

July 9, 1940.

E. N. MULLER

2,207,467

AUTOMATIC TUNING DEVICE FOR RADIO RECEIVERS

Filed June 29, 1937

2 Sheets-Sheet 1

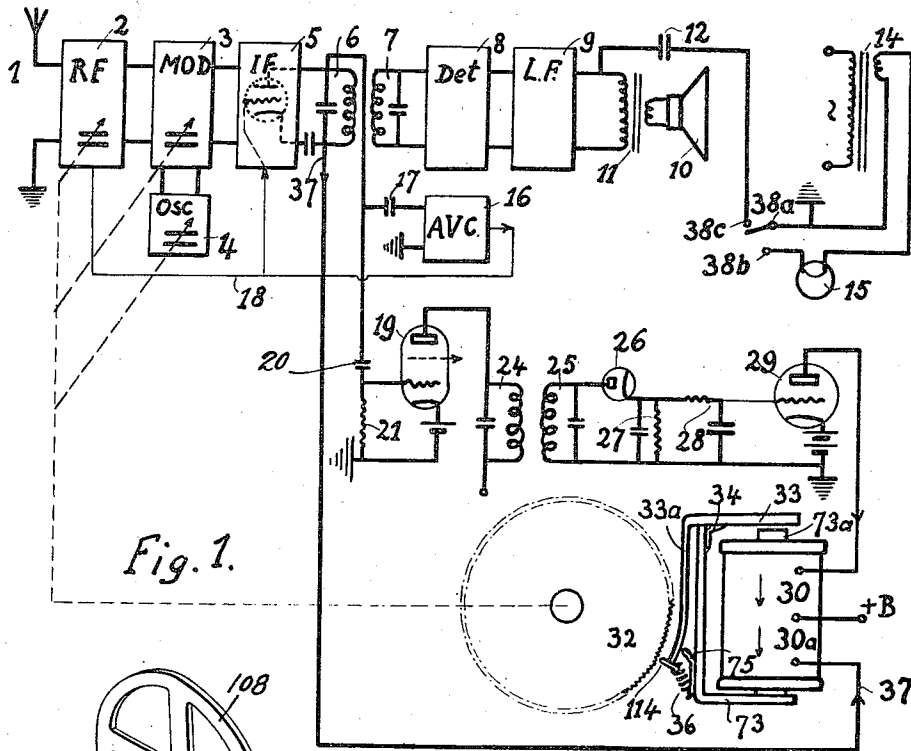


Fig. 1.

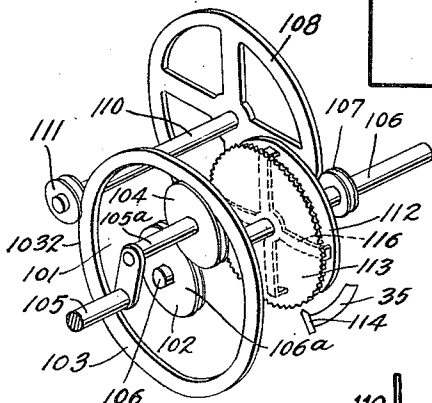


Fig. 2.

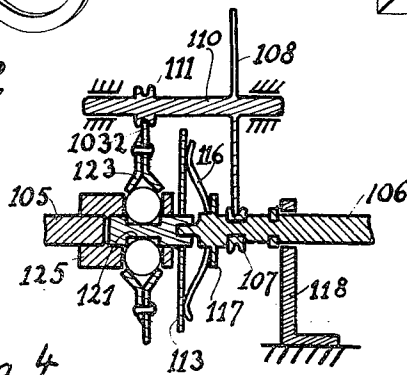


Fig. 4.

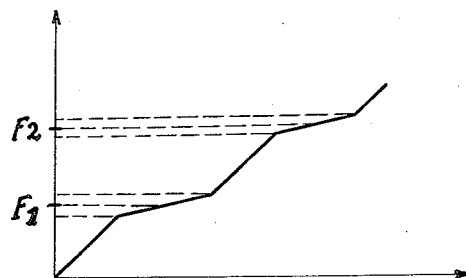


Fig. 3.

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2 Sheets-Sheet 2

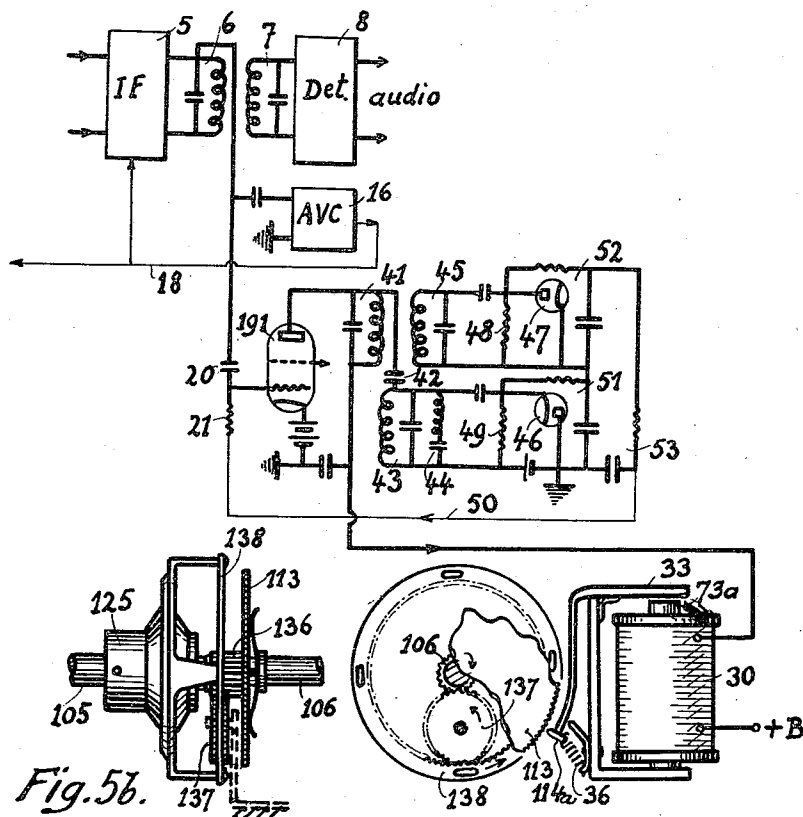


Fig. 5b.

