

Jan. 30, 1945.

J. E. KEISTER

2,368,474

DECOUPLING UNIT

Filed Sept. 24, 1942

Fig. 1.

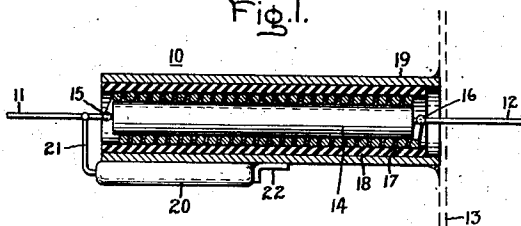


Fig. 2.

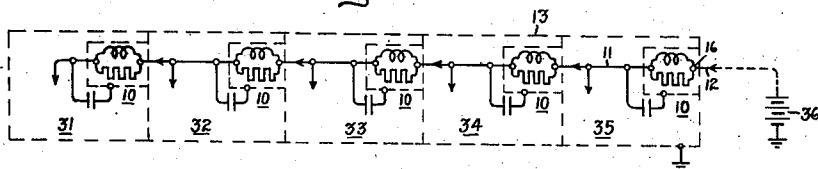


Fig. 3.

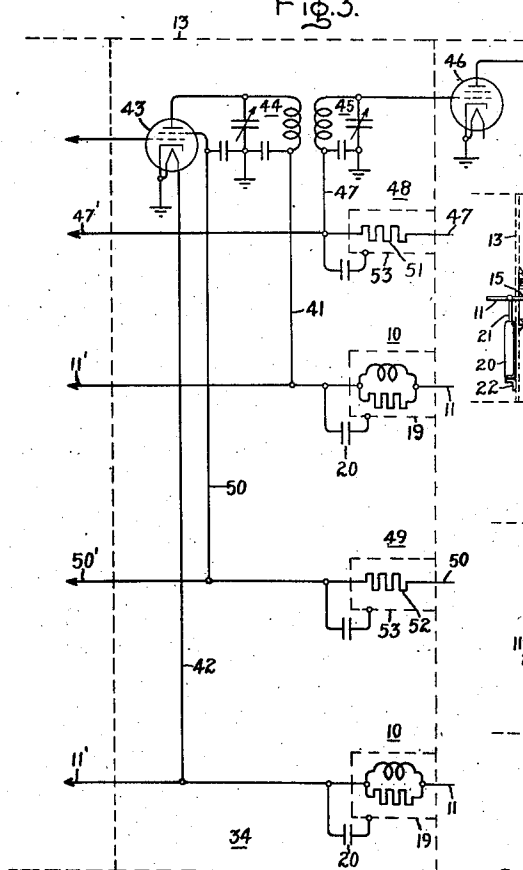


Fig. 4.

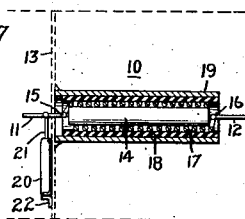
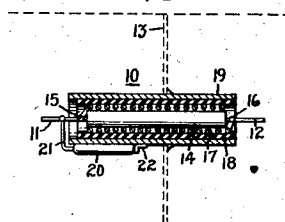


Fig. 5.



Inventor:
James E. Keister,
by *Harry E. Dunham*
His Attorney.

UNITED STATES PATENT OFFICE

2,368,474

DECOUPLING UNIT

James E. Keister, Scotia, N. Y., assignor to General Electric Company, a corporation of New York

Application September 24, 1942, Serial No. 459,495

4 Claims. (Cl. 179-171)

My invention relates to filter units, in particular to filter units for inter-stage decoupling of power leads in high frequency amplifiers, and has for its object to provide a filter which is non-radiating and which has large attenuation at high frequencies, but practically no attenuation at power frequencies.

In high gain amplifiers without frequency conversion, especially when employed at very high frequencies, the problem of multi-stage feed-back is quite serious. Even when complete shielding of each stage is included, the power leads supplying voltages to the electron discharge devices in the different stages cause feed-back between succeeding stages. It is an object of my invention to provide an improved decoupling unit for the power lead of a given stage at its point of entry into a higher level stage which reduces feed-back between the stages and which may be used in cascade for several or more stages.

A further object is to provide a decoupling unit which may be easily constructed from small standard filter elements and which is not critical to frequency.

The features of my invention which I believe to be novel are set forth with particularity in the appended claims. My invention itself, however, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawing, in which Fig. 1 shows a preferred form of the decoupling unit of my invention; Fig. 2 shows how the unit of Fig. 1 may be used in cascade decoupling of successive stages of a radio frequency amplifier; Fig. 3 illustrates the manner in which a plurality of the filter circuits of Fig. 1 are used in each stage to obtain a maximum decoupling between the stages; and Figs. 4 and 5 show modifications of the filter of Fig. 1.

