Sept. 16, 1941. L. L. DE KRAMOLIN 2,255,915

TUNING ARRANGEMENT

Filed April 22, 1938 3 Sheets-Sheet 1

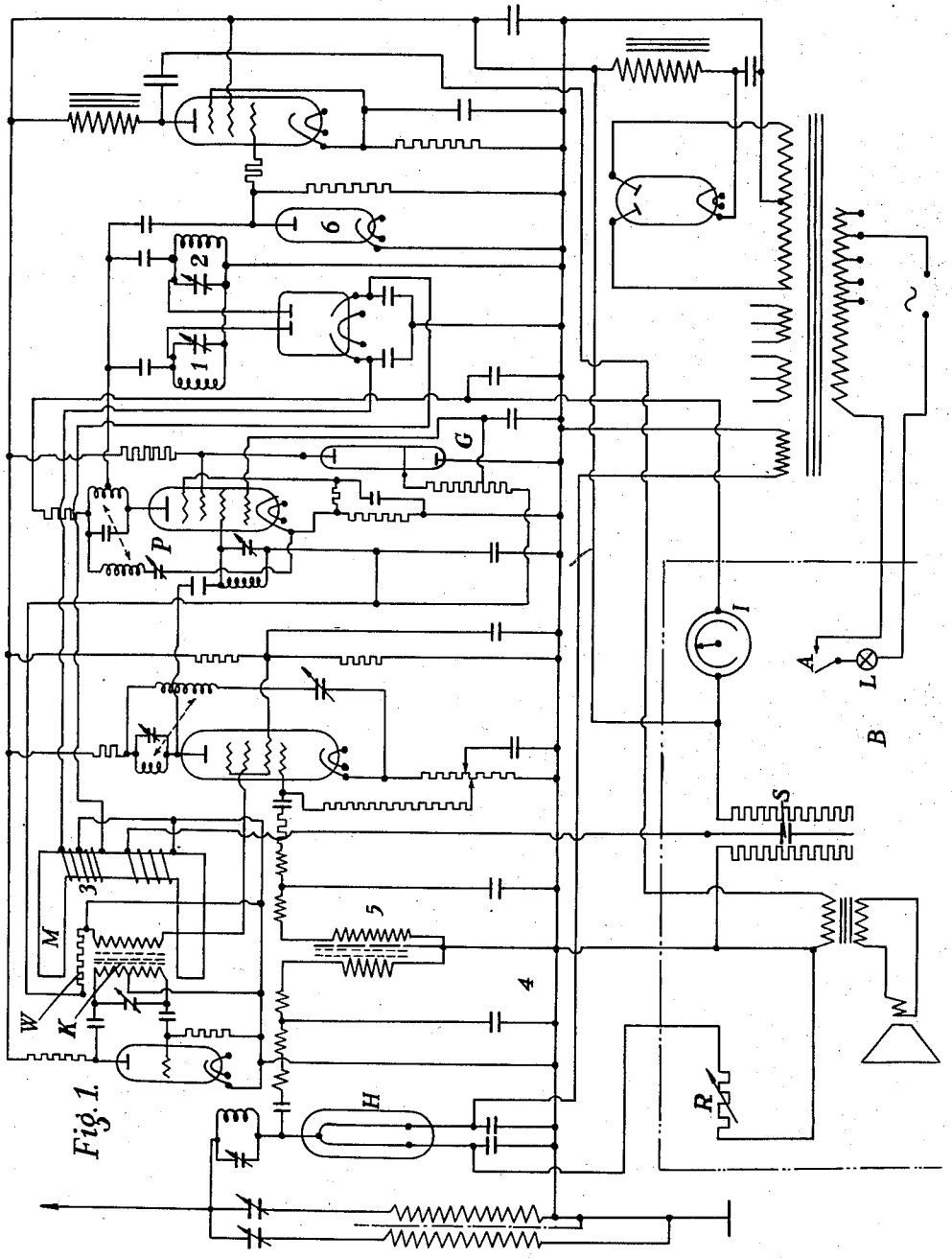


Fig. 1.

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Filed April 22, 1938 3 Sheets-Sheet 2

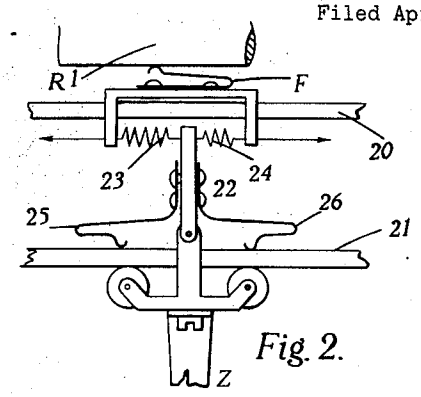


Fig. 2.

Fig. 3.