Fig. 5.

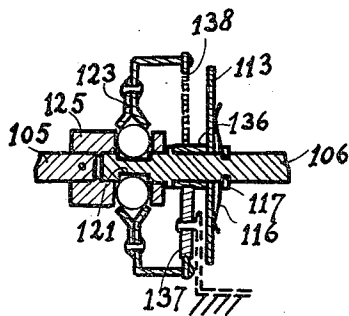


Fig. 5a.

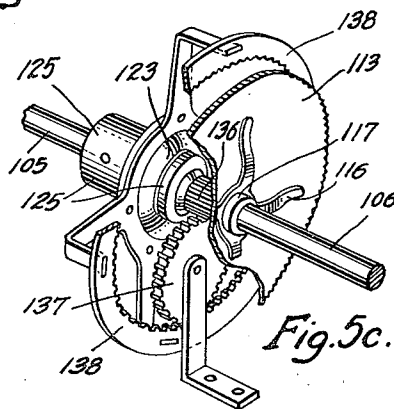


Fig. 5c.

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UNITED STATES PATENT OFFICE

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AUTOMATIC TUNING DEVICE FOR RADIO RECEIVERS

Egon Nicolas Muller, Esch, Alzette,
LuxemburgApplication June 29, 1937, Serial No. 150,922
In Luxemburg July 1, 1936

8 Claims. (Cl. 250-40)

My present invention applies to radio receivers of the type preferably wherein the tuning frequency may be varied through a range of substantial width, and relates more particularly to apparatus, and to the attendant circuits, for facilitating the tuning-in of the desired program.

In most receivers due to the high selectivity thereof, some difficulty is experienced in exactly tuning in the incoming signal. Of course, when the receiver is not sufficiently well in resonance with the carrier frequency, this will result in a distorted reproduction. It is well known, that those receivers wherein the operator must rely on visual or aural indications, are scarcely satisfactory since a considerable amount of care is required which most listeners are unwilling or unable to expend. Frequently, a so called inter-station noise suppressor means has been incorporated in modern receivers, to render the tuning apparently very sharp whereby to prevent a distorted reproduction. However, the operator in such eventuality might tune past the stations, unless he tunes very carefully, this making the "searching" of the different programs very tedious. This will readily be understood, when considering that in selective receivers a program can be adequately appreciated over a very restricted range of frequencies, not seriously in excess of 300 cycles on either side of the exact position, whereas the spacing of the various stations usually is not less than 10 kilocycles, even if it is assumed that there are no idle channels.

Another disadvantage of the conventional noise suppressor constructions is that they are comparatively expensive, since they should be purely electric in operation to permit a sufficiently low inertia, and that they frequently may give rise to distortions when the receiver is not strictly in resonance.

To avoid some of the above inconveniences, so-called automatic frequency control systems have been utilized in view of substantially suppressing manual tuning inaccuracies. However, such devices are comparatively expensive, and their adjustment and circuit design is comparatively very critical when they are to be effective when "searching" the different programs.

Accordingly, a broad object of the invention consists in the provision of means for avoiding the above inconveniences and drawbacks of the known systems. More particularly, an object of my invention consists in the provision of means whereby to "spread" the tuning positions, by which the entertainment value of the program

can be adequately appreciated or listened to without distortions, without thereby increasing the sweep of the tuning control member between the stations.

The operator accordingly needs no longer rapidly to brake or arrest the tuning knob as the station is heard, and he may, if desired, uniformly operate the tuning member whereby each program will be heard for a desired brief period of time, and quickly thereafter replaced by the following one.

An advantage of the invention is that the correct operation of a noise suppressor of simple character may easily be ensured.

The above and further objects which will result from the detailed description, I prefer to attain in accordance with my present invention, by means of electro-mechanical apparatus, which is spectacular in its effects, and permits attaining any desired proportion of "spread" of the station. Apparatus in accordance with the invention is cheap and easily manufactured, and may easily be incorporated in the receiver without giving rise to delicate circuit adjustments.

More specifically, according to my present invention, I provide variable-speed mechanism, for normally operating the tuning means at a desired moderate speed, and for increasing the speed of operation in a desired proportion when the receiver is sufficiently in resonance with a carrier wave, by suitably altering the effective gear ratio of the slow-motion drive system for the tuning means.

In the accompanying drawings, Fig. 1 shows one particular embodiment of control circuit for supplying the control potentials together with some of the mechanical elements of an embodiment of variable-speed mechanism, the control potentials in this instance being effective as soon as the amplitude of substantially any incoming waves which the receiver is responsive to exceeds a predetermined intensity.

Fig. 2 shows a perspective view of an embodiment of variable-speed mechanism, the speed of which is adapted to be altered stepwise from a position of low drive ratio to a position of high drive ratio, and vice-versa.

Fig. 3 is a graph showing change in frequency with respect to operation of the tuning control member, in response to the operation of the mechanism in Fig. 2.

