Sept. 5, 1944. S. H. M. DODINGTON 2,357,442

RADIO RECEIVER

Filed June 12, 1942 2 Sheets-Sheet 1

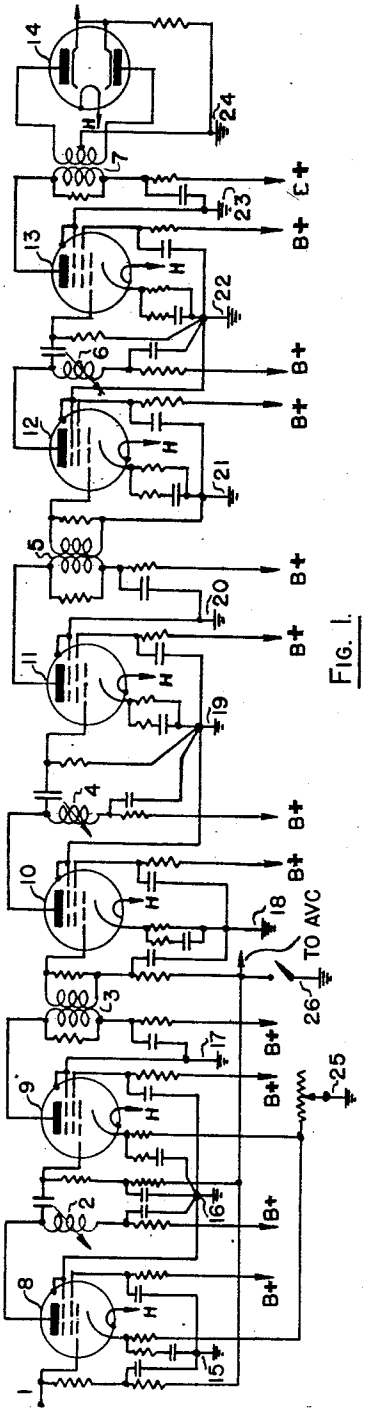

FIG. 1.