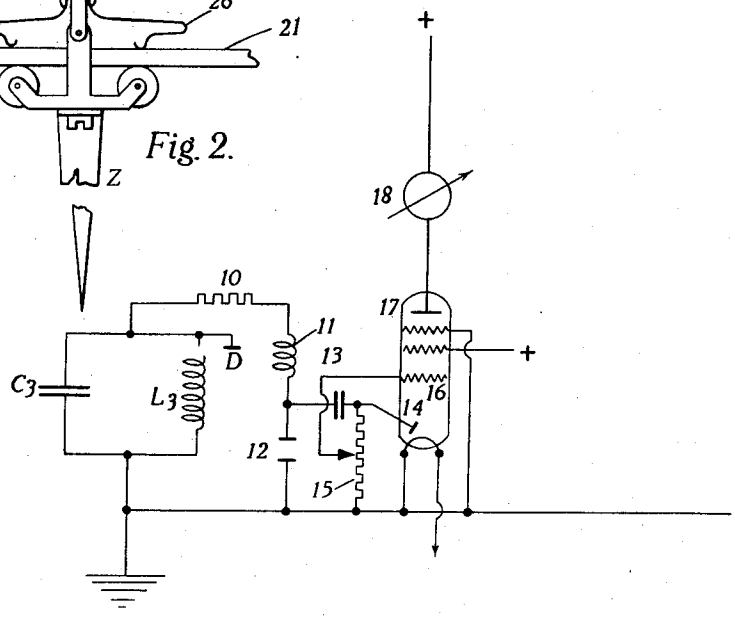
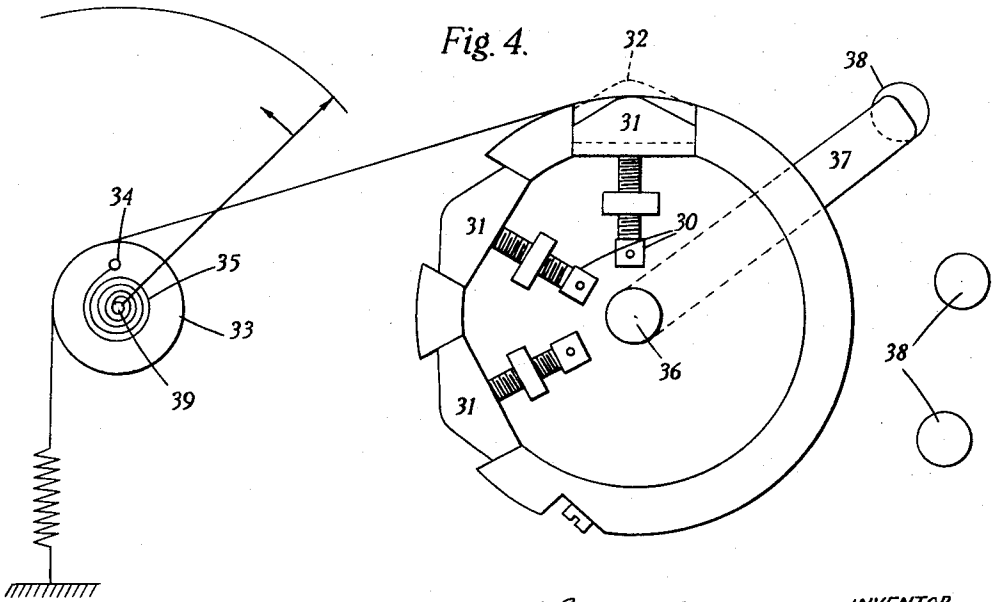


Fig. 4.



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TUNING ARRANGEMENT

Filed April 22, 1938 3 Sheets-Sheet 3

Fig. 5.

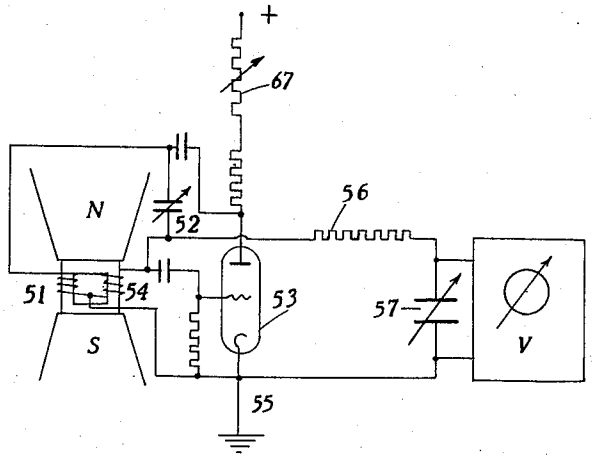
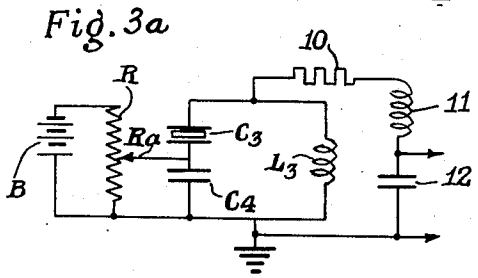


Fig. 3a



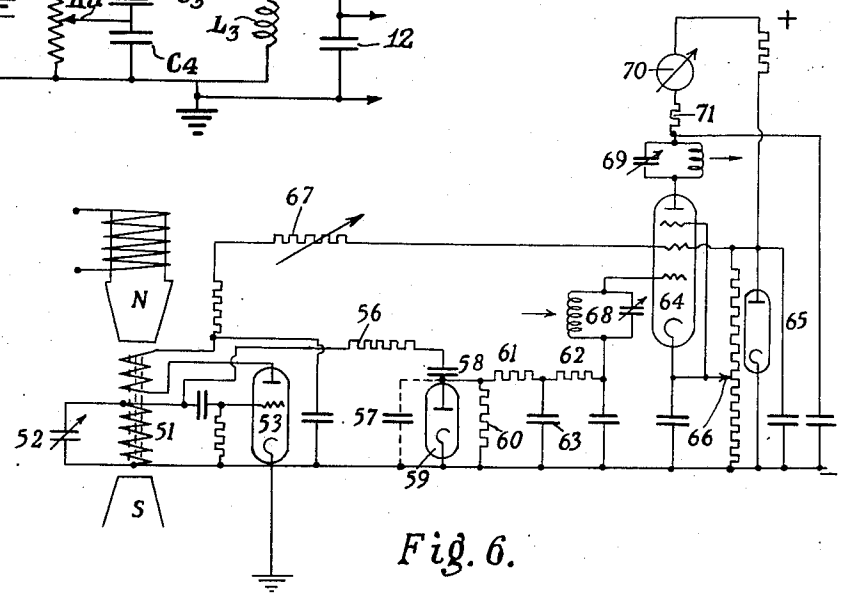


Fig. 6.

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UNITED STATES PATENT OFFICE

2,255,915

TUNING ARRANGEMENT

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Application April 22, 1938, Serial No. 203,688
In Germany April 27, 1937

8 Claims. (Cl. 250—40)

The present invention relates to tuning arrangements, particularly to tuning arrangements for oscillatory electric circuits such as in radio receivers and the like.

In my prior British Patents Nos. 449,240, 451,097, 451,098, 473,384, 455,190, 470,945 and 481,062, arrangements have been described for tuning an oscillatory electric circuit by varying the alternating current impedance of the circuit by means of an applied regulating current or potential. The applied bias may vary the inductance of an inductance coil mounted on a magnetic core by varying the pre-magnetisation of the core or may vary a capacity in the circuit, the value of which depends upon the applied bias.