Fig. 4 shows a practical construction of the mechanism in Fig. 2.

Fig. 5 shows an alternative form of control circuit wherein the control potential is effective

tive in the event only of the incoming carrier or other wave exceeding in a desired proportion the background of noise due to static. The lower right-hand portion of this figure also shows an elevational front view of some of the mechanical elements of a modified arrangement of variable-speed mechanism. Fig. 5a shows a sectional view of the modified tuning mechanism; Fig. 5b is a side-view in elevation thereof; Fig. 5c is a perspective view of this mechanism.

In the accompanying drawings, similar circuit elements or parts are indicated by the same or analogous reference numerals.

Reference should now be had to Fig. 1, wherein the invention is arranged for use with a superheterodyne receiver. The signal energy from the collector 1 is applied to a tunable radio-frequency amplifier 2, the output of which is coupled to a frequency changer device comprising a modulator stage or first detector 3, which co-operates with a tunable local oscillator 4, so as to produce beat oscillations of a fixed intermediate frequency. As is common practice in modern receivers, the different tunable circuits in the sections 2, 3 and 4 are uni-controlled, and in the instance shown each of these receiver sections includes a variable tuning-condenser, these condensers being ganged and adapted to be manually operated by means of a tuning knob, which is coupled to the spindle of the gang-condensers through the variable-speed mechanism described hereinafter.

The intermediate-frequency oscillations are applied to a tuned amplifier-section 5, the output circuit of which is coupled to the demodulating detector 8 through a transformer with a resonant primary circuit 6 and a resonant secondary 7, both circuits being tuned to the operating intermediate frequency, and being moderately coupled by mutual inductance.

The second detector is coupled to an audio-frequency amplifier-section 9 which serves to actuate a reproducer 10 associated with an output transformer 11.

The signal energy across the tuned circuit 6 is maintained substantially uniform despite variations in the strength of the signals at the input circuit of the receiver, by means of an automatic volume control network of conventional design, which comprises a rectifier-amplifier 16 fed with signal-energy from the resonant circuit 6, through the condenser 17. The uni-directional potentials which are produced at the output of the device 16, are applied to the amplifiers 2 and 5, through the lead 18, whereby to regulate the gain of these receiver sections.

The variable-speed mechanism described in detail hereinafter is controlled in response to the output of a control channel which includes a high frequency amplifier tube 19, a rectifier 26 and a direct-current amplifier tube 29. The input circuit of the amplifier 19 is coupled to the resonant circuit 6 through a condenser 20, the grid of the tube 19 being grounded through the grid leak 21. The cathode of this tube is slightly positive with respect to ground, whereby the tube amplifies under optimum conditions. The rectifier 26 is of the diode type and is coupled to the plate circuit of the amplifier 19 through a transformer with a resonant primary 24 and a resonant secondary circuit 25, these two circuits being tuned to the operating intermediate frequency, and being loosely coupled, as by mutual conductance. Accordingly, when the incoming signal is substantially in tune, the signal

energy is effectively transferred to the rectifier 26, and same moreover presents in substance a predetermined amplitude by virtue of the automatic gain control. However the signal when mistuned will be effectively attenuated, and will not be able to apply an appreciable proportion of energy to the rectifier 26.

The cathode of the diode 26 is connected to ground through a load-resistor 27, whereby a positive D. C. potential will be produced across cathode and ground in response to the amplitude of the signal as applied to the rectifier. This potential is applied to the grid of the tube 29 through a filtering network 28 comprising a resistance and capacity, to prevent the transfer of signal energy to the tube 29. The anode current of this tube is arranged to flow through the (main) winding 30 of an electromagnet which forms part of the variable-speed mechanism. This electromagnet comprises a U-shaped core 73 of soft iron, the magnet coil being wound on the leg 73a. The magnet armature 33 is hinged at 34 and is provided with a lever portion 33a, the end of which carries a sharp-edged projection 114 adapted in the attracted condition to engage the rim of a toothed disk 32 which forms an important constituent part of the embodiment of control mechanism described in detail hereinafter. The armature is normally maintained a small distance from the upper end of the core 73a by means of the tensioned spring 36, whereby to leave some small clearance between the projection 114 and the teeth of the disk 32, the proportion of clearance being limited by means of an abutment 75.

The cathode of the tube 29 is adjusted to a suitable positive potential, whereby the grid is normally biased to a substantial negative potential. Accordingly in the absence of signal energy across the rectifier 26 no current will flow through the magnet-winding 30.

It may be observed that in most instances the conventional automatic gain control networks are not sufficiently effective to maintain a strictly uniform energy across the circuit 6; in actual fact, the level of energy will be somewhat higher when the carrier tuned in very powerful. Accordingly, unless the resonant circuits 24, 25 in the control channel are highly selective, thus making the adjustment thereof excessively critical, a substantial amount of energy will be transferred to the rectifier 26 to remove the excess-bias of the tube 29 when the receiver is still mistuned by 2 or 3 kilocycles with respect to the frequency of a strong station, whereby the electro-magnet will operate and the reception will suffer serious distortions.

