Dec. 3, 1940. R. M. SMITH 2,223,835

ULTRA HIGH FREQUENCY DEVICE

Original Filed Jan. 29, 1938 2 Sheets-Sheet 1

FIG. 1.

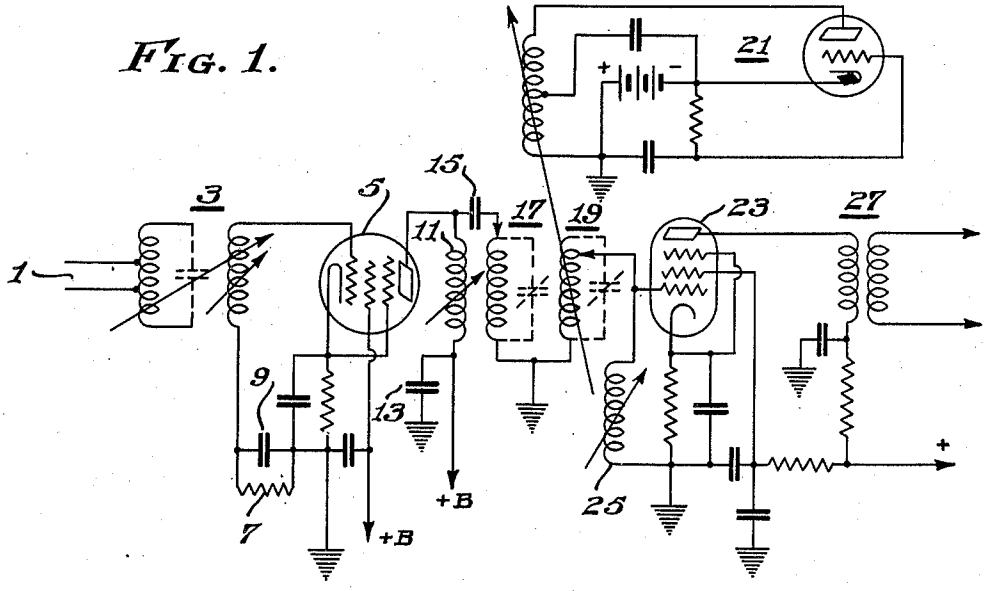
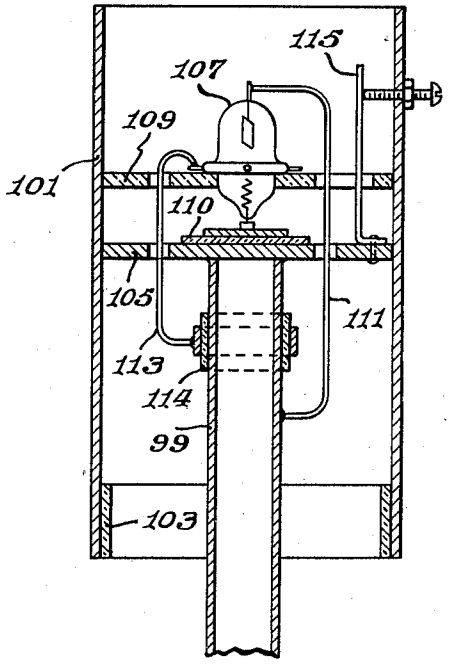


FIG. 3.