Since the adjusted value of the alternating current impedance depends upon the applied bias, it is important that the supply voltage should be maintained constant and in the specification of my British Patent No. 481,062, arrangements are described for stabilising the supply voltage and preventing fluctuations thereof from affecting the adjusted value. In the case of the remotely controlled sets this permits the regulating device to be more accurately calibrated.

However, due to after effects or lag in the variation of the alternating current impedance, difficulties still arise in accurate calibration since due to this phenomenon, different adjusted values of the alternating current impedance may be obtained with the same position of the regulating device depending upon whether the applied bias has been increased up to the adjusted value or decreased to the adjusted value.

For example, if a mass core similar to the well-known high frequency mass iron core is employed in the tuning device and is arranged between the poles of an additional magnet for the purpose of varying the pre-magnetisation, this magnet causing by variation of its exciting current intensity or the like a variation of the pre-magnetisation in the mass core, it is found that the inductance value of the inductance wound on the mass core is not equal for equal current values of the exciting current if, in one case, the current in the exciting winding of the magnet has been increased from zero to the desired value and, in the other case, the current has been decreased from the maximum value to the desired value.

This variation of the inductance value with the same energising current in the pre-magnetising magnet constitutes a drawback if the potentiometer or resistance which regulates the pre-magnetising current of the magnet is to be calibrated directly in wave-length values of an oscillatory circuit of a receiver or transmitting apparatus of which the inductance forms part. It should be realized that a part of the disturbing coercive force lies in the material of the energising magnet and a part in the material of the high frequency iron core.

Therefore, to remove these disturbances it is desirable to use material of as small a coercive force as possible in these two parts. Very soft kinds of iron are suitable as such materials for modest requirements, but considerably more favourable results can be obtained if nickel alloys are employed, such a, permalloy-like alloys, in which the magnitude of the coercive force as compared with the softest types of iron and normal transformer laminations customary in commerce is smaller by more than the tenth power.

Compressed bodies or bodies of certain oxides behaving ferro-magnetically and held together by some binding agent are also suitable for this purpose. The remanence may be reduced by increasing the compression pressure in the production of the core, by reducing the thickness of the insulating layers separating the individual core particles or by somewhat increasing the core particle size with respect to normally high frequency coils, although the latter possibility must not be exaggerated owing to the rapidly increasing damping losses. Since such materials have a permeability which is relatively very high for high frequency cores this is an advantage since it enables a larger tuning range to be covered with a given controlling current at the magnet.

If such materials are employed the disturbing coercive force may be reduced to such an extent that the resultant departures, for instance, in an otherwise normally constructed superheterodyne receiver of which the local oscillator circuit is tuned by one of the inductances in question, correspond approximately to the range covered by the sidebands of a station so that no calibrating difficulties arise since in any case it is not possible in practice to effect the calibration more accurately than this.

If, however, such arrangements do still not produce the desired accuracy or if for considerations of price or other reasons it is desired to be free in the choice of the constructional materials employed, either in the case of the energising magnet or of the material of the mass core or both, other arrangements also in accordance with the invention are advisable.

To this end means are provided for compensating for the after effect phenomena, or the calibrated scale may comprise an instrument which

directly reads the adjusted field strength or the adjusted frequency.

In order that this feature of the invention may be more clearly understood reference will now be made to the accompanying drawings which show by way of example various embodiments thereof. In the drawings

Fig. 1 shows the circuit of a radio receiver in which the adjusted field strength is read and operates an indicating instrument.

Fig. 2 shows a mechanical device for compensating the after-effect phenomena.

Fig. 3 shows an arrangement for reading the adjusted frequency.

Fig. 3*a* is a fragmentary circuit diagram showing a modification of Fig. 3 where the frequency is adjusted by varying the bias applied to a condenser.

Fig. 4 shows a detail of the indicating instrument.

Figs. 5 and 6 show various other alternative arrangements.

In the form of construction shown by way of example in Fig. 1, M is the influencing magnet which acts on the mass core K. This mass core K carries windings, which constitute the inductance or coupling inductance of a tuning circuit for the local oscillator of a superheterodyne arrangement. If there is chosen for the material of the magnet M and of the core K a constructional material which has relatively high coercive force, it is not possible at the remote operating post B of the set, which is shown enclosed by a chain dotted frame, to read off the adjusted frequency or wave length of the station accurately, say by the position of the slider S at the regulator which regulates the magnetising current of the magnet M, since the position of the slider S with regard to the adjusted station is ambiguous owing to the hysteresis loop of the material employed.

In order to remove this ambiguity, a bismuth resistance W is arranged between the poles of the magnet M in addition to the core K. As is well-known, the resistance value of a bismuth resistance varies under the influence of an acting magnetic field and the resistance of W is therefore an index of the prevailing field strength and therefore also of the adjusted wave-length.

Instead of this bismuth resistance, all other well-known effects indicating directly the magnetic field strengths may also be used for indication, that is, for instance, the Hall effect or the magnetron effect or the magnetic deflection of a cathode beam in a discharge vessel and the like constructed after the fashion of a Braun tube or the like.

These arrangements which react directly on the field strength can either be used in combination with a measuring instrument, to make readable the adjusted field strengths and thus the adjusted inductance value or the wave-length or the like, or these field strength determining arrangements may be used to compensate, by compensating circuits, the material determined departures in regard to the adjustment of the slider S or the like which are given by the width of the hysteresis loop.

In the present case of Fig. 1, as has already been mentioned, a compensation is not effected in such a manner that the slider position of S constitutes an index of the wave-length, but the slider adjustment S remains to a certain extent independent of the adjusted wave-length and the true field strength and thus the adjusted wave-length values are merely indicated at the operating post by a special measuring instrument controlled by the bismuth resistance W.

Since, however, the resistance variations at small variations of the field are very small, very sensitive measuring instruments for the wave-length indication would be necessary at the operating post. Apart from this, it is only possible with difficulty to make the value of the resistance W very large in proportion to the resistance of the lead connecting the operating post with the apparatus (even if the bismuth resistance is made by vapourising bismuth in vacuo onto a small mica plate or similar base in a thin layer or by applying it to the plate in some other manner and by subdividing the bismuth surface into a serpentine band by means of scratched-in lines on opposite sides) if the distance between the apparatus and operating post is considerable so that the indications would then be falsified by the line resistance which has been inserted or are made dependent upon the latter.