Automatic gain control means are known the effectiveness of which is more nearly complete, however, these are rather expensive; in most instances, it is preferable to avoid the above inconvenience by providing a compensation circuit, whereby in substance to balance out, from the point of view of the operation of the electromagnet, the amplitude variations left by an A. V. C. device the effectiveness of which is comparatively reduced. To this end, the operation of the magnet may be made dependent on the output of a second rectifier fed through a path with lesser selectivity than the feeding path of the rectifier 26. In the instance shown, the auxiliary control potentials are derived from the A. V. C. rectifier, the super-imposition of the two sets of potentials being in the electro-magnet provided to this end with a compensating winding 30a, 75

which through the leads 37 is connected in the anode circuit of an amplifier tube in the amplifier section 5, to the grid of which are applied A. V. C. potentials over the line 18. Since an increased signal strength brings about a decreased negative bias of the tube 29 and an increased negative bias of the amplifier 5, both windings should in effect be connected so that their magnetic fields are in the same direction. The compensating potentials are preferably effective only when they exceed a predetermined amplitude, the A. V. C. device being to this end preferably provided with a delay-bias, arrangements of this character being well-known in the art. In the absence of a signal the flow of current due to the tube 5 may be moderate, same depending on the effectiveness of the A. V. C. device.

The circuits in Fig. 1 also comprise a three-pole switch 38A—38B—38C, of which the central contact 38A is grounded, and in one of the switch positions 38C is connected to the upper end of the loud-speaker circuit, through a bypass condenser 12 of high capacity value, whereby in effect to short-circuit the output of the receiver; whereas in the other switch-position 38A—38B the current of the secondary of the mains transformer 14 is arranged to flow through the incandescent lamp 15 to illuminate same; this lamp may be arranged behind the tuning dial to illuminate the name of the station which is in tune.

Before I shall proceed to the explanation of the operation of the control circuit in Fig. 1, the remaining portions of the variable-speed mechanism will first be described, with reference to Fig. 2. The mechanism shown is adapted to be interposed between the tuning control on one hand, and the ganged tuning condensers for setting the tuning frequency of the receiver, on the other hand. The spindle 106 may to this end carry a knob adapted to be manually actuated by the operator, in well-known fashion. Whereas for the convenience of description the tuning drive means in the foregoing are referred to as a "tuning knob," which may be directly operated manually, it will readily be seen that flexible operating spindles, or fly-wheels, or other devices well-known per se, may serve in connection with a device according to the invention, for providing indirect or remote tuning; or again the tuning means may be adjusted by the aid of an electrical motor, which may be appropriately controlled manually, by switches. It will be observed that in most instances the character of the tuning control unit does not bring about any particular difficulties, and may be designed along the lines well-known in the art. The spindle 105 might be directly coupled to the spindle of the tuning unit; however when a variable condenser is employed, the entire sweep of which frequently does not exceed half a turn, it is usually preferable to arrange a slow-motion drive between the spindle 105 and the actuating spindle of the condenser unit. This slow-motion drive may be of any well-known construction, for instance of the friction type. The value of ratio thereof may be moderate, and it will be observed that the mechanism shown will effectively increase the resulting ratio even when in the low-ratio condition. Whilst it may be preferable to select a slow-motion drive which shall not be hard in operation, it will be appreciated that the construction of the mechanism shown would be adequate in practically every instance since capable of transmitting a torque of high value.

There is provided "planetary" gearing indicated by the general reference number 101, for combining the effects upon the spindle 105 of two movements deriving from the rotation of the control spindle 106 through different ratio values. As shown, the planetary gearing comprises three elements, viz, an inner main wheel 102, an outer main wheel 103 and a planet wheel 104. All of these elements might be cog-wheels, but I have preferred to show same as being of the friction type.

The inner main wheel 104 is pulley-shaped and is coupled to the driving spindle 106 through clutch mechanism, and is secured to an auxiliary spindle 106a in alignment with the spindle 106. The clutch comprises a driving flange 112 secured to the spindle 106, a driven clutch member 113 on the spindle 106a and a spider-shaped spring 116 frictionally engaging the driving and driven parts. It will be understood that a suitable arrangement of the supporting bearings (not shown) will prevent relative axial displacements of the spindles 106 and 106a and clutch-members thereon. The driven clutch-member 113 is disk-shaped and provided with fine teeth and is adapted to co-operate with the projection 114 of the arresting lever 35, all as described hereinbefore with reference to Fig. 1.

The outer main-wheel 103 of the planetary gearing in effect is shaped as an annulus and is adapted to be driven at all times by the control spindle 106 through auxiliary slow-motion drive mechanism. The annulus 103 is arranged to be rotatable about the ideal axis of the spindles 106 and 106a, and apart from an inner race 1031 which is meshing with the planet wheel, same comprises an outer race 1032 for co-operation with the auxiliary slow-motion drive. The latter includes a spindle 110 which is parallel to the main spindles 106—106a—105, and is supported by bearings, not shown, in invariable relation with respect to the chassis. The spindle 110 carries a friction disk 108 meshing with a pulley 107 firm with the control spindle 106, and a pulley 111 meshing with the outer race 1032 of the annulus 103, the disk 108 and pulley 111 being in invariable rotational relation. It will be understood that as the spindle 106 is rotated, the annulus 103 is moving with a seriously lower speed, as defined by the relative diameters of the elements 107—108 and 111—1032. The speed reduction might for instance be 1:40.

The planet wheel 104 is pulley-shaped, and is positioned freely to rotate about the spindle 105a, and is meshing simultaneously with the pulley 102 and with the race 1031. When driven by the latter elements, the spindle will move along a circle the center of which is on the ideal axis of the spindle 106, this motion being imparted to the spindle 105 which is in alignment with the spindle 106, the spindles 105 and 105a being to this end kept in invariable mechanical relation.