Referring to Fig. 1, the decoupling unit 10 is shown as inserted in series with the power leads 11 and 12 which may supply voltage respectively to a given stage and a higher level stage of a radio frequency amplifier (not shown), each of said stages being completely shielded, in well-known manner, by a metallic shield 13. The decoupling unit 10 comprises the fixed resistor 14, preferably of the insulated type familiar to those skilled in the radio art and having a relatively high resistance, for example, 5000 ohms. The ends of resistor 14 are connected respectively to the power leads 11 and 12 at the points 15 and 16. Connected in shunt to the resistor 14, be-

tween the points 15 and 16, and spirally arranged on the outer surface of resistor 14 is a conductor 17 having a resistance of relatively low value. The individual turns of spirally arranged conductor 17 are closely spaced so that the conductor 17 acts as an inductance coil and presents a path in shunt to resistor 14 having a low resistance for the supply current and a high reactance for radio frequency current. Surrounding the spirally arranged conductor 17 is a layer 18 of suitable insulating material, such as varnished tape or cambric. Preferably, the conductor 17 is wound tightly about the resistor 14 and the layer 18 of insulating material is wound tightly about the conductor 17. A tube or casing 19, of any suitable conductive material, such as copper, encloses the decoupling unit thus far described and forms therewith a small unitary structure. The tube or casing 19 is secured to the shield 13 in any desirable manner, such as by soldering or brazing. A capacitor 20 is also provided for by-passing high frequency currents from the power lead 11 and is connected by a very short lead 21 to conductor 11 as closely as possible to the point 15. Conductor 21 is secured to one electrode of capacitor 20, the other electrode being connected to the member 22 provided for attaching the capacitor 20 to the metal casing 19.

As previously stated, conductor 11 is connected to the lower level stage of the two amplifying stages between which the decoupling unit 10 is to be inserted. Radio frequency currents, picked up by the conductor 12 in the higher level stage, are filtered out by means of the high reactance of conductor 17 in series with the low reactance of capacitor 20. The spirally arranged conductor 17 of the unit acts both as a path of low resistance for power currents supplied over leads 11 and 12 and as a radio frequency choke to suppress any high frequency energy picked up by the lead 12 before leaving the shielded compartment of the higher level stage of the amplifier. By proper choice of the size of conductor 17, a negligible power voltage drop occurs in the filter unit 10. The casing 19 serves to shield the inductance coil 17 to prevent any feed-back of radio frequency energy by this coil. Since there is a tendency, at high frequencies, for the inductance 17 to resonate with the capacitor 20, the resistor 14 is provided as a damping means to prevent excessive resonances in the coil of conductor 17 or in the inductance and capacitor combination. Preferably, the leads 21 and 22 connecting capacitor 20 respectively to the power

lead 11 and the casing 19 are made very short so that the inductance of these leads is very low and, hence, a very low reactance can be achieved between point 15 and ground.

In Fig. 2 is shown schematically a cascade arrangement of the decoupling unit 10 for a plurality of stages 31-35 of the radio frequency amplifier, the level of the radio frequency energy progressing successively from stage 31 to stage 35. As shown, each of the stages is completely shielded, the shields 13 being grounded. A suitable source of power, such as the battery 36, is directly connected by means of conductor 12 to the decoupling unit 10 in the highest level stage 35, power for the lower level stages being supplied by conductor 11.

The cascade decoupling, as shown in Fig. 2, has the advantage over other types of decoupling in that, as the power circuit progresses to a more and more sensitive stage, greater and greater feed-back attenuation is introduced. Thus, between the high level stage 35 and the low level stage 31, there are four decoupling units 10 to prevent feed-back of energy from stage 35 to stage 31.

Fig. 3 shows how a single stage of the amplifier, for example the stage 34, may include a plurality of decoupling units, the exact construction of a particular unit depending upon the portion of the circuit to which the power is being supplied. Thus, in Fig. 3 two decoupling units 10 of the type shown in Fig. 1 are connected in series with the leads 41 and 42 supplying power respectively for the anode and filament of an electron discharge device 43, the conductor 11 being the power lead connected to the stage of higher level and conductor 11' supplying power to the stage of lower level. The conductor 41 is connected to the anode of device 43 through a tuned circuit 44. Tuned circuit 45 is inductively coupled to tuned circuit 44 and supplies high frequency signal potentials to the control electrode of the electron discharge device 46 in the succeeding stage of the amplifier. Bias potential for the control electrode of device 46 is supplied by means of the conductor 47 from any suitable source, not shown, conductor 47' similarly supplying bias potential to the lower level stages of the amplifiers. Since bias potential for other stages of the amplifier is obtained preferably from the same source, in order to prevent feed-back of radio frequency energy between stages, the decoupling unit 48 is connected in series with the conductor 47 and the tuned circuit 45. This decoupling unit 48 is similar to unit 10 with the exception that the inductance 17 has been omitted. The omission of this inductance is permissible in this instance because either very low or zero power currents are involved in the biasing circuit of the control electrode of device 46. However, since the conductor 47 itself comprises an inductive coupling between the stages sufficient to feed back high frequency energy picked up in the higher level stage, the use of the decoupling unit is desirable to maintain this feed-back at a minimum.

