropriate gearing, one or more single-turn shaft positioning units of the kind illustrated here, and possibly also one or more multiturn units, a unit of this latter type being described and claimed in Arthur A. Collins application Serial No. 472,717, filed January 18, 1943. The general arrangement of a multiplicity of such units is more fully described in certain issued patents of the said Arthur A. Collins, and in the above mentioned and other copending applications of the said Arthur A. Collins and of myself; and the present description will hereafter be limited to the specific unit illustrated.

In the particular embodiment of my invention illustrated herewith it will be seen that the various mechanical parts adapted to effect automatic positioning of the shaft 10, which may be the shaft of a conventional variable condenser 11, or any other conventional radio tuning element requiring one turn or less for its adjustment, are arranged in a self-contained unit mounted between the end plates or bearing plates 12 and 13. These plates are held in the desired relationship to each other, to make a single mechanical unit, by the spacing studs 14. A drum 15 is fixedly mounted on the shaft 10, as may be best seen in Figure 4. The drum carries any desired number (here shown as four) of tuning stop rings, these being here identified as 16a-d; non-rotatable spacer rings or washers intermediate the stop rings and keyed to the drum, these being here identified as 17a-d; and a terminal position stop ring 18, this latter also being keyed to the drum. Adjacent the front end of the drum is an end member or clamping member 19 threaded on to the shaft 10, as may be best seen in Figure 4, and provided with an outer locking knob 19a. At its inner end, the clamping member is provided with an annular portion 19b adapted to bear against the end spacer washer 17a. When the clamping member is backed off or away from the rings 16, 17 and 18 (as by counterclockwise rotation of the knob 19a), the rings are loosened and the stop rings 16 may be individually adjusted to desired positions, the other rings remaining stationary by reason of their keyed connection to the drum; and when the clamping member 19 is moved up against the rings (as by clockwise rotation of the locking knob 19a) the stop rings are clamped and held in the variously angularly spaced positions to which they may have been adjusted. Stopping of the stop ring drum, and thus of the rotatable shaft 10, at either of its two terminal positions approximately 360° apart, is effected by engagement of a projecting stop lug 18' with a terminal-stop stud 20.

Rotation of the shaft 10 and the other rotatable parts of the unit driven thereby is effected, in a manner fully illustrated and described in the

aforesaid Arthur A. Collins Patent No. 2,285,414, and therefore not shown here, by a reversible drive motor and a line shaft having driving connection through a worm or other appropriate gear 100 with the clutch drive gear 21. As may be best seen in Figure 4, this gear is mounted coaxially with the shaft 10, but it is freely rotatable about such shaft. It meshes with a stop element drive gear 22 to drive the stop element in a manner which will hereafter be more fully described; and, through a torque limiting device here shown as a slip clutch, it effects rotation of the stop ring drum 15 and the main or tuning shaft 10. As may be best seen in Figures 4 and 6, this latter drive is effected by engagement of a stud 23, rigidly mounted in the gear 21, with one end or the other of an annular friction shoe 24 of Bakelite or some other plastic or non-metallic friction material. The friction shoe or band 24 surrounds and bears against a clutch drum 15a which is a portion of the stop ring drum 15; and it is held in engagement with this drum by a substantially circular band of spring metal 25. This particular clutch construction has certain advantages in automatic shaft positioning apparatus which will not be gone into in detail here since the clutch illustrated here is claimed and more fully described in a copending application of the said Arthur A. Collins, Serial No. 483,899, filed April 21, 1943.

Adjacent the shaft 10 and parallel thereto is an auxiliary shaft 26, the gear 22 being rotatably mounted on this shaft. A pair of stop element drum end plates 27 and 28 are rigidly mounted on the shaft 26, these end plates being held together by screws 28 and rigidly holding between them four stop element rings 29a-d and intermediate spacer rings or washers 30a-c. The thickness of these rings 29 and 30, and their location on the shaft 26, is such that the axial spacing of the stop element rings 29a-d corresponds with that of the stop rings 16a-d, as may be best seen in Figure 4. As may be best seen in Figure 3, the stop element rings are provided with relatively narrow radially projecting stop portions 29a'-d', these being equally angularly spaced about the generally cylindrical stop element, also being axially spaced, of course, so that their arrangement is helical. Each of the stop rings 16 is also provided with a relatively narrow radially projecting stop shoulder or lug portion, as may be best seen in Figure 3, these being here identified as 16a'-d'. When the stop element drum has been rotated to a selected position bringing one of the stop portions 29a'-d' adjacent and in stopping relation to the stop ring drum (as the stop portion 29a' shown in such position in Figure 3), rotation of the tuning shaft 10 in its tuning direction (clockwise as viewed in Figure 3) brings the corresponding one of the stop shoulders 16a'-d' (as the stop shoulder 16a') into stopping relation with the stop element portion, thus positioning the shaft 10 accurately at a position previously determined by adjustment of that stop ring of the operative stop combination. When the stop element drum is in the position shown in Figure 3, for example, none of the stop shoulders other than the stop shoulders 16a' will be operative, since the relation of the drums is such that the stop shoulders clear the periphery of the stop element rings, and are stopped only by engagement with their particular cooperating projecting stop portion, as the portion 29a'.