The operations of the system is as follows:

When the receiver is not tuned to a carrier wave, no potential will be set up across the load resistor 27 of the diode 26, and the tube 29 will be left excess-biased, whereby no substantial current will flow through the winding 30 of the electro-magnet: On the other hand, there will be no A. V. C. potential, and the anode current of the amplifier 5 flowing through the winding 30a will be maximum, matters being arranged so that this current is insufficient to cause attraction of the magnet armature. Accordingly, by virtue of the friction between the clutch-parts 112, 113, the

pulley 102 will be driven with the same speed as the tuning control spindle 106, whereas the race 1031 of the planetary will be driven at a considerably lower speed, in the same direction. The mediate pulley 104 will accordingly rotate in response to the combined and additive effects of these two movements, of which the former of course is predominant, and the spindle 105 will be driven with a relatively predetermined speed which in the main is defined by the construction of the planetary drive, which operates as a slow-motion drive of moderate ratio.

When the receiver is nearly in tune with a weak station, the proportion of mistuning being less than 300 cycles, a potential of substantially predetermined amplitude will be present across 27, the excess-bias of the tube 29 being removed whereby a current of considerable amplitude will flow through the magnet winding 30, which is sufficient to bring about attraction of the magnet armature; the intensity of the current through the winding 30a does not however appreciably change, since the amplitude of the station is insufficient to bring about an appreciable A. V. C. potential. The projection 114 by engaging the toothed rim of the disk 113 prevents further rotation of the spindle 106a and pulley 102 thereon, any further rotation of the control spindle bringing about a slip between the two clutch-parts. However, since the outer main wheel 103 continues to rotate with a relatively predetermined speed, the pulley 104 and the tuning spindle 105 continue to rotate slowly, whereby the tuning frequency gradually approaches strict resonance and thereafter brings about gradually increasing proportions of mistuning beyond the point of exact resonance.

As soon as the receiver is mistuned by about 300 cycles, the potential across the diode 26 is insufficient to cause energization of the electro-magnet. The spring causes retraction of the arresting projection 114, whereby the direct coupling between the control spindle and the pulley 102 is restored, the tuning frequency of the receiver thus quickly retiring from the resonance frequency of the station which was in tune.

Obviously, the operator is at liberty at any instant to cease turning the control spindle, and this he would do at some desired instant when the high gear ratio is effective, this condition being indicated visually and aurally by the circuit elements which are actuated through the switch 38 A—C, the proportion of mistuning in this event being lower than some 300 cycles, so as to prevent a distorted reproduction. It should be noted however that in certain instances an appreciable higher amount of mistuning would be admissible in which case the device would operate to prevent tuning past the station, even when the control knob is operated very carelessly.

Let it now be assumed that the receiver is in resonance with a powerful station. A comparatively higher potential will now be effective across the load-resistor 27 of the diode 26, as compared with the foregoing instance. Accordingly, the negative bias of the tube 29 will be further reduced, and the current through the winding 30 will be more intense. However, since a considerable A. V. C. potential is applied to the amplifier 5, the current through the winding 30a will be very small, whereby the sum of the effects of the two windings will in substance remain constant. In immediate proximity of exact resonance, the current through the winding 30a tends

to increase, whereas the current through the winding 30x must quickly decrease; however the operation of the electro-magnet, as a function of the proportion of mistuning does not appreciably suffer since the selectivity of the control circuit is appreciably higher than the selectivity of the A. V. C. channel, whereby the change in current through 30 will be considerably more marked.

It may be noted that when the control knob is actuated rather speedily and since the armature of the electro-magnet presents some inertia, the high gear ratio will be rendered effective only when the receiver is at the point of exact resonance, or even when this point is already exceeded; whereas when the operator tunes more carefully, the change-over of gear ratio will take place when the proportion of mistuning is still some 300 cycles. The proportion of "spreading" of the tuning positions is thus dependable on the mode of actuation of the tuning control, this being advantageous.

The operation of the control device is indicated graphically in Fig. 3, in which the movement of the tuning knob or other control member is plotted horizontally, and the resonance frequency of the receiver is plotted vertically. It will be seen that a comparatively very small variation in frequency in immediate proximity of the exact resonance upon a carrier wave such as F1 or F2, corresponds to a comparatively very large sweep of the control knob; frequently it is convenient to select the ratio values of the variable gearing in such a way that the sweep of the control knob for turning from one station to the next may be about the same width as the "spreaded" in-tune positions.

In the practical construction shown in Fig. 4, which in substance conforms to that indicated in more schematic fashion in Fig. 2, the planetary gearing is of a ball-bearing type, widely used in radio receivers as a conventional slow-motion drive. The drive ratio thereof may be 1:5.5, assuming that the outer ball-race is maintained stationary. The ball-cage 125 is fixed upon the spindle 105, which latter is preferably coupled to the gang condensers through an additional slow-motion drive of moderate ratio. The outer ball-race 123 is formed with the circular extension 1032 in such a way as to form a friction disk, which engages the pulley 111. The inner ball-race 121 is suitably lengthened and provided with a recess which is engaged by the end of the control spindle 106 opposite the tuning knob (not shown). The toothed disk 113 is fastened upon the lengthened inner race, and is frictionally engaged by the spider-shaped spring 116 which on the other hand bears on a flange 117 of the control spindle 106, relative axial movement being prevented by a suitable arrangement of the bearings, one of which is shown at 118. The control spindle also carries the pulley 107 which is fastened thereon, and which meshes with the friction disk 108, the latter firm with the same auxiliary spindle as the pulley 111.