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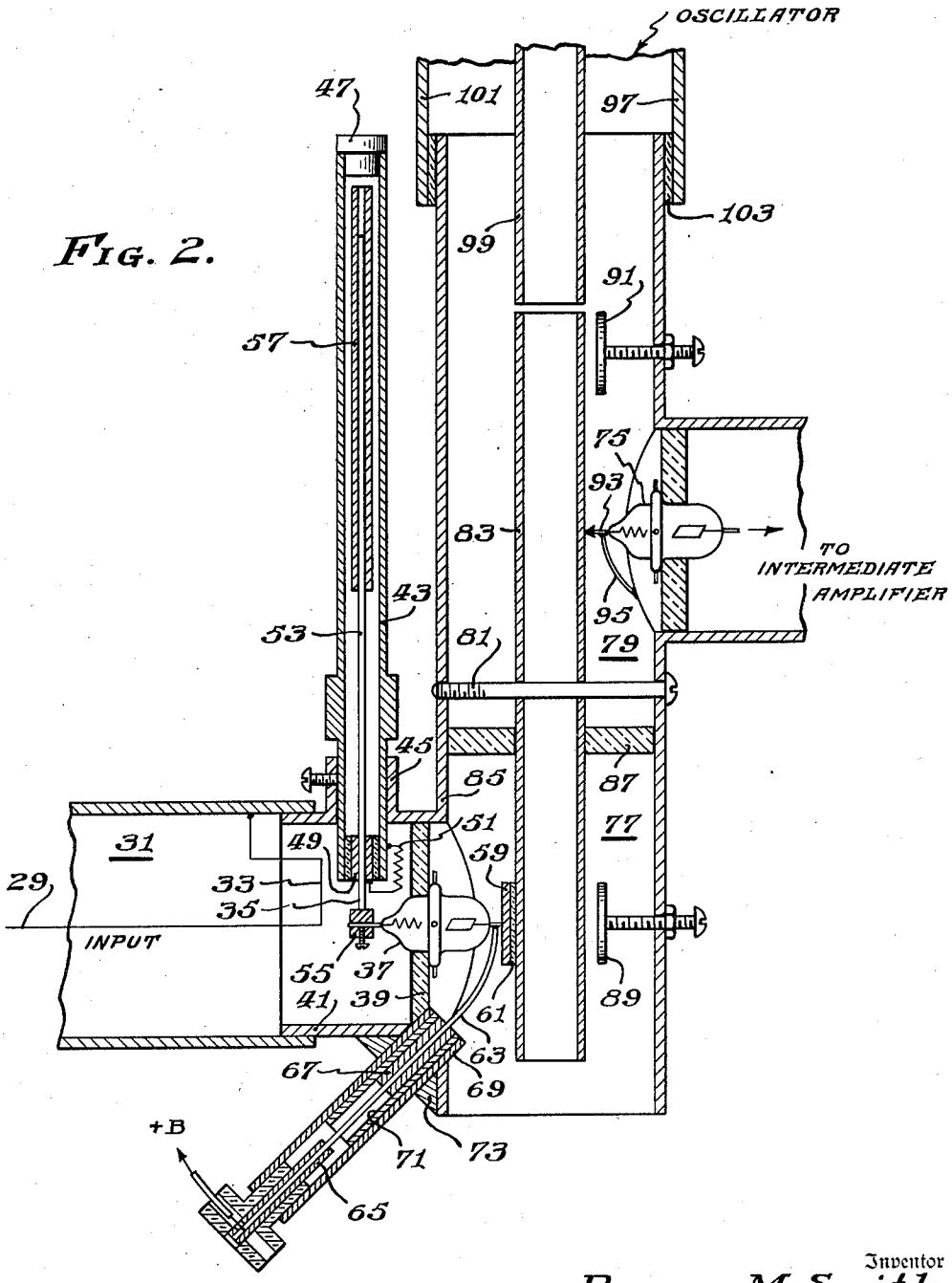
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ULTRA HIGH FREQUENCY DEVICE

Original Filed Jan. 29, 1938 2 Sheets-Sheet 2

FIG. 2.



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Patented Dec. 3, 1940 2,223,835

UNITED STATES PATENT OFFICE

2,223,835

ULTRA HIGH FREQUENCY DEVICE

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Original application January 29, 1938, Serial No. 187,607. Divided and this application September 6, 1939, Serial No. 293,624

6 Claims. (Cl. 250—20)

My invention relates to ultra high frequency devices, and especially to means for tuning ultra high frequency devices whereby undesired reactances may be neutralized.