To obviate this difficulty, the resistance variation occurring at the resistance W is not directly given on a measuring instrument, but is used merely to control the amplified current in an amplifier-like arrangement, for instance, in an electron tube. If a saturated tube is employed, then, in addition to the possibility, obtained by means of the amplification, of using less sensitive and therefore cheaper indicating instruments, the advantage can be obtained that the indication is practically independent of the line-length.

In the present example of Figure 1, there is used a pentode system P which has a high amplification factor, but any other suitable amplifying arrangements may be employed.

However, since it is desirable for the constancy of such an arrangement that the screen-grid voltage of a pentode, hexode or other screen-grid tube shall not alter, then in the present case the glow-divider tube G has been employed for the stabilisation of the screen grid voltage.

The voltage variation resulting at the bismuth resistance on passing over the tuning range was so small in the chosen constructional example that thereby, at the tube P, only an anode current variation of about 1½ milliamperes resulted.

If a tube is chosen, the normal anode current consumption of which amounts to about 4 to 6 milliamperes, then, owing to the small anode current variation of about 1½ milliamperes, the control range is only displaced so little that the tube can be utilised without hesitation for a further amplifying effect, for instance, for the intermediate frequency amplification, as is shown in the constructional example of Fig. 1.

The instrument I, which lies in the anode circuit of the tube P, is now biased to such an extent (for instance, by the instrument springs constituting the directional force) that the pointer moves out of its zero position only when the anode current exceeds 4 milliamperes. The sensitivity of the instrument is so adjusted that the current variation of 1½ milliamperes obtainable by the bismuth resistance, that is, an increase from 4 to 5.5 milliamperes causes a full deflection of the instrument. As an instrument which may be selectively arranged also at the apparatus itself, for instance, can be plugged in, there is preferably employed a circular scale instrument (with a deflection of about 270°) or a profile instrument which has a sufficiently large scale length, in order, for instance, in a radio receiver, to be able to distribute all the stations of the receiving

range so that they can be clearly read on the entire scale.

The mechanical biasing of the instrument so that it commences to deflect only from a certain current value onwards has shown, moreover, the great advantage that the pointer, when the current is not switched on, bears firmly against the stop and is not moved even on rough treatment, so that this arrangement acts as an arresting means.

The above described method of transmission of measuring values or the like through an arrangement acting approximately as a saturated electron tube, for the purpose of making the measuring values approximately independent of the line resistance, is to be protected, however, not only in combination with the remaining parts of the present application, but quite broadly, independently of these other parts of the application or in any desired combination therewith, as, in general, also separate protection is sought for all observations made in connection with the present application. What has been said at one point of the application is also intended to apply accordingly to constructional examples described elsewhere.

As has already been pointed out above, an ambiguity of an adjustment of the slider S with respect to an adjusted wave-length can arise owing to the remanence. By use of the instrument I as an indicating instrument, the position of the slider S in the tuning operation becomes meaningless. However, yet another defect persists, which may sometimes be unpleasantly manifested in apparatus for maximum demands. When the adjustment is effected then a small reduction of the remanence can occasionally be observed, whereby, after the adjustment to a transmitter has already been effected, small departures in the oscillator adjustment and thus disturbances in the reproduction quality in the case of a received transmitter are then manifested after a certain period of operation. In order to obviate these disadvantages, it is preferable to provide an arrangement for automatic tuning correction.

With the existence of a tuning magnet M such an arrangement can be relatively simply arranged. In the constructional example illustrated in Fig. 1 two oscillatory circuits 1 and 2 coupled to the anode circuit of the tube P are used for this purpose, one of which is adjusted in a manner well-known per se to a somewhat higher frequency and the other to a somewhat lower frequency than the intermediate frequency. According to the direction in which the oscillation effective in the intermediate-frequency amplifier departs from the theoretical value, the voltage at the circuit 1 or at the circuit 2 will increase. By the aid of a double diode, the two voltages are rectified and supplied to a differential winding 3 at the magnet M. Therefore, according to the departure which has occurred, the magnetic flux is strengthened or weakened and thus a correction of the tuning is effected.

Since the automatic tuning correction on passing from one station to the other may cause difficulties owing to the automatic tuning tending to keep the receiver tuned to the same station even though the tuning control be moved through some considerable distance, it is desirable to cut out the automatic tuning correction during the operation of the slider S at the operating post. This can be effected simply by disconnecting the anode voltage of the tube P by means of a cut-out switch or short-circuiter which automatically comes into action on touching the handle of the slider S, which is possible without additional leads, since the instrument I, is, of course, located in the anode circuit of the tube P.

The switching off and on of the receiver is effected by means of the switch A, which breaks the primary circuit of the transformer. In this circuit there is provided also a fuse lamp L, which may be employed at the same time for illuminating the scale of the instrument I at the operating post. If several operating posts are provided, which may possibly be permanently inserted, the instruments I existing at various places are connected in series.

What was said above regarding the negligibility of the external resistance in the circuit of the tube P enables the selective insertion of one or more indicating instruments without appreciable influencing of the measuring value.

Instead of working with a current intensity dependent upon the particular resistance W in the installation, arrangements may also be employed in which the voltage in a measuring lead alters in accordance with the resistance W, in which case the individual indicating instruments should then be connected in parallel as volt-meters.

The remotely operated volume regulator R is also to be pointed out. This regulator influences the heating current in a tube H. The tube H has a heating body which similarly as in the well-known "Urdox" resistances, consists of a material which consists substantially of uranium oxides or similarly behaving substances with a strong negative temperature coefficient.

Such resistances varying under the influence of a heating current have already been proposed for remote regulation. These well-known arrangements, however, have the drawback that the heating acts only indirectly similarly as in an indirectly-heated amplifying tube. The well-known arrangements have substantially a tubular body of the temperature-sensitive material, in the interior of which a heating spiral is arranged. However, since the indirect transmission of heat is effected (substantially by radiation) with defective efficiency, these arrangements need an output of 4 to 6 watts which after all is considerable. This is already undesirable because the regulating resistance R must then be capable of receiving similarly high outputs, whereby, it becomes large and expensive if the regulation is to be effected in sufficiently fine stages.