It will be understood that when the control device is operated in response to the output of the control circuit in Fig. 1, the sensitivity of the receiver should be adjusted to a suitable value in response to the prevailing local reception conditions, there being to this end provided suitable means such as a variable biasing potentiometer for manually altering the gain of the amplifier section 5. Of course, when the level of back-ground noise due to static happens to be high, the sen-

sensitivity of the receiver being not reduced in a sufficient proportion, the correct operation of the control mechanism will be upset since sufficient energy will be applied to the diode 26 to simulate a carrier wave and to cause attraction of the electromagnet at all times. On the other hand, when the sensitivity of the receiver is lowered too considerably, the receiver will permit the reception of the very strong stations only. In fact, an inexperienced operator is not able as a general rule of adequately making use of his receiver, particularly so as the intensity of the noise is subject to considerable variations and moreover varies over the different frequency bands.

The above inconvenience of course results from the fact that the control circuit is not capable of discriminating between the carrier waves on one hand, and the back-ground of noise due to static on the other hand apart from the absolute intensity level of the respective waves, this inconvenience being besides also present in the many devices at present known for providing interstation noise suppression, or illumination of an indicator lamp when the receiver is in tune with a carrier wave, or for more or less related purposes. To avoid this drawback, I may prefer to utilize a control circuit for detecting the presence and the condition of exact resonance of a carrier wave, of the type disclosed in the specification of Luxemburg Patent No. 22,599 of August 1, 1936 (in U. S. application Ser. No. 155,909 filed July 27, 1937). An advantage of this device resides in the fact that the sensitivity of the receiver may at all times be a maximum permissible by the prevailing reception conditions, whichever may be the skill of the operator. For a complete disclosure of the details of the method, reference should be had to the specification mentioned; it may be stated however that the operation of the control circuit depends on the co-operation of at least two rectifiers, operation of the tuning device or other device for employment of the control potentials being permitted only when the intensity of the output of one of these rectifiers associated with selective networks for providing peak response at a frequency or frequencies somewhat spaced from the intermediate frequency, is below a given value with respect to the output of the second rectifier having peak response in proximity of the intermediate frequency, so as to show off the absence of noise in excess of a predetermined level relative to the level of the desired wave.

Reference should now be had to Fig. 5 which illustrates an embodiment of control-circuit of the character just indicated, in combination with a modified arrangement of variable-speed gearing, the latter also shown in the sectional view of Fig. 5a.

The control channel includes a high-frequency amplifier tube 191 the input circuit of which is coupled to the tuned circuit 6 arranged in a manner similar to that indicated for the tube 19 in Fig. 1. The anode circuit of the amplifier 191 includes a resonant circuit 41 the selectivity properties of which may be moderate or low, and which is tuned to the operating intermediate frequency. The high-frequency energy across the circuit 41 is transferred to the rectifiers 46 and 47, which are indirectly heated diodes. The rectifier 46 is arranged to produce "positive" potentials across its load resistor 49, whereas the rectifier 47 is adapted to set up "negative" potentials across the load resistor 48 thereof. The load re-

sistors 49 and 48 are connected in series, and the resulting super-imposed potential variations with respect to ground are transferred to the grid of the amplifier 191 over the line 50. The anode circuit of this tube also includes the winding 30 of the electromagnet which forms part of the gearing mechanism, and which is by-passed from the high-frequency point of view, the tube 191 accordingly performing at the same time the function of the relay-tube 29 shown in Fig. 1.

The coupling path of the rectifier 46 and resonant circuit 41 comprises a condenser 42 and a network 43-44 which latter consists of a parallel-resonance circuit 43 shunted by a series-resonant circuit 44, both circuits being separately tuned to the operating intermediate frequency. The resonance curve of such a network is double-humped, the peaks of maximum response being for instance at 2 kilocycles off resonance on both sides of the operating intermediate frequency. Same should be sufficiently pronounced so that when taking into account the selectivity characteristics of the receiver portion ahead of the condenser 42, the peaks of maximum response are left sufficiently pronounced for instance at ± 1.5 kilocycles off resonance, with a sufficiently marked response depression at the operating intermediate frequency, the difference in the responses being for instance 1:2.5. The response to the frequencies of the adjacent carrier waves is preferably kept very low.

The rectifier 47 is coupled to the circuit 41 through a resonant circuit 45 tuned to the intermediate frequency, the selectivity thereof being, preferably rather sharp, though in actual fact this requirement is not essential.

The level of energy of true intermediate frequency is arranged to be the same across both rectifiers. The circuit of the rectifier 46 includes a biasing source of potentials, the cathode of the diode 46 being for instance biased at +2.5 volts with respect to ground, to prevent the appearance of rectified potentials across the load resistor until the high-frequency energy impressed on the rectifier exceeds the threshold bias. Each load resistor 49, 48 is associated with a filtering network 51, 52, to avoid undesired interaction between the associated circuits, the time-constant of each filter being conveniently given the same value. A filter 53 comprising a resistance and capacity is also arranged in the line 50 to prevent high-frequency being fed back on the grid of the amplifier 191. When no high-frequency energy is impressed on the diodes 46, 47, the potential of the grid at 191 is that of the biasing source of potentials associated with the load resistor 49, the cathode potential of the tube being given a slightly higher value so that the grid may be slightly negative with respect to the cathode, the anode current thus being a maximum; the signal energy impressed on the tube 191 will at the same time be effectively amplified. It will be understood that when the control circuit in Fig. 1 is applied to control the mechanism shown in Figs. 2 or 4, the polarity of the potentials across the load resistors 48 and 49 being as shown, the arrangement of the armature 33 and of the spring 36 should be somewhat modified so that the projection 114a may normally be kept in engagement with the toothed disk through spring action, the armature when attracted causing retraction of the arresting projection. However, with the modified construction of variable-speed mechanism more particularly shown in Figs. 5a, 5b, 5c, the electro-magnet may be ar-

ranged in the same way as in Fig. 1, as explained more particularly hereinafter.