In order to enable the stop element arrangement to firmly withstand the stopping torque re-

sulting from engagement of a stop ring shoulder with a stop element, as 16a' with 29a', a ratchet is provided, as may be best seen in Figures 1 and 2. This ratchet also has the function of precisely determining and accurately reproducing selected positions of the stop element, it being a four-tooth ratchet, final position of the stop element being determined by engagement of one of the ratchet teeth with one of the cooperating shoulders on the ratchet detent rather than by any attempt to use the selector switch for precision positioning. The ratchet detent wheel 31 is rigidly mounted on the shaft 26, and is provided with four detent teeth 31a-d. These teeth are adapted to cooperate with a shoulder on a ratchet detent arm 32, as may be best seen in Figure 1, this arm being pivoted about the stud 33 and being normally urged down toward the detent wheel by the spring 34. Because of this ratchet arrangement, the stop element drum can be rotated only in one direction, clockwise as viewed from the front of the unit, the direction in which it is adapted to be driven during the preliminary portion of the tuning cycle, when the tuning shaft 10 and the stop ring drum carried thereby are rotated in counterclockwise direction toward terminal or home position. The electrical selecting means is so arranged as to cause the detent wheel to overrun the position shown in Figure 1 by a few degrees before it stops, to ensure movement of the ratchet arm 32 into stopping position, engagement of a stop shoulder with the operative stop portion, during tuning rotation of the shaft 10, backing the detent wheel up into firm engagement with the detent arm.

The driving connection between the stop element drive gear 22 and the stop element drum is of the lost motion type, as may be best seen in Figures 2 and 4. The drive gear 22 carries a pin 22a adapted to engage the projecting end of an eccentric lost motion drive arm 35, this arm being mounted on the shaft 26 between the gear and the stop element drum, but freely rotatable on such shaft. The stop element drum carries a pin 28a adapted to be engaged by this lost motion drive arm, the resultant drive connection being such as to permit more than one full revolution of lost motion between the drive gear 22 and the stop element cylinder. This enables the drive gear 22 to rotate without rotating the stop element drum while the shaft 10 and its stop ring drum are moving to terminal position; and then, the lost motion slack having been taken up, enables positive driving of the stop element drum and the rotatable portion 36f of the selector switch 36, the clutch band slipping on the drum during this further driving action to enable the gear 21 to turn without rotation of the shaft 10. This selecting portion of the drive continues until, as will be better understood from a consideration of the circuit diagram shown in Figure 8, an open-circuit portion of the rotatable selector switch member 36f reaches the contact which has been put into circuit by some remote switch means, whereupon the drive motor is reversed and drive is effected in the opposite or tuning direction. During this portion of the drive the pin 22a backs away from the lost motion arm 35 without effecting rotation of the stop element drum, leaving it in the selected position; and in due course the stop shoulder cooperating with the selected stop portion strikes such stop portion, backs the detent wheel up a few degrees until firm engagement takes place with the shoulder on the detent arm, and stops the shaft 10 at an accu-

ately selected position. A lost motion arrangement in the driving connection to the selector drum (here also the stop element) is not claimed here, inasmuch as it is more especially the subject of, and claimed in, my copending application Serial No. 515,250, filed December 22, 1943.