This application is a division of my copending application Serial No. 187,607, filed January 29, 1938, entitled "Ultra high frequency devices."

In radio circuits operated at frequencies up to thirty megacycles per second the capacitors and inductors used for tuning are usually of the lumped or concentrated type. For example, conventional electrical condensers and solenoid types of inductors are used from the lowest radio frequencies and up to frequencies of the order of thirty megacycles per second. At frequencies approaching five hundred megacycles per second and upward transmission lines of the two wire or concentric type are used as resonant circuits.

When transmission lines and associated thermionic tubes are used at ultra high frequencies, the input impedance of the tubes has an important effect on the results obtainable. It is well known that the electrons moving from cathode to anode through the grid electrode of a thermionic tube, while of slight or negligible effect at low frequency, cause a very substantial reduction of input impedance at the ultra high frequencies. The natural capacity between the cathode and grid electrodes, as well as electrode leads having appreciable length, while effecting slight reactance at low frequencies, offer large reactive effects at the ultra high frequencies.

The net effect of the input resistance and input reactance of thermionic tubes operated at the ultra high frequencies is to establish phase shifts which are often large enough to have adverse effects on the tubes as amplifiers. I have found that similar effects in the anode or output circuits account for an actual attenuation of signal frequency currents instead of an expected gain. These effects may be overcome by suitable tuning adjustments, provided the tuning elements are designed so that the connecting leads offer negligible reactance.

In practice a real problem is presented in the elimination of the effects of connecting leads. One might assume that a capacitor could always be connected to by-pass the ultra high frequency currents. However, the use of a by-pass capacitor usually simply shifts the problem from the original leads to the leads of the capacitor itself. The importance of the lead lengths at five hundred megacycles per second can be illustrated by stating that a grounded lead fifteen centimeters long standing in space will have minimum impedance at the grounded end and maximum impedance at the free end. Obviously, intermediate lead lengths will have intermediate impedances.

My invention has for one of its objects the provision of means for eliminating the effects of lead lengths in ultra high frequency circuits. Another object is to provide means for eliminating the reactive effects of the interelectrode capacities within a thermionic tube. Another object is to provide means for tuning the transmission lines associated with ultra high frequency thermionic tubes. An additional object is to provide means for efficiently converting currents of ultra high frequency to currents of intermediate frequency. A further object is to provide means for preventing sustained blocking of an ultra high frequency receiver by the application of signals of large amplitude.

My invention is described by reference to the accompanying drawings in which

Figure 1 is a schematic circuit diagram of a radio frequency amplifier, local oscillator and first detector;

Figure 2 is a sectional view of one embodiment of my invention; and

Figure 3 is a sectional view of an oscillator which may be used in conjunction with the apparatus of Fig. 2.

Referring to Fig. 1, which is a diagrammatic circuit used for purposes of illustration only, a transmission line 1 is connected by a matching transformer 3 to the input of a thermionic amplifier 5. The input circuit of the amplifier includes a resistor 7 and a capacitor 9 which prevent overloading or blocking on application of signal currents of large amplitude. The output circuit of the amplifier includes an adjustable inductor 11, a bypass capacitor 13 and a coupling capacitor 15.

The coupling capacitor 15 is connected to a pair of resonant coupled circuits 17, 19 which are grounded. The second resonant circuit 19 is mutually coupled to a local oscillator 21. The second resonant circuit is also connected to a first detector or mixing tube 23. The input of the detector includes an adjustable inductor 25. The output of the first detector includes a network 27 which is preferably tuned to intermediate frequency currents and which is connected to an intermediate frequency amplifier and second detector. The intermediate frequency amplifier and second detector are not illustrated because they are not essential parts of my invention and they are well known to those skilled in the art.

It should be understood that the thermionic tubes of the foregoing circuit are energized by application of suitable anode, screen, and heater currents. Likewise, the grid electrodes may be biased negatively with respect to cathodes by self-biasing means, biasing batteries or the like. Bypass capacitors are shown as applied in the conventional manner. While the schematic diagram shows the inductors, and capacitors as conventional elements, such showing is for the purpose of illustration only.

