Oct. 4, 1949. W. A. GOLD 2,483,409

TUNING ARRANGEMENT FOR THERMIONIC VALVE CIRCUITS

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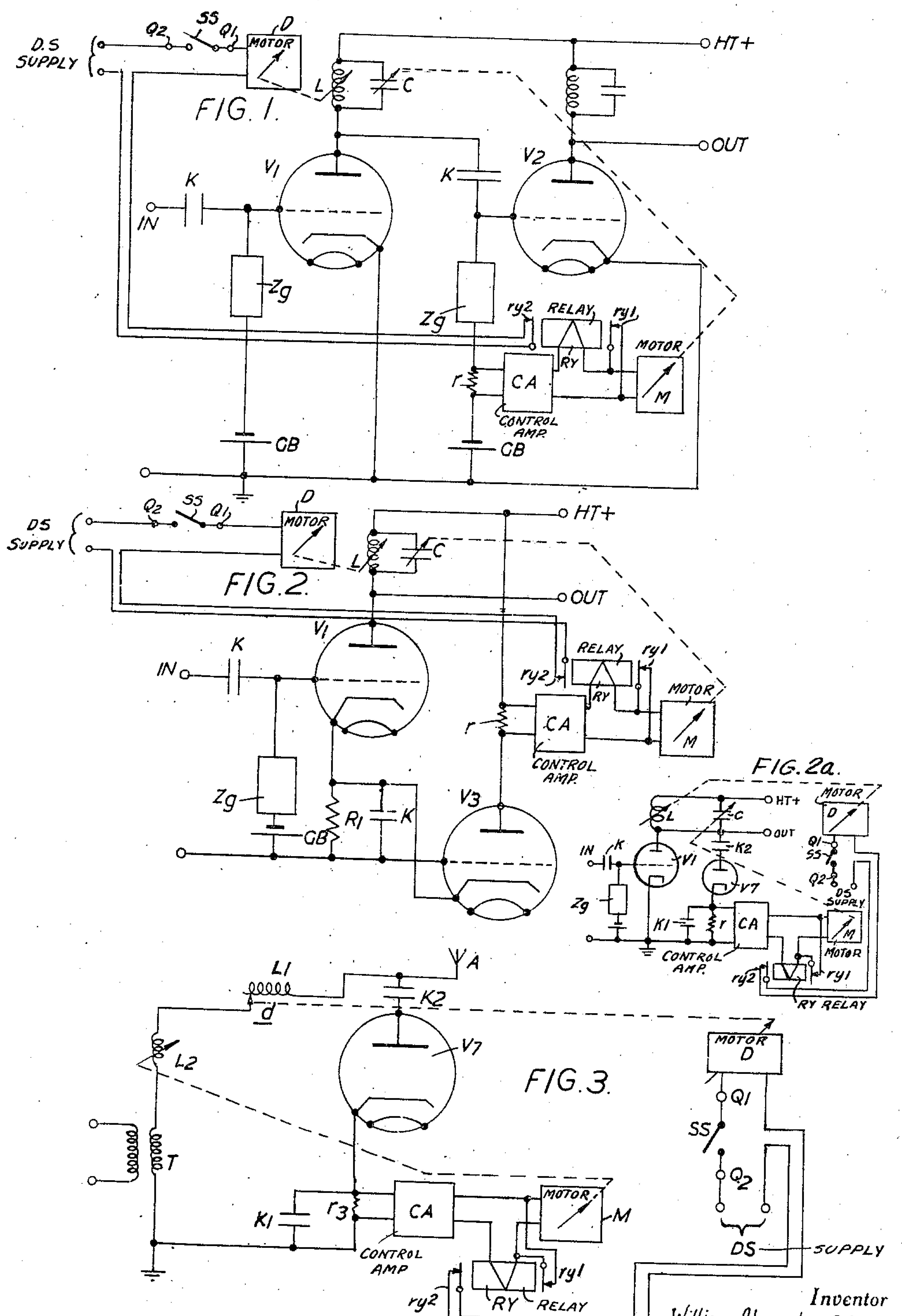

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FIG.4.