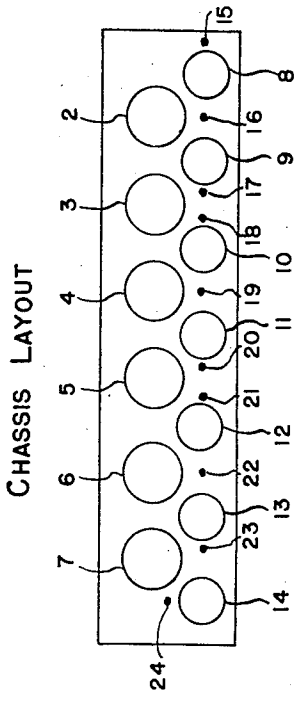

FIG. 2

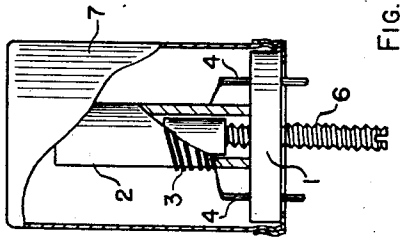

FIG. 3

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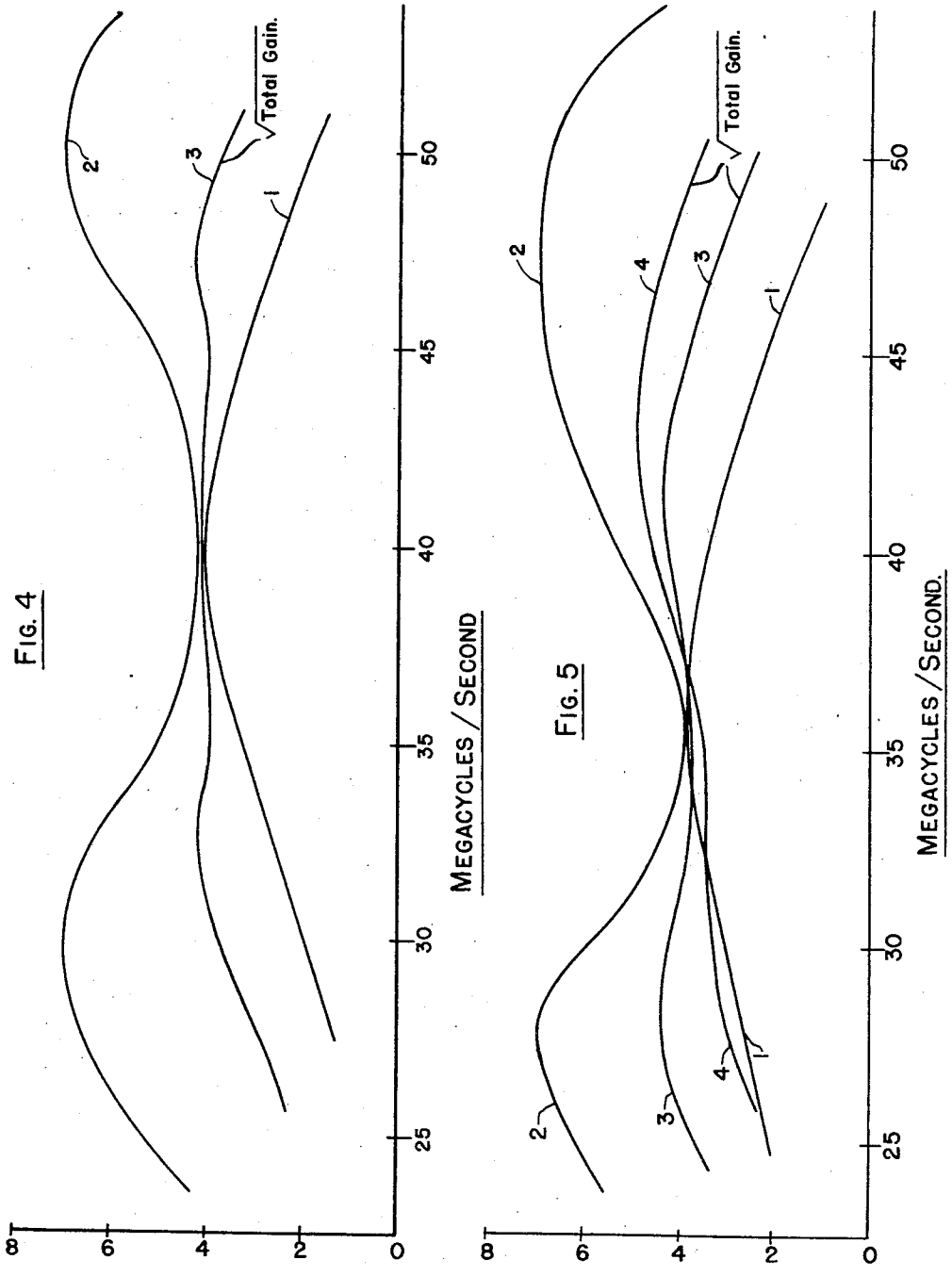

FIG. 4

STAGE GAIN WITH 1852 TUBE

FIG. 5

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Patented Sept. 5, 1944

2,357,442

UNITED STATES PATENT OFFICE

2,357,442

RADIO RECEIVER

Sven H. M. Dodington, Forest Hills, N. Y., assignor to Federal Telephone and Radio Corporation, a corporation of Delaware

Application June 12, 1942, Serial No. 446,780

1 Claim. (Cl. 179—171)

My invention relates to radio receivers and more particularly to radio frequency amplifiers.

Heretofore, a multi-stage transformer coupled radio frequency amplifier has required some variable means such as a variable shunt capacitance for adjusting the coupling device to obtain maximum amplification. While not troublesome at low frequencies, this has been a decided disadvantage in ultra high frequency circuits wherein the least possible amount of capacitance is desirable.

With an amplifier having, say, alternate singly and doubly tuned coupling circuits and means to vary the tuning thereof, the singly tuned interstage coupling circuits may be adjusted to produce a single humped frequency response characteristic and the doubly tuned coupling circuits may be adjusted so as to produce a double humped frequency response curve. The latter is accomplished by increasing the coupling beyond its critical value. As the coupling is still further increased, the two curve peaks move further apart and the hollow between them becomes deeper. The combined response of two such stages will be such as to produce an amplification characteristic which will be substantially uniform throughout the band-width. To obtain uniform amplification over a wide band of frequencies, however, means of varying the doubly tuned coupling circuits has heretofore been necessary.