The control mechanism in Figs. 5, 5a, 5b, 5c, again comprises a "planetary" drive, of the ball-bearing type, for super-imposing two movements derived from the tuning control member. The advantage of constructions including planetary gearing as compared with mechanism for providing change-over from gearing of a given ratio to gearing of a different ratio, consist in seriously increased smoothness of operation at the instant of change-over from one drive ratio to the other, and in the possibility of having lower control-power. Use is made in the present instance of differential combination of the effects of the two movements in the planetary drive, whereby to provide more easily high values of drive ratios, in the low-speed condition. Slow-motion drives of the differential variety are of course well known; however, in the present instance, a few additional parts only are required which in the main provide both the desired ratio characteristics and the control action.

The inner race 121 of the ball-bearing is provided with an extension spindle, at 106, which may directly support the tuning knob, and is thus adapted to be driven at all times. The ball-cage is directly fixed to the tuning spindle 105 or slow-motion drive thereof. The outer race is arranged to be kept stationary in the "quick" drive condition, by the intermediate of gearing 136—137—138, whereby the ball-bearing drive operates under conventional conditions. In the "slow" drive condition, the outer race is driven through the spindle 106 in a sense opposite to that of the inner race, by the intermediate of the gearing 136—137—138 just referred to, and which comprises a pinion 136 adapted to be driven by the spindle 106 through a friction clutch, an annulus 138 with internal gear teeth, and a mediate gear wheel 137 which is freely rotating about a stationary pivot, and which is meshing with both the pinion 136 and outer wheel 138 to transmit the movement from the former to the latter. The outer ball-race 123 is formed with suitable radial extension-arms for supporting the annulus 138. The toothed disk 113 is fastened to the pinion 136 and forms the driven member of the friction clutch just referred to, which latter comprises a flange 117 on the control spindle, and a spider-shaped spring 116. The ratio of the slow-motion drive 136—138 should be somewhat lower than that of the ball-bearing, and may be about 1:5 if the "normal" ratio of the latter (i. e. assuming the outer race to be held fixed) is 1:5.5. In such latter case, supposing that the inner race is held fixed, the drive ratio of the ball-cage with respect to the outer race establishes as the inverse of $(1+1:5.5)$, i. e. about 5.5:6.5; accordingly, supposing that the ball-cage is solely driven through the toothed wheels 136—137—138 and through the outer race, the inner ball-race being held fixed, the drive ratio of the ball-cage with respect to the pinion 136, establishes as $(1:5) \times (5.5:6.5)$ i. e. about 1:6. However, this drive condition is not actually used in the construction shown, and when the ball-cage is effectively subject to the combined and opposing movements, which when considered per se would be effective through ratios of 1:5.5 and of about 1:6, and which both issue from the main driving spindle 106, their difference only will be effective in driving the ball-cage, and is about $\frac{1}{10}$ the speed of movement which may take place through the first-named or "normal" ratio (1:5.5).

The operation of the modified device in Fig. 5 is as follows: Suppose that no appreciable high-frequency energy is impressed on the control channel; the negative bias of the tube 191 in such event will be low, and a substantial current will flow through the winding of the electromagnet, which will bring about a positive arrest of the toothed disk so as to prevent the outer ball-race 123 from being driven by the control spindle, whereby the frequency-setting of the receiver will be permitted through gearing of comparatively low ratio (such as 1:5.5, in the numerical instance given in the above).

Now assume that the receiver is in resonance with a station of substantial amplitude, with respect to the noise level. A substantial proportion of high-frequency energy will be impressed on the diode 46 whereby to exceed the threshold bias thereof, an equivalent proportion of energy being applied to the diode 47. Since the potentials across the respective load resistors 48 and 49 are connected in opposition, they will cancel each other, and the outgoing line 50 will in effect be at ground potential. The resulting increased negative bias of the tube 151, which for instance may vary from -3 volts to -5.5 volts, brings about a reduced anode current, reliably to cause retraction of the armature of electromagnet, thereby releasing the toothed disk, to permit the outer ball-race 123 to be driven by the control spindle 106. The ball-cage is now subject to the differential effects of the movements of the inner and outer ball-races, the resultant gear ratio of the latter driving connection in effect being about $\frac{1}{10}$ higher in the instance mentioned than the former, whereby the tuning condensers may be rotated over the point of exact resonance at $\frac{1}{10}$ the normal speed, to provide an effective "spreading" of the in-tune position. It will be observed that the grid potential of the amplifier 191 does not depend on the intensity of the carrier wave, whereby the operation of the system is in substance independent from the effectiveness of the A. V. C. device.

When the receiver is slightly or moderately off resonance with respect to a carrier wave of sufficient intensity, the positive potential across the load resistor 49 relatively increases, whereas the negative potential across the load resistor 48 relatively decreases, by reason of the selectivity characteristics of the networks 45, and 43—44, these two effects being cumulative in lowering the potential of the outgoing line 50, the variation in potential being particularly marked in proximity of exact resonance.

The negative bias of the tube 191 is thus considerably lowered and may even attain a positive value; however the resulting overload of the tube does not mean a serious inconvenience since in practice the tuning does not remain for a considerable period of time in this condition.

When the receiver is considerably off resonance with respect to a carrier wave, no positive potential will be set up across the biased rectifier 46; however, negative potentials will still be produced across the rectifier 47. By virtue of the provision of the resonant circuit 41, these cannot however reach a value sufficient to cause attraction of the magnet armature.