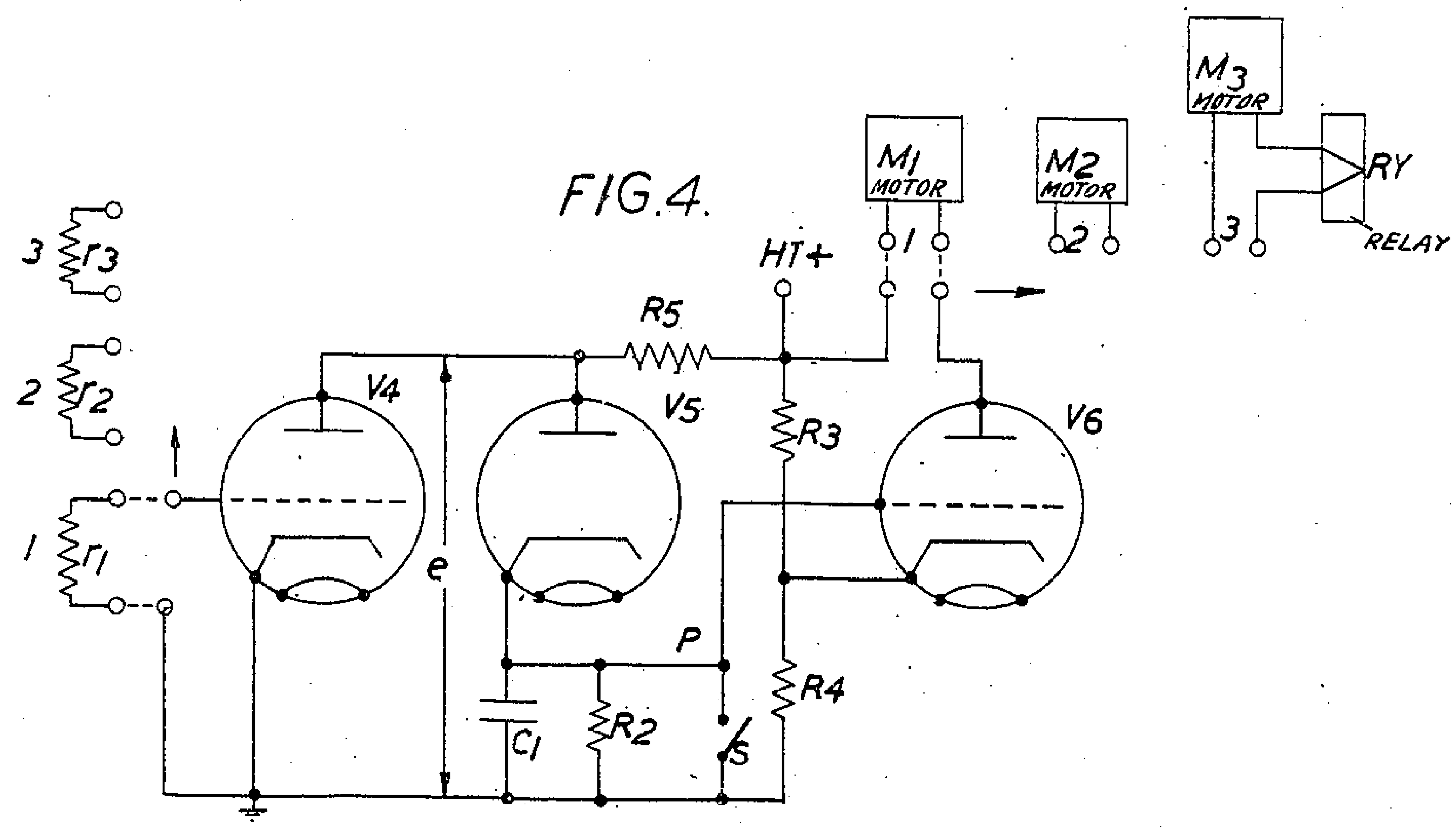


FIG.5.