For reception of ultra high radio frequencies, it may be necessary to use intermediate frequencies in the normal radio frequency range. At these high frequencies, another troublesome feature has been the feedback to preceding stages precipitated by the circulating currents set up between tubes due to interelectrode capacities. These currents may become especially objectionable at ultra-high frequencies.

It is an object of my invention to provide an easily adjusted wide band amplifier which overcomes the objections of those of the prior art.

Another object of my invention is to improve the multi-stage type of wide band radio frequency amplifier having alternate singly and doubly coupled circuits wherein the singly coupled circuits may be tuned to compensate for the effects obtained by the tuning adjustment heretofore required of the doubly coupled circuits.

Still another object of my invention is to improve the multi-stage type of wide-band, radio frequency amplifier to restrict interstage circulating currents thereby minimizing objectionable feedback to preceding stages.

A further object of my invention is to provide an improved multi-stage, wide band, radio frequency amplifier having alternate doubly and singly coupled circuits wherein the singly coupled circuits may be tuned to compensate for the effects obtained by the tuning adjustment heretofore required of the doubly coupled circuits, the various ground points in the complete circuit being so grouped as to restrict interstage circulating currents thereby minimizing objectionable feedback to preceding stages.

I may accomplish the above and other objects of my invention by incorporating in a multi-stage radio frequency amplifier a means for adjusting the inductance of the tuning coil of the singly tuned circuits, for example, with an iron plunger arranged within the coil, so as to compensate for any mistuning of a preceding fixed doubly tuned coupling stage which may have been caused by error in manufacture. Feedback is minimized by grouping certain ground points so as to restrict circulating currents to their immediate circuits between stages.

My invention will be more fully understood by reference to the following description when read in connection with the accompanying drawings, in which,

Fig. 1 is a schematic wiring diagram of a radio frequency amplifier incorporating the features of my invention;

Fig. 2 is a general view of a typical physical layout of the tubes and coupling devices on top of the chassis;

Fig. 3 is a view of a singly tuned coupling coil showing enough of the cross section to illustrate the relation of the coil and plunger arrangement, which may be used for aligning the amplifier;

Fig. 4 is a series of curves showing characteristic frequency response with ideally tuned stages; and

Fig. 5 is a series of curves showing characteristic frequency response with mistuned doubly tuned coupling circuits, and the effect of compensation according to the teachings of my invention.

Referring to the schematic wiring diagram of Fig. 1, a straight-forward circuit of a typical multi-stage intermediate frequency amplifier for operating at a relatively high frequency is shown wherein alternate singly tuned coupling coils 2, 4 and 6 and doubly tuned coupling coils 3, 5 and 7 are employed between stages. At ultra-high frequencies, distributed capacities are generally sufficient to tune the circuit without added bridged condensers as in lower frequency amplifiers.

Tuning of the single coil stages may be accomplished by known arrangements of any suitable type, such as variometer or known plunger tuned coils. The device illustrated in Fig. 3 is well adapted for this purpose. This device consists of an insulated disc base 1 supporting a cylindrical insulated core form 2 around which is wound the necessary turns of wire 3 so that the coil will be substantially tuned to the particular frequency desired. The ends of the coil are ter-

minated at prong-like terminals 4 which project through the base to provide external connecting means. A powdered iron plunger 5, which could be of any paramagnetic material, is movably mounted within the form 2. Its outside diameter is slightly less than the inside diameter of the form 2 so that it is free to be moved. A screw 6 provides a means of adjusting said plunger lengthwise within the form. The entire device is inclosed in a shield can 7. By varying the position of the iron plunger within the coil, more precise tuning is accomplished. Of course, single coil stages may also be tuned by a variable capacitance as conventionally used at low radio frequencies. However, at ultra high frequencies, it is more desirable to restrict capacitance to a minimum and tune by means of a variable inductance.

The doubly tuned circuit coils 3, 5 and 7 indicated in Fig. 1, are of a conventional, predetermined, and fixed design tuned to operate within a specified frequency band. No trimming adjustments are provided on these coils. Other circuit elements are of such rating as to produce in cooperation with the coils, a frequency response curve similar to curve 1 in Fig. 4.