The decoupling unit 49 connected in series with the leads 50, 50' supplying potential to the screen electrode of device 43 and of the devices of the other stages is similar to the unit 48 in that the inductance coil 17 is omitted from the unit. The values of the fixed resistors used in units 48 and 49 depend on the currents flowing in the particular control circuits. Thus, resistance 51 of unit 48 may have a higher value of

resistance than the resistor 52 of unit 49, since the grid current of the device 46 is either zero or a very low value whereas the screen grid current is of a greater magnitude. It will be appreciated that in the decoupling units 48 and 49, the metal casing 53 acts as a shield to prevent the pick-up of high frequency energy from the intense field present in the stage.

In Fig. 4 there is shown an alternative method of installing the filter unit. The unit 10 is located in the higher level stage, being supported on the shield 13 separating adjacent stages. The capacitor 20 is located in the lower level stage and is connected by the short lead 21 to the power lead 11 and by the short connector 22 directly to grounded inter-stage shield 13. In all other respects the filter unit is the same as the unit shown in Fig. 1.

In the modification shown in Fig. 5 the filter unit is partially located in both of the adjacent stages, extending through an opening in the inter-stage shield 13. The unit may be supported in this position by soldering the casing 19 to the shield 13. The unit 10 in all other respects is the same as the unit of Fig. 1.

It is thus seen that my invention provides a filter unit particularly adapted for high gain amplifiers operating at high frequencies. By complete shielding of the filter unit, the pick-up of high frequency energy by the filter elements themselves is prevented. By proper selection of the units, a negligible voltage drop is obtained in the power source, as well as effective suppression of radio frequency energy from the lead connected to the power source. The presence of the fixed resistor in the circuit provides damping which prevents excessive resonances in the inductance coil itself or in the combination of the inductance coil and the by-pass capacitor. Moreover, this decoupling unit is particularly effective when used in cascade in successive stages of the radio frequency amplifier in the manner and for the reasons pointed out above.

In an amplifier operating at 50 megacycles, it was found that by the use of a 5000-ohm, one watt, resistor as the resistor 14, 50 turns of 30-mil wire as the spirally arranged conductor 17, and a .005 microfarad condenser as the capacitor 20, a single decoupling unit resulted in an attenuation of 40 decibels.

While I have shown a particular decoupling unit illustrated in Fig. 1, it will be apparent that various modifications may be made. Thus, in some installations it may be found desirable to omit the casing 19. In such a case, the capacitor 20 is directly connected to the stage shield 13. Thus, while I have shown particular embodiments of my invention, it will of course be understood that I do not wish to be limited thereto since various modifications may be made, and I contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In radio frequency apparatus having a low level stage, a higher level stage, and means common to said stages for supplying power currents thereto, means for filtering high frequency currents from said supplying means comprising, separate shielding means for said stages, an insulated resistor connected in said supplying means, a closely coiled conductor spirally wound on the outside surface of said resistor and conductively connected to the ends thereof, a metal shield

surrounding said conductor and insulated therefrom, said shield being connected to said shielding means, and a capacitor connected between said shield and the end of said resistor connected to said low level stage.

2. A device for decoupling the power leads between successive stages of high frequency amplifiers comprising, shielding means for each of said stages, an insulated resistor connected in series with said lead and having a conductor of low resistance value spirally arranged around its outer surface, said conductor being connected to both ends of said resistor and forming a path in shunt thereto having a low resistance and a high reactance, a metal tube insulatingly surrounding said spirally arranged conductor and conductively connected to said shielding means, and a capacitor connected between said tube and the end of said resistor connected to the stage of lower level.

3. A filter unit comprising an insulated resistor of large resistance value having spirally arranged

5 around its outer surface a conductor of low resistance value, said conductor being connected to both ends of said resistor and forming a path in shunt thereto having a low resistance and a high reactance, a continuous metal grounding shield surrounding said spirally arranged conductor and insulated therefrom, and a capacitor connected between one of said ends and said shield.

10 4. A high frequency suppressing device for a lead supplying unidirectional potential to an amplifying stage of radio apparatus having means for shielding said stage, comprising an insulated resistor connected in series with said lead, a continuous metal grounding tube surrounding said resistor and conductively connected to said shielding means, an inductance coil positioned within said tube and connected in parallel with said resistor, and a capacitor connected between said tube and the end of said resistor.

JAMES E. KEISTER.