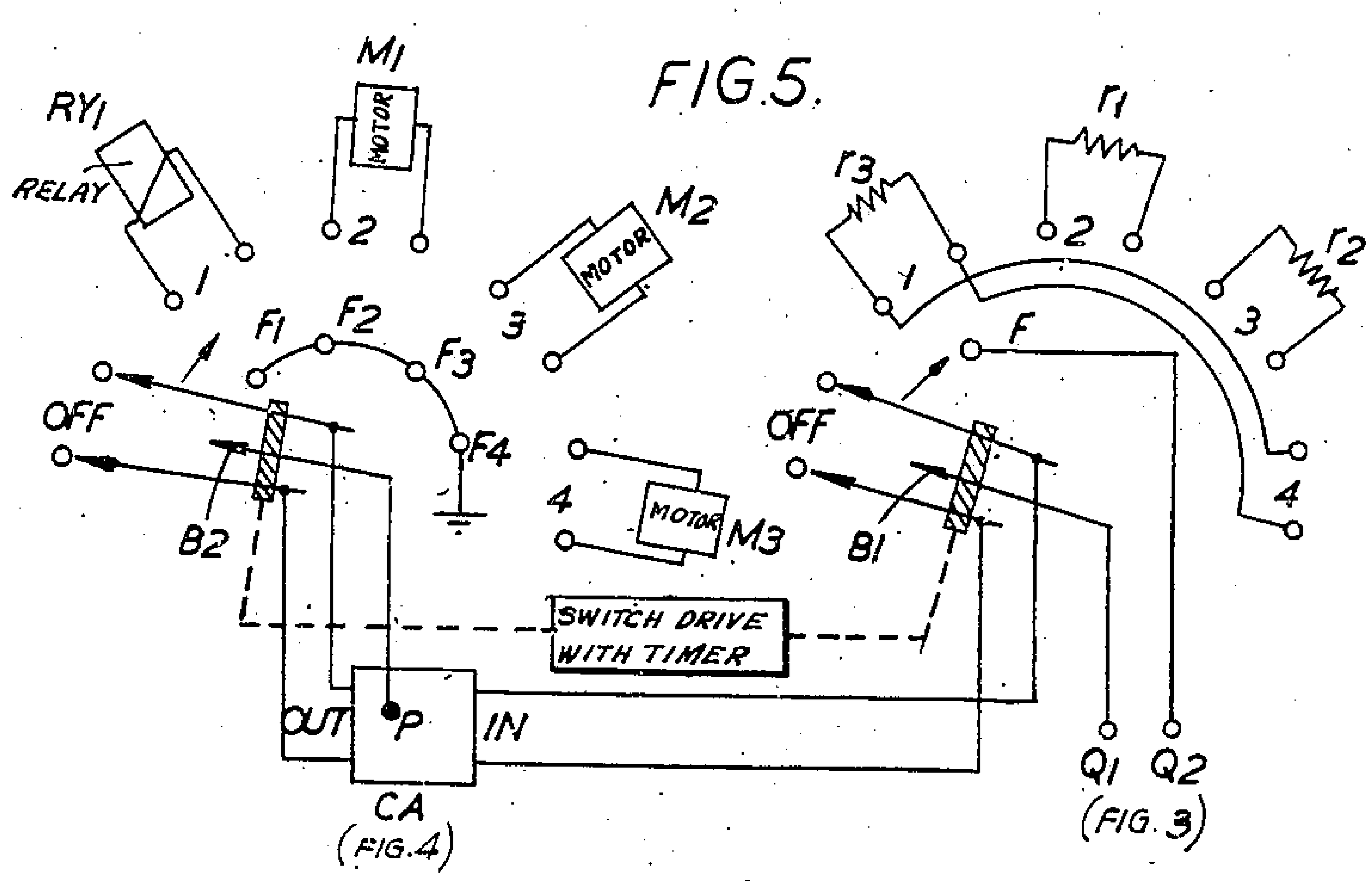
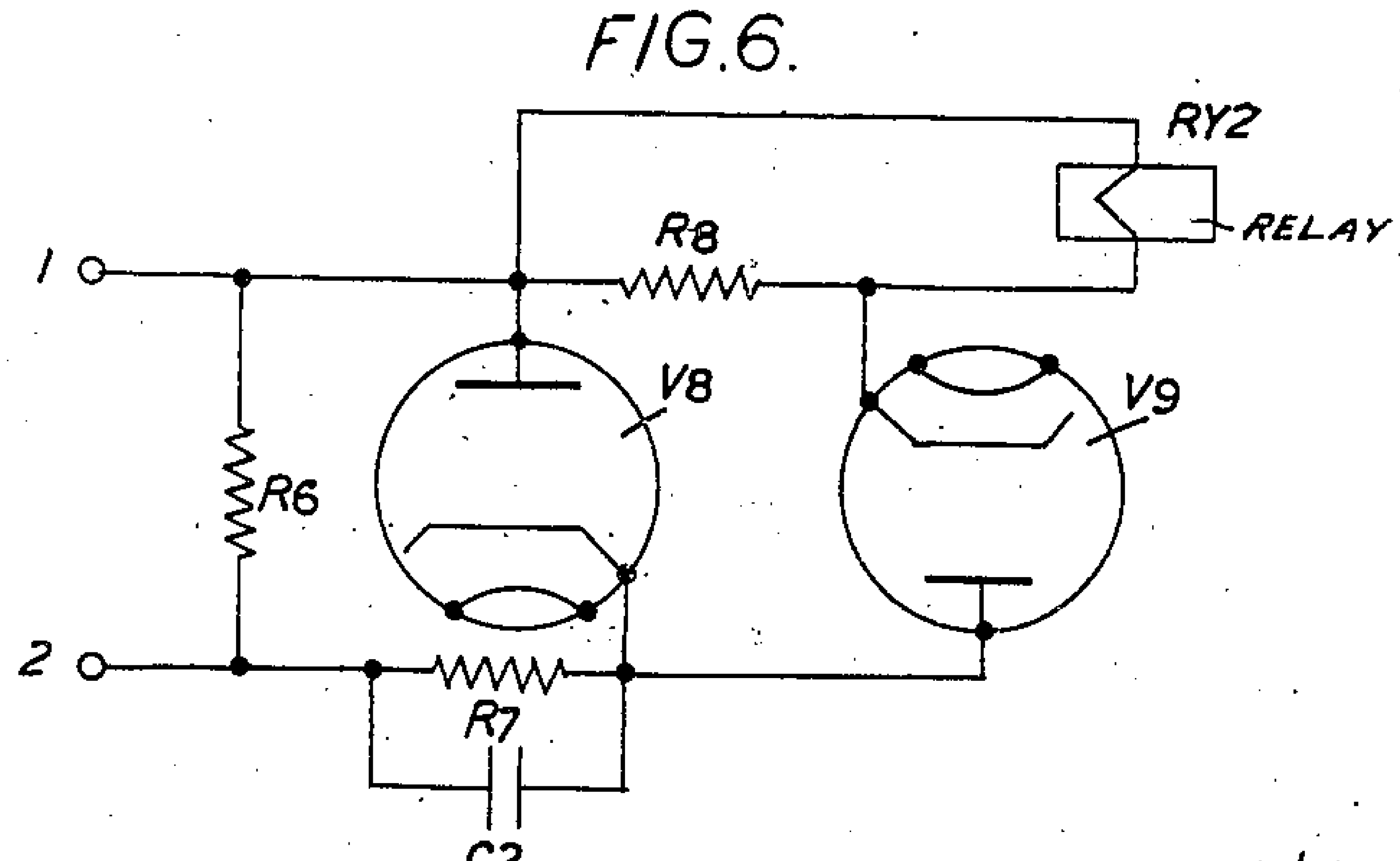


FIG.6.