When singly and doubly tuned coupling circuits are properly tuned to cover the desired frequency band, the frequency response curves will be as shown respectively by curves 1 and 2 in Fig. 4. The composite amplification characteristics for the two stages will be a three-humped curve as shown in curve 3, Fig. 4. It will be noted that this produces a substantially uniform amplification characteristic. Due to errors in manufacture, however, the frequency response of the doubly tuned coupling circuits may vary so as to actually produce a curve similar to that shown as curve 2, in Fig. 5.

While the tuning of the singly tuned circuit remains unchanged, a response such as curve 4 in Fig. 5 would result, producing distorted and non-uniform amplification within the operating band range. Now, by adjusting the tuning of the singly tuned circuit, curve 4 in Fig. 5 can be corrected to look like curve 3 in Fig. 5. This corrected curve is substantially uniform and covers approximately the same band width as shown in Fig. 4. It is thus clear that by use of the circuit in accordance with my invention a single tuning adjustment serves to correct substantial distortion.

A six stage, wide band, high gain intermediate frequency amplifier, built in accordance with my invention, gave an 86 db gain and at an extremely wide band width extending from 32 to 48 megacycles. Doubly tuned coils were mistuned to simulate the maximum distortion which might be caused by error in manufacturing tolerances, yet by tuning the singly tuned stages, I was able to satisfactorily compensate for the distortion caused by the said doubly tuned stages, so as to substantially recover the original frequency band width.

Referring again to Fig. 1, it will be noted that a plurality of separate grounding points exist but that certain of the circuit leads are grouped at common ground points. Let us now analyze the flow of currents in the circuits between any two tubes, say, 12 and 13. A current will circulate through coil 6, to the plate of tube 12 across through the shield capacitance and then to ground 21. Another current will circulate through coil 6 to the plate of tube 12 across the capacitance to the suppressor of tube 12 and again to ground 22. Still another current will flow through coil 6 to the control grid of tube 13 across the capacitance to the cathode of tube 13 and then to ground 22. A current will also flow through coil 6 to the control grid of tube 13 across the capacitance to the screen grid and return to ground 22. It will be seen, therefore, that the circulating currents due to the above mentioned interelectrode tube capacities, excepting the current from the plate to the shield of tube 12, all flow back to the common ground 22 and do not flow through either of the adjacent ground points 21 and 23. While all of the ground points are eventually connected to a main ground bus or to the chassis, according to the teachings of my invention circulating currents due to interelectrode tube capacities are restricted from establishing voltages between spot grounding points in latter stages and spot grounding points in the earlier stages, thus minimizing objectionable feedback.

In the above analysis, the circuits between tubes 12 and 13 are capacitively connected. When stages are inductively connected, such as by coils 5 between tubes 11 and 12, conductive means for connecting and terminating at a single point all ground leads which carry circulating currents due to plate capacities, such as in tube 11, may be still further separated from the conductive means for connecting and terminating all ground leads which carry circulating currents due to the control-grid capacities of a succeeding tube, such as in tube 12. However, if sufficient capacity exists in the coupling device as to cause an appreciable capacitive effect, thus permitting an appreciable circulating current to flow between ground lead terminating points, as between ground points 20 and 21, then such terminating points should be combined, as at 22.

While my invention is particularly advantageous in ultra high frequency circuits wherein advantage is taken of inherent distributed capacities, and condenserless circuits are more common, it should be understood that my invention may also be useful at lower frequencies such as where condenser tuning is tolerable.

While I have only shown and described a single form of my invention, I am fully aware that many modifications and variations thereof are possible and for this reason, it is to be understood that that form of my invention herein described is intended to be illustrative of the invention and not to limit the scope of the appended claim.

I claim:

An ultra high frequency amplifier comprising a first tube and a second tube, means coupling said tubes together, each tube having cathode, control grid, screen grid, suppressor grid and plate elements, a ground lead for each of said elements, the ground leads of the plate and the suppressor grid of said first tube and the ground leads of the cathode, control grid and screen grid of said second tube being connected to a common ground point, and the ground leads of the cathode, control grid and screen grid of said first tube being connected to another ground point and the ground leads of the plate and suppressor grid of said second tube being connected to still another ground point.

SVEN H. M. DODINGTON.