In order to ensure complete freedom of rotation of the stop element drum during the selecting portion of the tuning cycle, means are provided such that when the stop ring drum is in home position no stop shoulders can lie too closely adjacent the stop element. This is effected by providing the spacer rings with bent over lug portions 17b', 17c', 17d' and 18'', as may be best seen in Figures 2 and 5. Figure 5 is a perspective view clearly illustrating the way in which the lug 17b limits the range of adjustment of the stop shoulder 16a'; and since the other arrangements are similar the description will be limited to this pair of rings. It will be recalled that the spacer ring 17b is keyed to the stop ring drum, and the position of the lug is so chosen that when the stop ring drum is in home position a line between the centers of the shafts 10 and 26 bisects the lug 17b. The angular extent of this lug is such that it extends about 20° to each side of this center line. This prevents any adjustment of the angularly movable stop rings which would bring their stop shoulders within 20° of either side of the center line between the shafts; and since the stop shoulders and cooperating stop portions on the stop element occupy relatively little space angularly and are adapted to make engagement over only a small distance, this insures interference between the stop shoulders and any of the stop portions when the stop ring drum is in home position and the stop element is being rotated to the selected stopping position. A full 360° of adjustment of the stop rings is not needed when the automatic tuning device shown is coupled to a condenser or other similar tuning element, as illustrated, since in reality only 180° of rotation is necessary to change the reactance of such a tuning element from minimum to maximum.

Referring more particularly to Figure 8, the sequence control circuit and the general operation of an automatic tuning system embodying such a unit as is shown here will be more fully described. A manual selector switch, here identified in general as 37, is shown as having four switch taps 37a-d wired to the corresponding switch points or switch taps 36a-d of the automatic selector switch 36. The switch 37 is here shown as provided with a manually movable switch arm 37f adapted to engage any selected one of the four switch points, each switch point being effective, through operation of the automatic selector switch, to select a different stop position of the stop element drum in the mechanical portion of the apparatus. A relay here shown as having an operating coil 38a and movable switch elements 38c and 38f, cooperating with a limit switch having a rotatable member 39a, a movable contact 39b, and fixed contact 39c, effects the desired sequence of operations in each tuning cycle initiated by a change of position of the manually rotatable switch arm 37f.

Assuming that the parts have been in some position other than that shown in Figure 8, and that it is desired to select the frequency setting corresponding to the position shown in the drawing, movement of the switch arm 37f would be made to the contact 37a. This would complete a circuit from ground through the wire 40, the selector switch rotatable disc 36 (which would

then have the open-circuit portion adjacent some other contact), the wire 41, the operating coil 38a of the motor relay, and the battery 42 (representative of any appropriate source of electrical energy) back to ground. This causes the movable switch elements 38c and 38f to move from the position shown in the drawings to their lower positions. Thereupon the left hand field 43a of the two-field motor 43 is energized by a circuit starting from the "hot" side of the battery, through the wire 44, the contacts 38c and 38d, the wire 45, the field winding 43a, the wire 46, and the contact points 38f and 38g to the ground connected to the contact 38f. At the same time the armature 43c is energized by a circuit leading from the "hot" side of the battery through the wire 44, the wire 47, the armature 43c, the wire 46, and the contacts 38f and 38g to ground. This causes rotation of the driving motor in the home direction, rotating the mechanical parts in the tuning unit in a manner described earlier, the stop ring drum rotating in a counterclockwise direction (as viewed in Figure 3), the stop element drum remaining stationary (because of the lost motion connection) until the stop ring drum has reached terminal position determined by engagement of the stop shoulder 18' with the stud 20. Further driving movement of the gears leaves the stop ring drum stationary (through slippage of the clutch) but picks up the stop element drum and rotates it and the rotatable member of the selector switch until such rotatable member 36f reaches the position shown in Figure 8, with its open-circuit portion adjacent the switch contact 36a. This opens the circuit energizing the coil 38a of the motor relay, and the movable switch elements 38c and 38f thereupon return (under the urging of a spring in conventional manner) to the position shown in Figure 8. This breaks the circuit through the field 43a and completes a circuit through the oppositely wound field 43b, so that the motor stops and reverses.

In this latter case the field circuit is from the "hot" side of the battery through the wire 44, the contacts 38b and 38c, and the wire 48 to the field 43b; and, as before, through the wire 44 and the wire 47 to the upper end of the armature 43c. Connection from the other end of both of these elements is now completed through the wire 46, the wire 49, the contacts 39b and 39c and the wire 50 to ground through a circuit controlled by the limit switch. The mechanical construction of this limit switch may be analogous to that shown in Arthur A. Collins Patent No. 2,285,414 and will not be further described here. In this case driving rotation continues until the limit switch rotates clockwise to the position shown in the drawings and opens the engagement between the contacts 39b and 39c whereupon the drive motor stops. Operation of the limit switch is so synchronized with rotation of the stop ring drum that termination of the driving action takes place only after driving operation which would have been sufficient to rotate the stop ring drum one full revolution from its home position; although, as will be understood from the previous description, the stop ring drum has actually physically stopped at some selected position prior to this time by reason of operation of the selected stop combination.