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TUNING ARRANGEMENT FOR THERMIONIC VALVE CIRCUITS

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10 Claims. (Cl. 250—40)

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The present invention relates to tuning arrangements for electrical signal transmission systems, and concerns particularly the tuning of any number of stages in such a system to a signal wave of a particular frequency.

In a radio transmitter, for example, it is usually necessary to tune one or more thermionic valve stages to the frequency of the master oscillator; and furthermore, the aerial circuit may need to be similarly tuned. While the invention will be described in its application to a radio transmitter it is applicable to any transmission system having stages which need tuning to a signal frequency, and the ultimate load is not necessarily an aerial.

The invention is concerned with automatic means for performing the tuning, and may comprise two operations, in the first of which some or all of the amplifying stages are given a simultaneous rough tuning, and in the second each stage is separately given a final accurate tuning. The tuning arrangements are controlled by the variations of a rectified current in a valve or rectifier which passes through a maximum or minimum as the tuning is varied through the resonance point.

According to the invention there is provided in an electrical signal transmission system, an arrangement for adjusting a tunable circuit to resonate at the frequency of an applied signal wave, which comprises an electromagnetic device adapted to vary a reactance forming part of the tunable circuit under the control of a current derived from a thermionic valve or rectifier, which current is adapted to vary according to the instantaneous resonance frequency of the tunable circuit and to attain a maximum or a minimum value when the tunable circuit is in resonance with the signal frequency.

The invention will be described with reference to the accompanying drawings, in which:

Fig. 1 shows a schematic circuit diagram of one arrangement according to the invention;

Figs. 2 and 3 show two other arrangements;

Fig. 2*a* shows the application of the diode control of Fig. 3 to the circuit of Fig. 2.

Fig. 4 shows a control amplifier which may be used with any of the circuits shown in Figs. 1, 2 or 3;

Fig. 5 shows a diagram of a switching arrangement for facilitating the tuning of a number of amplifying stages; and

Fig. 6 shows a relay circuit which may be employed for preliminary tuning adjustments.

Fig. 1 shows two stages of a thermionic valve amplifier forming part of a wave transmission system, for example, a power amplifier in a radio transmitter. It will be assumed that the valve V_2 at least is operated under class C conditions, that is, the control grid is negatively biassed well beyond the cut-off point and the amplitude of the signal applied to the control grid is such that it is driven positive by the positive half waves. The resulting grid current will therefore increase as the amplitude of the applied signal increases, and vice-versa.

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In Fig. 1 the two valves V_1 and V_2 are provided with conventional auxiliary arrangements comprising appropriate impedances Z_g for connecting the control grids to suitable biassing sources represented by batteries GB. The condensers K are coupling condensers of suitable capacity.

The anode current of the valve V_1 is supplied from the high-tension source HT+ through a parallel tuned circuit comprising an adjustable condenser C and an inductance L which may also be adjustable as indicated. The valve V_2 may be supplied by a similar arrangement shown but not designated.

The condenser C is mechanically controlled by an electro-magnetic device M which is operated through a control amplifier CA (to be presently described) the input terminals of which are connected across a resistance r of suitable value connected in series with the control grid of the valve V_2, so that the grid current flows through the resistance. The device M is therefore effectively controlled by the grid current.

This device may be of any suitable type; it may, for example, be similar in principle to one of the well known types of direct-current indicating meters, the moving coil or armature being adapted to rotate a movable vane or vanes of the condenser C, or otherwise to vary its capacity. The device should in addition be provided with means for locking the movement in any position, preferably electro-magnetically controlled.

The function of the device M is to tune the circuit L, C accurately to resonance at the frequency of the waves applied to the control grid of the valve V_1 at the terminal IN. A preliminary rough tuning is first carried out manually or automatically by adjusting inductance L and the condenser C, but leaving the circuit slightly mistuned on one side or the other of the signal frequency according to the manner in which the device M varies the frequency of the circuit L, C as will be presently explained.

The control of the tuning depends on the variation of the grid current of the valve V_2. Having given a constant signal input at the terminal IN, the grid current will increase to a maximum as the resonance frequency of the circuit L, C approaches the signal frequency from either side. Assuming for clearness that the circuit L, C is left mistuned to a frequency slightly lower than that of the signal after the preliminary tuning, as the frequency is raised by the appropriate adjustment of condenser C the grid current of valve V_2 will increase until the signal frequency is reached and will thereafter decrease. It will, therefore, be arranged so that when the grid current increases it will operate device M in the direction to decrease the capacity of the condenser C so that the frequency change brought about by the movement of device M will tend to drive it in the direction to increase the change. When the maximum of the grid current is reached the device M will come to rest and will leave the circuit L, C tuned accurately to the frequency of the incoming signals. It is then locked in the rest position.

It will be understood that it could be alternatively arranged so that an increase in the grid current of valve V_2 causes device M to increase the capacity of the condenser C, in which case the preliminary rough tuning should leave the circuit tuned to a frequency slightly too high. Furthermore, the device M could be designed to control inductance L, or part of inductance L, instead of controlling condenser C.