A much more substantial drawback resides also in the fact that, also owing to the inertia of such an arrangement, the volume follows the adjusting operation only with a moderate time delay. It is found to be very unpleasant during manipulation if the adjusting knob is rotated and the volume is adjusted only after about half a minute to the amount which corresponds to the position of the regulator.

If, however, the direct heating according to Fig. 1 is chosen for the heating of the temperature-sensitive body, then by means of the differential circuit employed, an influencing of the high-frequency circuit can be avoided exactly as in the case of indirect heating; the capacity between high-frequency poles is even less and the effective resistance assumes the adjusted value with a small time delay.

The automatic tuning regulation described with reference to Fig. 1 works in such a manner that the entire correction output required for the

winding 3 is taken from the circuits 1 and 2 and thus from the intermediate-frequency amplifier. This is possible, since the output required by the magnet M (on suitable selection of the materials, for instance, when using nickel-iron alloys for K and M, which are very easily saturable) for the covering of the entire receiving range is only extremely low. It amounts to about 1 watt. It is therefore clear that for the small displacements of a few kilocycles at the most, only extremely small outputs are required in the winding 3. But after all this winding must be made extremely high-ohmic if the circuits 1 and 2 are not to be strongly damped, which is to be avoided. It may, therefore, be preferable to go not directly from the double diode to the winding 3, but again through an amplifying tube.

Owing to the degree of control required being small, the reflex principle may also be employed here, so that a special tube for this purpose is not necessary.

The circuit shown in Fig. 1 is a superheterodyne receiver operating on the "single-span" principle.

In this type of apparatus, it is, above all, essential that the mixing tube shall not be overcontrolled. It is therefore usual to provide a rejector circuit for a powerful local transmitter.

In the constructional example shown in Fig. 1, a series resonant circuit between the antenna and earth was provided for the elimination of such powerful local transmitters, that is, for instance, a powerful long-wave local transmitter and a strong local transmitter in the broadest wave-range, since it had been found in experiments that the series resonant circuits act more reliably than the normal rejector circuits. Between the coils of the two series resonant circuits a screen shown in chain dotted lines is provided, since this has proved to be desirable. The dimensioning of the series resonant circuits is effected in such a manner that they have very high inductance (possibly high-frequency iron coils), while the tuning capacities are kept small. Furthermore, a rejector circuit is provided, which is tuned to the intermediate frequency (for instance, 1600 kilocycles). This intermediate-frequency rejector circuit is then connected to the regulating tube H, which acts substantially like a variable resistance and thus allows of varying the input voltage. For heating the tube H, a separate secondary winding is provided in the present case at the mains transformer, which winding furnishes a suitable voltage. The heating connections are connected through condensers to earth, so that they are earthed as regards high-frequency.

Owing to the differential arrangement of the automatic connection to the heating body, in itself only a small disturbing component of the heating current frequency reaches the grid of the mixing tube. By the input filter 4, however, this residual low-frequency voltage is also kept away from the input grid of the mixing tube. Since the one-band superheterodyne, owing to its aperiodic input, of course, only receives a lower voltage at the mixing tube than superheterodyne receivers with sharply tuned input circuits, there is employed here in the filter a high-frequency transformer 5, which then transforms up the voltage which is effective at the tube H and enables a favourable matching of the filter input to the filter output.

As compared with the normal filters known in one-band superheterodyne receivers, the filter shown here allows a voltage increase, in order to obtain substantially 10 times the amount at the input grid.

An arrangement in which the reading is corrected in a mechanical manner, which is sufficient for simpler cases, is shown in Fig. 2. In this arrangement, the complete lack of dependence of the reading accuracy upon the adjustment is not obtained, as in the constructional example of Fig. 1. However, for most cases arising in practice in which a cheap magnetic material is used the inaccuracy of which is already somewhat greater than the calibrating accuracy of the reading scales which is necessary in practice, this arrangement is quite sufficient. It is based on the principle of the so-called drag indicator.

In Fig. 2, R^1 denotes a part of a cylindrical resistance body, for instance, a sliding resistance. Sliding on this resistance coil is a spring F which can be passed along the resistance body R^1 by means of an angle-member on the bar 20. The movement of the spring F on the bar 20 may be effected by means of an endless length of cord and a roller drive. On rotating the driving roller in one or the other direction, the spring F is then displaced by the lengths of cord acting in the direction of the two arrows, towards the left or right-hand side of the diagram. The pointer Z, which moves over the scale divided into wavelengths, is not rigidly connected with the spring F but moves along a second parallel bar 21, the movement of the spring F being transmitted to the pointer Z by a tilting-lever mechanism 22 through springs 23 and 24.

If, therefore, for instance, the spring F is moved to the right, the pointer Z does not rigidly follow up, but the pointer Z is set into motion only after the spring 23 has been somewhat relieved of tension and the spring 24 has then been somewhat tensioned. Since the two leaf springs 25 and 26 provide for a certain sliding friction between the pointer Z and the bar 21, then even on cessation of the movement of the spring F, the pointer will not follow up to such an extent that the two springs 23 and 24 have the same tension, but the pointer lags behind somewhat in the movement.

By this arrangement, therefore, the effect is produced that the pointer is adjusted to another part of the scale if, on the one hand a certain resistance value has been adjusted by the spring F, in which case this position, coming from small resistance values, has been reached and if, on the other hand, the same resistance value has been adjusted by the spring F, in which case this adjustment, commencing from high resistance values, has been obtained.

It is therefore seen that in the movement of the pointer an after-effect is mechanically introduced, which corresponds approximately to the magnetic after-effect, and by means of limiting or tensioning screws not shown in Fig. 2 the arrangement can be adjusted so that the mechanical after-effect extends approximately over a range which is somewhat smaller than the maximum magnetic after-effect which occurs. Thereby, the result is then obtained that at all points an approximately equally favourable correction of the reading is obtained, since at maximum deviation errors, it remains somewhat below the correction really necessary whereas in the case of smaller deviation errors it causes a small but not disturbing over-correction.