It will now be supposed that the receiver is not tuned to a carrier wave, and that there is static of substantial intensity. Since the energy of the static is in substance uniformly effective over a wide frequency range, (at the input of the receiver, and as transposed by the frequency

changer to extend around the intermediate frequency), and since the feed path of the rectifier 47 is predominantly effective at or about the exact intermediate frequency, the potential produced across this rectifier, for a certain amount of energy at the input of the receiver, will in substance be defined by the sensitivity or response at the exact intermediate frequency. On the other hand, since the feed path of the rectifier 46 is predominantly effective at frequencies moderately spaced from the intermediate frequency, and more particularly at the peak response frequencies; the potential due to static, for a certain amplitude of static at the input of the receiver, will predominantly be defined by the sensitivity or response at about the peak frequencies, the effect being rather analogous to that of a carrier wave moderately off resonance, as considered in the foregoing. Since the sensitivity or response at these peak frequencies is considerably higher as compared with the sensitivity at the intermediate frequency, and since the latter response is approximately the same as the predominating response, (at intermediate frequency) across the rectifier 47, there will be predominant influence of the positive output of the rectifier 46. The grid bias of the relay tube 191 cannot therefore reach a sufficiently high negative bias to cause retraction of the arresting lever. Furthermore, the excess of output of 46 is practically constant whichever may be the intensity of the static, and same depends only on the ratio of peak to crevasse response, of the resulting resonance curve characteristic effective across the rectifier 46.

When a sufficiently powerful station is tuned in, in the presence of a moderately intense background of static, the energy of "static" which in the main is defined by the peak response frequency, will not exceed the intensity of the carrier wave energy of the operating intermediate frequency across the rectifier 46, and will not therefore affect the operation of the arresting lever.

Brief interfering impulses due to atmospherics or to sparking engines or the like, will with the same speed set up potentials across both rectifiers, those due to the rectifier 46 being somewhat higher as in the above instance of uniform "static," and they cannot therefore cause an erroneous operation of the electro-magnet.

While I have indicated and described several selected embodiments of my invention, it will be apparent to those skilled in the art that my invention is by no means limited to the particular arrangements shown and described, but that many modifications may be made within the scope of my invention, as set forth in the appended claims.

I claim:

1. A radio receiver comprising tuning means, operating means for said tuning means, variable-ratio transmission mechanism coupling said tuning means and driving means; and means responsive to the tuning-in of a carrier-wave to vary the transmission ratio of said mechanism.

2. A radio receiver according to claim 1, said variable-ratio transmission mechanism comprising an electromagnetic device energized by current responsive to the tuning-in of a carrier-wave, said electromagnetic device serving to effect the alteration in the gearing ratio of the said mechanism.

3. A radio receiver comprising tuning means; operating means for said tuning means, transmission means normally coupling said tuning

means and said driving means, to provide a substantially definite normal speed of drive of the tuning means; further transmission means adapted for coupling said tuning means and said driving means, said further transmission means having a drive ratio different from that of the normal transmission means, and serving to provide a stepwise lower speed of drive of the tuning means; means responsive to the tuning-in of a carrier-wave and operable electromagnetically, for simultaneously rendering said normal transmission means in substance ineffective, and for rendering effective said further transmission means.

4. A radio receiver comprising mechanism according to claim 3, characterized in that the said electro-magnetically operable means includes a clutch operable by current responsive to the tuning-in of the carrier wave, for effectively preventing the coupling of said driving means and of said first-named transmission means, without simultaneously preventing the coupling between said driving means and said second-named drive transmission means.

5. A radio receiver comprising mechanism according to claim 3, additionally characterized in that the transmission path between said driving means and said first-named transmission means includes a clutch of the friction type, in substance positioned out of the coupling path of the driving means with respect to the said second-named drive transmission means, in combination with means including an electromagnet for preventing movement of the driven clutch member, by current applied to said electromagnet and responsive to the tuning-in of the carrier wave.

6. A radio receiver comprising mechanism according to claim 3, wherein the means for selectively making effective in substance one drive transmission path, includes, within the coupling path of the said first-named drive transmission means, and in substance out of the transmission path of the second-named transmission means, a friction clutch, in combination with a locking device for selectively preventing movement of the driven clutch member, the said locking device including a toothed disk for said driven clutch member, and an electro-magnet operated by current responsive to the tuning-in of the carrier-wave, for positively locking the said disk in position.

7. A radio receiver comprising variable-ratio transmission mechanism according to claim 1, said mechanism including planetary gearing with an output member and with two input members, in combination with drive transmission means of substantially predetermined drive ratio characteristics for coupling the driving means and the output member through one of said input members; further drive transmission means of a different ratio for coupling the driving means and the output member through the said second input member; said mechanism being further characterized in that the coupling for one of said input members is permanently effective, in substance thereby to define a definite driving speed; whereas said other input member is coupled to the said driving means through a clutch; and means for operating the said clutch in response to the tuning-in of a carrier-wave.

8. A variable ratio mechanism for a radio tuning device, said mechanism comprising planetary gearing with an output member and with two input members; an operating spindle for said

mechanism; drive transmission means for coupling the operating spindle and the output member, through each of said input members, said transmission means having respectively predetermined but unequal drive ratio characteristics; a clutch of the friction type in the drive transmission path between the operating spindle and one of said input members, while out of the transmission path of said other input member;

a toothed disk for the driven clutch member; means including an electromagnet operated by current responsive to the tuning-in of a carrier wave, an armature for said electromagnet; a projection for said armature; said projection serving positively to lock the said toothed disk in position, in response to the operation of the electromagnet. 5

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