It will be understood, also, that the preliminary rough adjustment must tune the circuit L, C sufficiently near the signal frequency so that the grid current has begun to flow in the valve V_2 in order that device M may be able to control the final adjustment, and moreover, device M must be arranged to control inductance L or condenser C so that the effect of the grid current is to move device M in the direction to improve the tuning.

Fig. 2 shows an alternative arrangement whereby the device M is controlled by the anode current of the valve V_1 instead of by the grid current of valve V_2 (which is not shown in Fig. 2). Assuming that a signal of constant amplitude is applied to the control grid, then the anode current passes through a local minimum value as the tuning of the parallel resonant circuit L, C is varied through the resonance point.

The anode current passes through the resistance R_1 connected in series with the cathode of the valve V_1 and shunted by the by-pass condenser K. The potential drop across resistance R_1 is applied between the control grid and cathode of a reversing valve V_3 so that the local minimum may be transformed into a maximum for operating the device M. The resistance r is connected in series with the anode of the valve V_3 and operates the device M through the control amplifier CA as already desired.

The valve V_3 does not need to be a power valve and should preferably be operated under class A conditions, suitable biassing arrangements (not shown) being provided by well known methods.

Fig. 3 shows an arrangement in similar principles adapted for adjustment of the aerial matching coils in a radio transmitting system, which includes automatic means for carrying out the preliminary as well as the final adjustment. The aerial A is connected to earth through an inductance coil L_1 adapted for the preliminary adjustment, a second inductance coil L_2 adapted for the final adjustment, and also through the secondary winding of an output transformer T the primary winding of which is connected to the last stage of the power amplifier of the radio transmitter, (not shown). The coil L_1 is adjusted by an electric motor D which controls a movable contact d on L_1 (or which may change the inductance in any other convenient way). The motor D is driven from a power supply connected to the terminals DS, through a starting switch SS.

The aerial A is connected to earth through a diode V_7 connected in series with a resistance r_3 shunted by a by-pass condenser K_1. A blocking condenser K_2 may be included if necessary. The control amplifier is connected as before across resistance r_3, and operates the device M in series with a relay RY. M controls the adjustment of L_2 in the manner previously described, and is short-circuited by the normally closed contacts $ry1$ of the relay RY; and the motor D is connected to the power supply through the normally closed contacts $ry2$ of the same relay.

When the adjustments of the coils L_1 and L_2 are to be made, it is first arranged so that coil L_2 is set at one end or the other of its range, and the starting switch SS is closed to connect the power to the motor D. Since the aerial A is initially out of tune, the signals derived from the transformer T will produce only a small rectified current in the circuit of the diode V_7. The motor, however, will be adjusting coil L_1 in the direction to improve the tuning, and the rectified current will increase until the maximum is reached when the aerial is tuned to the signal frequency. It is arranged so that just about this time, or perhaps a little earlier, the rectified current reaches a value sufficient to operate the relay RY which opens both the contacts $ry1$ and $ry2$. This cuts off the power driving the motor D, which will continue to run for a few revolutions before stopping. It should stop when the inductance L_1 has slightly overshot the resonance point. The opening of contacts $ry1$ when the rectified current reaches the value specified above permits the device M to make the final adjustment of inductance L_2 to bring the circuit back to resonance, in the manner already explained, being controlled this time by the maximum of the rectified current in the circuit of diode V_7.

It will be evident from what has been said that if inductance L_1 is set at the minimum value before the adjustment begins, then the motor adjusts it too high and inductance L_2 should therefore be at the maximum setting when device M is short circuited, so that device M may be able to make the necessary reduction in the total inductance. Similarly if coil L_1 is initially at the maximum, then coil L_2 must be initially at the minimum. It will be obvious that the total range of coil L_2 must be such as to cover with sufficient margin the amount of overshoot produced before the motor stops.

It will be seen that in general the device M will begin to operate before the motor D has stopped. Owing to the overshoot, there will be no confusion between the two adjustments since the device M tends to correct the overshoot, and will continue to adjust until after the motor has stopped.

It should be mentioned in connection with Fig. 2, that if the valve V_1 is operated under class C conditions, and if it is incompletely neutralised, the anode current minimum may not exactly correspond with resonance of the tuned circuit. In this case an arrangement employing a diode circuit like that shown in Fig. 3 may be used instead of the reversing valve V_3, so that the device M, which controls the adjustment of condenser C_1 is itself controlled by the anode voltage of valve V_1 instead of by the anode current. According to this variation, the diode V_7 (Fig. 3) would be connected to earth as there indicated, and its anode would be connected to the anode of valve V_1 in Fig. 2, through a blocking condenser, the valve V_3 and its connections being omitted.

It was stated above in connection with Fig. 1 that the device M comes to rest when the grid current maximum is reached. This however may not be the case if device M has any appreciable inertia, and its movement may tend to overshoot the accurate tuning point so that the grid current of valve V_2 will begin to decrease again. This will cause device M to swing back, and if it is again carried past the maximum, the resulting decrease in grid current due to the mistuning produced will drive the device still further backwards and the circuit may become mistuned to the limit of variation which device M is capable of producing. The same tendency is inherent in the arrangements shown in Figs. 2 and 3.

This tendency may be prevented by means of the control amplifier CA, details of which are shown in Fig. 4. This amplifier also introduces appropriate amplification for the satisfactory operation of the device M and relay RY (when used).