While I have shown and described certain embodiments of my invention, it is to be understood that it is capable of many modifications. Changes, therefore, in the construction and ar-

rangement may be made without departing from the spirit and scope of the invention as disclosed in the appended claims.

I claim:

1. Apparatus of the character described for positioning a rotatable shaft, including: means adapted to rotate the shaft; a plurality of axially spaced stop members mounted on and rotatable with said shaft, each such member having a stop shoulder, said shoulders being equally spaced axially but adapted to be variously spaced angularly; and a stop element rotatable about an axis parallel to and adjacent said shaft, this element having a similar number of similarly axially spaced stop portions rigidly secured thereto, each stop portion cooperating with one of said stop members, said portions being equally spaced angularly and adapted, by rotation of said element, to be selectively moved into stopping position to be engaged by the cooperating stop shoulder.

2. Apparatus of the character claimed in claim 1, including ratchet means permitting rotation of said stop element in one direction only.

3. Apparatus of the character described for positioning a rotatable shaft, including: means adapted to rotate the shaft; a plurality of axially spaced stop ring members mounted on and rotatable with said shaft, each such member having a radially projecting stop shoulder, said shoulders being equally spaced axially but adapted to be variously spaced angularly; and a generally cylindrical stop element rotatable about an axis parallel to and adjacent said shaft, this element having a similar number of similarly axially spaced radially projecting stop portions, each stop portion cooperating with one of said stop members, said portions being equally spaced angularly and adapted, by rotation of said element, to be selectively moved into stopping position to be engaged by the cooperating stop shoulder, whereby selection of the equally angularly spaced positions of the stop element effects stopping of the shaft in variously angularly spaced positions.

4. Apparatus of the character described for positioning a rotatable shaft, including: a plurality of stop members mounted on and rotatable with said shaft, each such member having a stop shoulder; a rotatable stop element adjacent said shaft and having the same number of stop portions as there are stop members, each stop portion cooperating with one of said stop members, said portions being adapted to be selectively moved into stopping position to be engaged by the cooperating stopping shoulder; and means adapted to rotate the shaft, said means also being adapted to effect position selecting rotation of the stop element.

5. Apparatus of the character claimed in claim 3, wherein the means for rotating the shaft is also adapted to effect position selecting rotation of the stop element.

6. Apparatus of the character claimed in claim 3, including a lost motion driving connection between the stop element and the means adapted to rotate the shaft, and a selector switch having a portion thereof rotatable with said stop element.

7. Apparatus of the character described for positioning a rotatable shaft in a desired position, including: drive means adapted to rotate the shaft in one direction until a terminal position has been reached and then in the other direction until the desired position has been reached; a plurality of axially spaced stop ring members mounted on and rotatable with said

shaft, each such member having a radially projecting stop shoulder, said shoulders being equally spaced axially but adapted to be variously spaced angularly; a generally cylindrical stop element rotatable about an axis parallel to and adjacent said shaft, this element having a similar number of similarly axially spaced radially projecting stop portions, each stop portion cooperating with one of said stop members, said portions being equally spaced angularly and adapted, by rotation of said element, to be selectively moved into stopping position to be engaged by the cooperating stop shoulder, whereby selection of equally angularly spaced positions of the stop element effects stopping of the shaft in variously angularly spaced desired positions; a lost motion driving connection between the stop element and the shaft; a selector switch having a portion thereof rotatable with said stop element; and a circuit arrangement associated with said switch for reversing the drive means when the stop element has reached a selected position.

8. Apparatus of the character claimed in claim 7, wherein the stop ring members are angularly adjustable on the shaft and means is provided limiting the range of angular adjustment to prevent any of the stop shoulders being adjacent the stop element when the shaft is in terminal position.

9. Apparatus of the character claimed in claim 3, wherein the means for rotating the shaft is adapted to rotate the shaft in one direction until a terminal position has been reached and then in the other direction until a desired position has been reached, wherein the projecting stop shoulders and stop portions occupy relatively little space angularly, and wherein the stop ring members are angularly adjustable on the shaft and means is provided limiting the range of angular adjustment to prevent any of the stop shoulders being adjacent the stop element when the shaft is in terminal position.

RICHARD W. MAY.