This rule, of course, does not have to be posi-

tively observed, but has proved to be advantageous.

Instead of the correction at the reading device and the direct operation at the adjusting device (in this case the spring F) it may also be done inversely and the reading device (in this case the pointer Z) may be directly adjusted and a correction may be effected at the adjusting member (corresponding to F) by any desired after-effect phenomenon.

Since, moreover, the after-effect is dependent upon how strongly magnetisation was previously effected or the magnetism has been weakened, it is preferable to provide in the devices described here an arrangement which makes the values of the after-effect dependent upon the magnitude of the previous displacement of adjustment.

In the constructional example shown in Fig. 2, this purpose is served by the tilting-lever mechanism 22 with the springs 25 and 26. If the spring F is laterally displaced to-and-fro only by small amounts, the tilting lever 22 is adjusted to the mean position shown in Fig. 2. The springs 25 and 26 then bear with relatively slight tension and, thus, also slight friction on the bar 21, and the pointer Z since the whole system only has slight friction with respect to the bar 21, follows the movements of the spring F rather freely from after-effect. If, however, the spring F is displaced relatively quickly by a larger amount to the right or left, as is the case when it is desired to change over to an adjustment of the scale which is far removed from the place already adjusted, the rapid and strong movement on the tilting lever 22, since this tilting lever has a relatively small mass in relation to the pointer system Z with the corresponding running rollers, results in a considerable tilting of the lever 22 owing to its much smaller inertia. Therefore, by strong tensioning of the spring 25 or 26, the friction of the pointer is increased with respect to the bar 21 and a strong tension of the spring 23 or 24 is necessary in order to overcome the friction resistance. This means, however, that in this case the amount by which the pointer Z shifts with respect to the mean position between the springs 23 and 24 is larger than in the preceding case.

In order that, on cessation of the movement of F, the pointer will not spring into the mean position, whereby the whole compensation of the reading would thus lose its object, an additional friction producing element, say, a felt pad or magnetic attraction between a pre-magnetised slide 21 and magnetic parts of the pointer system or the like is employed. The additional friction producing element may come into action only on stopping the movement of F.

Fig. 3 shows another embodiment according to the invention for reading the adjusted frequency.

Here, L_3 C_3 is the oscillator oscillatory circuit, which is excited to oscillation in any manner and by any desired circuit. D is the anode of a diode path which is assumed to be biased and which may accordingly be replaced by any other current or voltage limiting element. In addition to stabilised current sources, which in many cases are alone sufficient, the diode, the bias of which, for highest accuracy demands, is also to be kept constant by stabilising means of any kind, has the purpose of maintaining constant the amplitude of the oscillatory circuit L_3, C_3.

Connected to this circuit is a combination of impedances 10, 11, 12 of which at least two must be existent and of which at least one must be an alternating current impedance. Connected to a member of this impedance combination, in the present case the condenser 12, preferably through a blocking condenser 13, is a diode path 14 which produces at the resistance 15 a direct current voltage, the amplitude of which is dependent upon the frequency of the circuit L_3 C_3.

This direct current voltage is supplied to the control grid 16 of the amplifying tube 17 in such a direction that the control grid 16 is negative with respect to the cathode. Since it is here again a question of a direct current voltage amplification, the multi-grid tube 17 may also be replaced by a series connection of tube systems. For the purpose of obtaining maximum accuracy in the wave length indication, the voltages of the tube 17 particularly the screen grid voltage, are kept constant by suitable stabilisers or the like.

In the anode circuit of the tube 17 the ammeter 18 is situated, the deflection of which constitutes a clear index of the adjusted frequency, so that, therefore, independently of any coverage errors in the adjustment, by this arrangement a clear wave length indication is obtained. The biasing voltage supplied to grid 16 from resistance 15 varies inversely with the frequency of the tuned circuit L_3—C_3, but since this voltage is negative with respect to the cathode, the resulting variations in plate current flowing through ammeter 18 will vary directly with the frequency of tuned circuit L_3, C_3. The cathode of the tube may, bearing in mind the above given instructions, again be directly heated even in the case of alternating current supply. Since the internal resistance of the tube is generally very large as compared with the instrument resistance almost any desired number of instruments may be connected in series without affecting the indicating accuracy which is of importance in the case of several operating posts.

Since there is a dependent relation between frequency and wave length, the indication by meter 18 may be interpreted either in terms of frequency or in terms of wave length. Also, since condenser C_3 is constant, there is a dependent relation between the impedance of coil L_3 and the frequency or wave length of the circuit L_3—C_3, and the indication of meter 18 may be interpreted in terms of impedance of coil L_3 if desired.

The instrument 18, particularly if very large wave ranges are to be covered by the receiving set, which is possible with the "single-span" superheterodyne receiver, must have a very high accuracy which would considerably increase the cost of the instruments. It is therefore proposed to sub-divide the wave range into a large number of sub-ranges. This sub-division of the wave range is, however, effected preferably not in the receiving set, if a one "single-span" set is employed as a remotely-operated set, since it is a welcome quality of such a set for remote operation that, in the actual receiving set no single-mechanically-moved part is provided, but the sub-division into several sub-ranges is effected only at the remote operating place itself.

To this end, the regulating resistance serving for wave-length adjustment or the regulating potentiometer is sub-divided into several fixed resistances which can be successively inserted in steps and the sub-ranges resulting thereby may be traversed by ordinary commercial potentiometers, for instance carbon or graphite

potentiometers with sufficient accuracy to obtain a satisfactory and easy tuning operation.

The same operating knob as effects the wave-range change by changing the resistance at the operating post also varies, by an adjusting or interchanging operation, the instrument scale existing at the time, and causes a variation of the directional force of the instrument. Fig. 4 shows, by way of example, a form of construction.

33 is a roller which carries the fixing point 34 of the spring 35 representing the directional force of an instrument. If, therefore, by rotation of the axis 36, the switch lever 37 is moved from one of the contact segments 38 to another contact segment, whereby, according to the above, by variation of the inserted resistance step, another sub-wave range is inserted, then also by variation of the directional force which is exerted by the spring 35 on the axis 39 of the instrument system, another measuring range of the instrument, the pointer of which deflects from right to left in the constructional example of Fig. 4 is inserted. The instrument itself is therefore a combination of a torsion instrument with a normal pointer instrument.