The control amplifier comprises two amplifying valves V_4 and V_6 coupled by a circuit which includes a diode V_5. Resistance R_5 is the anode supply resistance for the input valve V_4 and the anode of valve V_6 is connected to the high tension source at terminal HT+ through one of the electromagnetic tuning devices M such as M_1 which corresponds to the stage of the transmission system which is being tuned, the connection being indicated by the dotted lines in Fig. 3. The cathode of valve V_6 is appropriately biassed by the voltage-divider bleeder network comprising resistances R_3 and R_4 connected to the high tension supply so that there is never at any time any appreciable grid current. The input terminals of the control amplifier are connected across the resistance r_1 corresponding to the stage which is to be adjusted. The same control amplifier may be used for any number of stages by the use of an appropriate switch as shown in Figure 5 which selects the corresponding resistance r and device M for each stage as indicated.

The coupling network comprises a condenser C_1 and a resistance R_2 connected in shunt to the control grid of valve V_6, and the impedance of the diode V_5 connects the anode of valve V_4 thereto. The anode of the diode is connected to the anode of valve V_4 so that it will conduct when the potential of the anode of valve V_4 changes positively. A pair of contacts S, normally open, and controlled by the above-mentioned switch, is connected across the condenser C_1.

The resistance R_2 should have a high value (for example 10 megohms) and the capacity of the condenser C_1 should be large, (for example 1 microfarad) so that the time constant of this circuit is sufficiently large.

For the sake of clearness it will be assumed that the control amplifier is connected in the control grid circuit of the valve V_2 in Fig. 1, and that at the beginning of the final tuning operation, the grid current is small, the connections being poled so that a small negative voltage is applied to the control grid of valve V_4. There will be a relatively large anode current in valve V_4 and the anode potential e will accordingly be relatively low due to the potential drop in the resistance R_5. Assuming that the contacts S are open, as shown, the condenser C_1 will be charged up to the potential e through the diode V_5. As the grid current of the valve V_2 increases during the final tuning operation already described, the potential of the anode of valve V_4 will continually rise due to the increasing negative potential applied to its control grid. The anode of the diode V_5 will accordingly be positive to its cathode, and provided that the impedance of the diode in the conducting direction is low so that the time constant of the coupling network is sufficiently small, the anode potential increases will be almost immediately applied through the diode V_5 to the condenser C_1, whose potential, which is also that of the control grid of valve V_6, will rise accordingly, causing the anode current, which operates device M_1, to increase in the same way. If, however, for any reason the grid current of valve V_2 (Fig. 1) should begin to decrease, the potential of the anodes of valves V_4 and V_5 will also decrease and valve V_5 will immediately cease to conduct, and the potential of the condenser C_1 will not be accordingly reduced (except very slightly through resistance R_2). Thus, if the device M_1 should be liable to overshoot, the resulting initial decrease in the grid current of valve V_2 will not be passed on and the device M_1 will be held by the anode current of valve V_6, which does not decrease because the control grid voltage remains practically constant.

A reversal of the grid current change in valve V_2 may also be produced if the signal waves are modulated or are subject to interruption or interference. The tuning will be arrested every time this occurs, but will be resumed directly as the grid current increases again, until the tuning is completed.

The slow discharge of the condenser C_1 through the resistance R_2 will only result in a very slight mistuning which being equivalent to a decrease of the grid current of valve V_2 will not be passed on through the amplifier so that it will not initiate a complete mistuning.

As soon as the tuning of the stage has been completed, the control amplifier may be transferred by the switch of Figure 5 to the resistance r_2 and device M_2 of the next stage to be tuned. At some point during the change-over the contacts S are momentarily closed by the switch and short circuit the condenser C_1, so that the tuning of the new stage may start at the beginning. Any number of further stages may be tuned in turn by switching the control amplifiers to the corresponding resistance r and device M in each case.

It will be evident that the diode device V_5 may be replaced by any other kind of rectifier (such as a selenium or copper-oxide rectifier) arranged so that its forward or conducting direction is from the anode of valve V_4 to the control grid of valve V_6. Also the control grid of valve V_6 may be biassed in other well known ways, and any other suitable conventional arrangements may be used instead of those shown. It will be obvious, also, that any additional amplifying stages necessary may be introduced in any well known manner.

Similarly the diode V_2 in Fig. 3 may be replaced by some other kind of rectifier.

It will be understood that several stages in a transmission system may need to be tuned to the operating frequency. For this purpose it may be convenient to couple together the rough tuning arrangements of all such stages so that they can be simultaneously adjusted; then the stages can be arranged to be finally adjusted separately in turn by any of the methods described, if necessary with the help of the control amplifier, Fig. 4. It is to be understood that the separate motor D shown in connection with Figures 1, 2 and 3 is primarily for illustration purposes only and, as explained, a single motor D connected with the tuning means of a plurality of stages, such as one or more amplifier stages of Figures 1 and 2 and the aerial connection stage of Figure 3, may be used and is the simpler form.

The preliminary tuning arrangement described with reference to Fig. 3 may be applied with slight modification to the preliminary tuning of all the stages of the system. For clearness the system will be assumed to be a radio transmitter but the arrangement will be equally applicable to other systems, which may have some other final load than an aerial.

Referring to Fig. 3, the preliminary tuning elements of all the stages are coupled mechanically to their respective adjustable tuning means such as coil L_1 so that they will be simultaneously adjusted by the motor D. It will, of course, be necessary to arrange so that the separate elements are adjusted at appropriate rates so that they will reach the tuning point at approximately the same time, and further, since the same transmitter may be used with a number of different aerials, it may be necessary to provide interchangeable units for coil L_1 so that a suitable adjustable coil can be selected for the aerial to be used.

The rough and final tuning can be carried out by the methods explained, by the help of a switching arrangement such as that shown in Fig. 5. A pair of coupled rotary switches is shown having four positions and an off position. The switch may, of course, have as many positions as there are stages to tune.

The right hand portion of the switch is adapted for connecting the input of the amplifier across the resistance r of the various stages in turn, and the left hand position is used for connecting the output to the corresponding device M (or to a relay RY_1). Position 1 is used for the rough tuning. The right hand part of the switch connects the input of the amplifier CA to the resistance r_3 of Fig. 3 and the output to a relay RY_1 which controls the contacts ry_2 of Fig. 3. This relay therefore takes the place of the relay RY and the device M shown in Fig. 3, the latter being not required for the rough tuning.

The right hand portion of the switch carries a third brush B_1 which makes contact with a stud F in position 1 only. Brush B_1 and stud F are connected to the points Q_1 and Q_2 respectively in Fig. 3 and represent the switch SS. When, therefore, the switch is moved to position 1, the motor D is started and the rough adjustment is carried out as already explained, the relay RY_1 operating and opening the contacts ry_2 as soon as the maximum current through the resistance r_3 is reached.

The left-hand portion of the switch also carries a third brush B_2 which is adapted to make a temporary contact with any of the studs F_1, F_2, F_3 etc. while the switch is passing between the successive positions. These studs, F_1, F_2, F_3 etc., are all connected to ground, and the brush B_2 is connected to the point P in the control amplifier (Fig. 4). The brush B_2 and studs, F_1, F_2, F_3 etc., therefore correspond to the contacts S and ensure that the condenser C_1 will be momentarily short circuited immediately before each tuning operation. It will be understood, of course, that when the switch is finally set in any of the positions, the brush B_2 is approximately half way between a pair of the studs F.

When the rough tuning is completed, the switch may be moved to position 2, by which the control amplifier is connected between the resistance r_1 and device M_1 of the first stage. The final tuning then takes place as described. All the other stages may be tuned in turn by moving the switch one step each time. The position 4 is allotted to the fine tuning of the aerial A (Fig. 3) and so the studs of the positions 4 and 1 on the right-hand side of the switch are multipled together so that the resistance r_3 is again used.

The left-hand studs are, however, connected to the measuring device M which controls inductance L_2.

The switch shown in Fig. 5 is only diagrammatic and may be constructed in any desired form; some or all of the switching may be performed indirectly in known manner. The switch can be manually or power driven, and may be provided with appropriate timing arrangements so that sufficient time is allowed on each step for the tuning operations to be completed. The switch may also be provided with contacts (not shown) for energising the locking arrangements of the devices M.

In Fig. 6 is shown a relay circuit which may be substituted for the relay RY in Fig. 3 or relay RY_1 in Fig. 5 and is adapted to operate only when the preliminary tuning point has been actually passed, during the adjustment of coil L_1. The input terminals 1, 2 are intended to be connected in the place of the corresponding terminals of the relay RY or RY_1 so that the terminal 1 is positive to the terminal 2.

The relay circuit comprises two diodes V_8, V_9 (or any other type of rectifiers) connected in opposition, a resitsance R_8 being connected between the anode of diode V_8 and the cathode of diode V_9. Diode V_8 is connected with its anode to terminal 1, and with its cathode connected through the resistance R_7 and condenser C_2 in parallel to terminal 2. A relay RY_2 having a suitable self locking arrangement (not shown) may be connected across resistance R_8 and may be adapted to control the contacts $ry2$ and $ry1$ (if used), in Fig. 3. A suitable resistance R_6 may be connected as shown across the terminals 1 and 2 to provide a conducting connection at all times.

While the potential of terminal 1 increases positively with respect to terminal 2, the condenser C_2 charges up through the diode V_8, but since the diode V_9 is connected in the backward direction no current will pass through it. Moreover, after the maximum of the controlling current through the resistance r_3 (Fig. 3) has been passed, the potential of the terminal 1 will begin to decrease. Owing to the charge in the condenser C_2, the difference of potential across the diodes is now reversed in sign, and diode V_8 becomes non-conducting, and diode V_9 discharges the condenser through the resistance R_8 producing an impulse which operates and locks the relay RY_2. It will thus be seen that the relay RY_2 will be operated as soon as the maximum has been passed. Means can be provided (for example in the switch shown in Fig. 5) for releasing the relay RY_2 when the tuning has been completed.