By adjustment of the screws 30 only three of which are indicated in the figure, but of which preferably as many are provided as individual ranges are existent (in which case for example, for compensation of inaccuracies in the instrument operation, several could also be provided per wave range), the parts 31 may be moved out of their position of rest and, for example, into a position which is symbolised by the dotted line 32. In this way, in the case of each individual sub-range, the pointer zero-position, the pointer mean-position or any other pointer position, which it is desired to choose as reference point for a wave range, can be corrected and, therefore, since only a much smaller number of stations is existent on each wave range, instruments of a much lower degree of accuracy are required. In addition, the reading and adjustment of a station is facilitated.

Although Figs. 3 and 4 have been described with reference to a "single-span" set and with reference to the remote-tuning method shown by way of example in Fig. 1, they have, notwithstanding particular advantages in this special case, general applicability and may also be used in normal superheterodyne and straight receivers as well as in the adjustment of transmitters and in any desired method of remote operation.

It has already been pointed out above that the covering errors can be removed by using methods of measurement which directly determine the field strength existing at the place of the action.

In Fig. 5, there is shown an arrangement in which the oscillations of the local oscillator of a superheterodyne receiver is used as the measuring oscillation. N and S are the poles of a magnet which serves for the remote tuning of the local oscillator (of course, the subject of the application need not concern superheterodyne receivers or, receivers in general, but any desired oscillatory circuit or any desired inductance may serve for the application of the idea of the invention, the advantages being particularly obvious in the circumstances described here by way of example).

51 and 52 are the tuning coil and the tuning condenser respectively of the oscillator circuit, the coil 51 being arranged on a ferro-magnetic mass core. The capacity is shown as being variable, in order to be able to effect an adjustment of the set to the desired wave range, as well as to have also a tuning means available. 53 is the oscillator tube, which, if necessary, may also be the triode system of a multiple mixing tube or the like. Between the grid connection 54 and the earth connection 55, a circuit formed from the resistance 56 and the capacity 57 is provided, to the capacity 57 of which a tube voltmeter V is connected. Since, on tuning variations, both the frequency and the amplitude in the oscillatory circuit 51, 52 varies simultaneously with the inductance of the coil 51, then, since, moreover, owing to the selected magnitudes, the frequency dependency of the voltage at the condenser 57 alters in the same sense, a very considerable alteration of deflection is produced at the tube volt-meter V on variation of the tuning, so that the tube voltmeter can be calibrated with great accuracy in wave lengths or frequencies. Since the indicating instrument of the tube voltmeter is a direct current instrument, the indication may be transmitted to a great distance without conflicting with the mode of operation of the receiving set or the like. Any covering errors no longer occur here in practice.

The principle according to Fig. 5 can be applied in many different ways in a receiving set or transmitting apparatus or the like. Fig. 6 shows an arrangement by way of example. N and S are again the poles of the magnet carrying out the tuning, 51 is the coil of the oscillator, 52 the oscillator tuning capacity, 53 the oscillator tube. A branch 56, 57 is again derived from the oscillatory circuit 51, 52. In order to prevent the anode voltage of the oscillator from reaching the capacity 57, if the oscillator circuit has anode voltage potential, a blocking condenser 58 may be provided, the capacity of which is large as compared with the capacity 57.

The high-frequency voltage is rectified in the present constructional example by the diode 59. Since the capacity 57 need only be chosen so large that it is just capable of furnishing the measuring voltage, it may be omitted in certain circumstances and may be replaced merely by the natural capacity of the diode 59 and the connected circuit elements, for which reason the capacity 57 in Fig. 6 is shown in dotted lines. In a practical constructional example, the resistance in a 1600 kilocycles "single-span" superheterodyne receiver was 3000 ohms and the capacity 20 cms. Instead of the diode 59, of course, an amplifying tube connected as a rectifier may also be employed in audion or anode rectifier connection.

The voltage rectified by the diode 59 is derived at the resistance 60, the alternating current component is filtered out by the filter member 61, 62, 63, and the voltage is supplied to the control grid of the amplifying tube 64.

In order that the measuring results shall, in fact, be clear, the voltages and characteristic data of the tubes employed are to be invariable if possible. The voltages can preferably be stabilised by a glow-discharge stabiliser tube 65. Instead of this tube, combinations of resistances with high positive or negative temperature coefficients (iron-hydrogen resistances or Urdox resistances or the like) could be employed. Leakage transformers, saturated tubes and all stabilising means known at present can also be used.

In the constructional example of Fig. 9, only

the screen-grid voltage of the tube 64 is stabilised, since it has been found that this is sufficient to produce stable conditions in this tube. The grid bias of this tube is also stabilised by the tapping 66. Likewise the cathode voltage supply of the tube 53 is connected to the tube 65. Moreover, in this supply, a regulating resistance 67 is provided, which allows of subsequently regulating the anode voltage of the tube 53, so that the calibration of the reading apparatus can be corrected, if this should prove to be necessary. The tube 64 has a high-frequency input circuit 68 and output circuit 69, so that it can be utilised for high-frequency amplification substantially in the intermediate-frequency part or at some other point of the apparatus. Of course, it could also be utilised for low-frequency amplification.

At the same time, voltages derived at the resistance 60 which are an index of the adjusted wave-length, are, however, also amplified by the tube 64 and are rendered readable by the instrument 70 at the operating post. The instrument 70 may be de-coupled by a resistance 71, so that the instrument lead carries no high-frequency voltages or low-frequency voltages (if the tube is used at the same time for low-frequency amplification). Owing to the high amplification factor of the tube 64, several reading instruments 70 may also be connected in series without substantially falsifying the reading. Line resistances are also harmless to a high degree. If the tube 64 has a curve of high steepness, then rather insensitive instruments may be employed. Otherwise, of course, the tube may also be replaced by a cascade of amplifying tubes.