What is claimed is:

1. In a class C amplifier having a first tube

with a tuned anode circuit, an output tube, and at least one grid in said output tube, the output tube being grid fed from the tuned anode circuit of the preceding tube, a motor, and tuning means in said tuned anode circuit, the method of automatically tuning said anode circuit to secure maximum input to said grid, which includes the steps of measuring the current to said grid, causing said current to operate said motor in proportion to the current, and operating said tuning means from said motor to vary the tuning of said anode circuit while said grid current increases, in a direction to cause still further increase thereof, and to cease varying said tuning at the point of maximum grid current.

2. In a class C amplifier having a first tube with a tuned anode circuit, an output tube, and at least one grid in said output tube, the output tube being grid fed from a tuned anode circuit of the preceding tube, a motor, and tuning means in said tuned anode circuit, the method of automatically tuning said anode circuit to secure maximum input to said grid, which includes the steps of measuring the current flowing in said anode circuit, obtaining therefrom a secondary current exhibiting a maximum when said anode current reaches a minimum, causing said secondary current to operate said motor in proportion to the current, and operating said tuning means from said motor to vary the tuning of said anode circuit while said secondary current increases, in a direction to cause still further increase thereof, and to cease varying said tuning at the point of maximum secondary current.

3. In an electrical signal transmission system including a variable reactance and a valve having a tunable anode circuit, said variable reactance comprising part of said tunable anode circuit, means electrically associated with said tunable circuit for producing a control current proportionally varying according to the instantaneous resonance frequency of said tunable circuit and attaining a critical value at the point of resonance of said tunable circuit with a signal frequency, said control current producing means including a series resistor in said anode circuit and a polarity reversing valve having its grid and cathode connected respectively to the lower and higher potential ends of said series resistor whereby said control current reaches a maximum when the current through said resistor reaches a minimum, electromagnetic means responsive to said last mentioned means, coupling means between said electromagnetic means and said variable reactance for varying said reactance under control of said electromagnetic means.

4. In an electrical signal transmission system including a tunable circuit having a variable reactance means electrically associated with said tunable circuit for producing a control current proportionally varying according to the instantaneous resonance frequency of said tunable circuit and attaining a critical value at the point of resonance of said tunable circuit with a signal frequency, electromagnetic means responsive to said last mentioned means, coupling means between said electromagnetic means and said variable reactance for varying said reactance under control of said electromagnetic means and control amplifier means connected in front of said electromagnetic means and adjusted to operate it in accordance with the variation of the controlling current for causing said electromagnetic device to respond when the value of said controlling current changes in one direction and for preventing said device from responding when the value of said controlling current changes in the other direction.

5. In an electrical signal transmission system including an aerial circuit and a tunable circuit in said aerial circuit having a variable reactance, means electrically associated with said tunable circuit and including a rectifying device and resistance connected in series between said aerial and earth for producing a rectified control current proportionally varying according to the instantaneous resonance frequency of said tunable circuit and attaining a critical value when said tunable circuit is in resonance with a signal frequency applied to said system, said rectified control current producing a potential difference in said resistance, electromagnetic means responsive to said last mentioned means, coupling means between said electromagnetic means and said variable reactance for varying said reactance under control of said electromagnetic means, and additional variable reactance in said tunable circuit, a driving source varying said additional reactance, and a relay connected in series with said electromagnetic means being adjusted to disconnect said driving source when the rectified current reaches a predetermined value not greater than the maximum value.

6. In an electrical signal transmission system according to claim 4, including control amplifier means with its output arranged to be connected in front of the electromagnetic means and its input arranged to be connected across a resistor in series with said control current, a switching arrangement for facilitating the preliminary and final tuning of a number of similar amplifier stages, each having control current producing means with a series resistor and each being provided with an additional variable reactance connected with a driving source common to all stages for preliminary adjustment, and the last of said stages including a relay and means whereby the controlling current corresponding to the last tunable circuit of said last stage operates said relay for disconnecting said driving source on reaching a predetermined value not greater than the maximum value, said switching arrangement comprising a pair of coupled rotary switches having one more position than the number of stages to be tuned, said one more position being for preliminary tuning of all stages simultaneously and said other positions being for the final tuning of each stage in turn, one switch of said switching arrangement being adapted for connecting in said other positions the input of said control amplifier across said resistances of the various stages in turn, the other of said switches being adapted for connecting in said other positions the output of said control amplifier to the corresponding electromagnetic means.

7. In an electrical signal transmission system according to claim 6 where said relay circuit includes two rectifying devices connected in opposition and a relay arranged between the anode of the first rectifying device and the cathode of the second rectifying device and shunted by a resistor.

8. In an electrical signal transmission system according to claim 4 where said control amplifier includes two valve amplifying stages and an interstage network including therein a rectifying device, said coupling network comprising a condenser connected to be charged through said rectifying device when the anode potential of the first amplifying stage becomes increasingly posi-

tive, the rectifier preventing the condenser from discharging when the said anode potential decreases, whereby change of direction of said controlling current causes said control amplifier to cease to yield an output.

9. In an electrical signal transmission system according to claim 8 in which the potential of said condenser is applied to the control grid circuit of the second amplifying stage, said electromagnetic means being connected in series with the anode circuit of said second stage.

10. In an electrical signal transmission system according to claim 5 where said relay circuit includes two rectifying devices connected in opposition and a relay shunted by a resistor arranged between the positive terminal of the first rectifying device and the negative terminal of the second rectifying device.

WILLIAM ALEXANDER GOLD.

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