The observations made in the present application to tuning with the aid of variable inductances applies accordingly, of course, also to the tuning or remote tuning with capacities, for instance, with tubes acting as capacities dependent upon voltage. As far as pure electron tubes are concerned in this case, in which covering errors do not arise, a reading by the control voltage of the tuning element itself may, of course, also be effected. If, however, in the case of the capacities dependent upon voltage, it is a question of gas or vapour-discharge tubes, piezo-electric crystals, Rochelle or Seignette salt, quartz or the like, in which case also covering errors result and these have an undesired value, then the capacity which has just been adjusted is also again determined by an auxiliary voltage or auxiliary frequency and measured at a distance.

An example of an arrangement wherein the tuning is accomplished by controlling a biasing potential applied to a condenser is shown in Fig. 3*a*, which is a modification of the arrangement shown in Fig. 3. In this arrangement, the tuning condenser C_3 is provided with a dielectric, such as Rochelle salt, which is sensitive to a biasing voltage. The capacity of condenser C_3 is varied by impressing a variable biasing voltage upon the condenser from a suitable source, such as battery B. The variable voltage is introduced into the tuning circuit L_3—C_3 by the variable contact R_a on potentiometer resistance R. A condenser C_4 is connected across the variable bias connection to exclude high frequency current from the battery B and resistance R. The indicator connections across the terminals of condenser 12 are the same as shown in Fig. 3.

Here also the remote measurement may again be effected either at the actual tuning element itself or at an auxiliary element combined with this tuning element or connected either in parallel or series therewith or otherwise, at which then in turn the measuring voltage or measuring frequency is effective. In this case, similarly as has been described here in Figs. 5 and 6 for a magnetically variable inductance, a measuring voltage or a measuring current may be derived by means of impedances dependent upon frequency, the magnitude of which impedances is then an index of the adjusted frequency or capacity.

The direct current voltage variation which occurs at the oscillator tube anode on tuning may (possibly amplified) also be used for indication.

I claim:

1. Tuning arrangement for an oscillatory electric circuit comprising an alternating current impedance which changes in value in response to a variable energizing bias applied thereto, said impedance being such that there is a lag between the change in impedance with respect to the change in bias, manually operated regulating means for varying the bias applied from said source to said alternating current impedance for tuning the oscillatory electric circuit to different frequencies, an indicating means, means for producing an electric current in accordance with the adjusted value of the alternating current impedance, and means for conducting said electric current to operate the indicating means.

2. Tuning arrangement for an oscillatory electric circuit comprising an alternating current impedance which changes in value in response to a variable energising bias applied thereto, a biasing means for varying the value of the alternating current impedance, manually operated regulating means for varying said bias for tuning the oscillatory electric circuit to different frequencies, an indicating means, means for producing an electric current the value of which depends upon the adjusted value of the alternating current impedance, an amplifying tube, and a connecting line for feeding said electric current to said indicating means through said amplifying tube whereby the indication given by the indicating means is substantially independent of the resistance of the connecting line.

3. Tuning arrangement for an oscillatory electric circuit comprising an inductance impedance which changes in value in response to a variable energizing bias applied thereto, said impedance being such that there is a lag between the change in impedance with respect to the change in bias, a ferromagnetic core in said inductance, a biasing current for varying the permeability of said core, manually operated regulating means for varying said bias for tuning the oscillatory electric circuit to different frequencies, an indicating means, means for producing an electric current the value of which depends upon the adjusted permeability of said core, an amplifying tube, and a connecting line for feeding said electric current to said indicating means through said amplifying tube whereby the indication given by the indicating means is substantially independent of the resistance of the connecting line.

4. Tuning arrangement for an oscillatory electric circuit comprising a capacity impedance which changes in value in response to a variable energizing bias applied thereto, said impedance being such that there is a lag between the change in impedance with respect to the change in bias, a biasing potential for varying the value of the capacity, manually operated regulating means for varying said bias for tuning the oscillatory

electric circuit to different frequencies, an indicating means, means for producing an electric current the value of which depends upon the adjusted value of the capacity, and means for conducting said electric current to operate the indicating means.

5. A heterodyne receiver comprising a local oscillator circuit, an alternating current impedance which changes in value in response to a variable energizing bias applied thereto, said impedance being such that there is a lag between the change in impedance with respect to the change in bias in said local oscillator circuit, a biasing means for varying the value of said alternating current impedance, manually operated regulating means for varying said bias for tuning the local oscillator circuit for the reception of different frequencies, an indicating means, means for producing an electric current proportional to the adjusted frequency of the local oscillator circuit, and means for conducting said electric current to operate said indicating means.

6. A tuning arrangement for an oscillatory electric circuit comprising an alternating current impedance which changes in value in response to a variable energising bias applied thereto and which is such that there is a lag between the change in impedance with respect to the change in bias, a biasing means for varying the value of said alternating current impedance, a manually operated regulating means for varying said bias for tuning the oscillatory electric circuit to different frequencies, a calibrated scale, a pointer, and coupling means for moving said scale relative to said pointer by the operation of said manually operated means, said coupling means being such that the movement of the indicating means lags behind the movement of the manually operated means and compensates for the lag in the variation of the impedance with respect to the operation of the manually operated regulating means.

7. Tuning arrangement for a radio receiver comprising an oscillatory electric circuit including an alternating current impedance which changes in value in response to a variable energising bias applied thereto and which is such that there is a lag between the change in impedance with respect to the change in bias, a source of electrical energy, a manually operated regulating means for varying the bias applied from said source to said alternating current impedance for tuning the oscillatory electric circuit to different frequencies, an indicating means, and means for actuating the indicating means to indicate the adjusted value of the tuning irrespective of the lag in the response of the alternating current impedance with respect to the operation of the continuously variable manually operated regulating means.

8. Tuning arrangement for an oscillatory electric circuit comprising an alternating current impedance which changes in value in response to a variable energising bias applied thereto, said impedance being such that there is a lag between the change in impedance with respect to the change in bias, a biasing means for varying the value of the alternating current impedance, regulating means for varying said bias for tuning the oscillatory electric circuit to different frequencies, indicating means, means for producing an electric current the value of which depends upon the adjusted value of the tuning, a high impedance device, and a connecting line for feeding said electric current to said indicating means through said high impedance device whereby the indication given by the indicating means is substantially independent of the resistance of the connecting line.

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