For the practical application of my invention reference is made to Fig. 2 in which the line 29 represents the inner conductor of a concentric transmission line, which is terminated by a coupling or matching transformer 31 of the concentric line type. The inner conductor 33 is inductively coupled to the grid connection 35 of the radio frequency amplifier 37 and is terminated by grounding on the outer conductor of the transformer. The input circuit to the amplifier 37, which includes the leads and electrodes within the thermionic tube, is arranged as follows: The amplifier tube is mounted on a plate 39 which is located within a metal housing 41. A metal tubular member 43 is adjustably mounted within a boss 45 in the housing. The tubular member may be capped by an insulated plug 47. At the lower end of the tubular member a bypass capacitor is formed by insulating, with "Styrol" or the like, a metal plug 49 from the tubular member. The capacity of this condenser is purposely made small so that sustained blocking will not occur when signals of large amplitude cause grid current to flow. A resistor 51 is connected between the plug 49 and the tubular member 43. A rod 53 is slidably mounted within the plug, and fixedly connected to the grid electrode of the amplifier 37 by a suitable clamp 55.

The tubular member 43 may be moved up and down in the boss to thereby adjust the length of the circuit between the grid electrode and the bypass capacitor formed by 49, etc. The inductive reactance of this circuit is adjusted to substantially neutralize the capacitive reactance of the amplifier input. It should be recognized that the leads and electrodes within the amplifier are a part of the resonant circuit. It will be observed that the capacitance of the bypass capacitor remains fixed. To insure that the junction of the bypass capacitor and the housing shall be grounded at a point of suitable impedance, the rod 35 is concentrically extended within the tubular member 43 and terminated by a sliding concentric tube 57. This supplemental grounding circuit is required because of the relatively small capacity of the bypass condenser.

If the ground connection is to be made of low impedance, the slidable tube 57 is adjusted so that the rod 53 and tube 57 have an effective length of one quarter wave measured from the ground point toward the high potential end of the system. If the ground termination is to be terminated by a high impedance for any reason, the effective length should be a half-wave. I prefer the quarter wave adjustment in the present circuit. Thus arranged the amplifier input circuit may be made to resonate at the operating frequency and the bypass capacitor and resistor 51 have leads of negligible length, if they can be said to have any leads at all. The capacitor and resistor described immediately above correspond respectively with the elements 9 and 7 of Fig. 1. The balance of the amplifier input circuit corresponds to the transformer 3 of Fig. 1.

The output circuit of the amplifier 37 is as follows: The anode is connected to a plate 59 which is separated by an insulator 61 from a quarter wave line hereinafter described. The anode is also connected, through a conductor 63 of adjustable length, to the positive terminal of a B-battery. The upper portion of the conductor 63 is slidable with respect to a metal plug 67, which is separated from an outer tubular member 69 by a suitable insulator 71, such as "Styrol." The plug 67, the insulator 71 and the tubular member 69 form a bypass capacitor, which is adjustably mounted in a grounded member 73. This bypass condenser may have a large capacity because the problem of blocking does not present itself in the anode circuit. Also no supplemental ground circuit is required because the capacity may be made sufficiently large to effectively bypass. If, however, the capacity for any reason is to be kept low, the structure described in connection with the amplifier input circuit may be used.

The effective length of the conductor 63 is adjusted by moving the tubular member 69 back and forth within the member 73. The bypass capacitor formed with the tubular member 69 is fixed in its capacitance, has for practical purposes no leads, and directly and effectively forms a bypass from the conductor 63 to ground. Thus, the effective length of the anode circuit may be adjusted to neutralize capacity reactance with the amplifier 37. The conductor 63 and the bypass capacitor 67, 71, 69 correspond to the inductor 11 and the capacitor 13, respectively, of Fig. 1.

The coupling between the amplifier output circuit and the input to the detector 75 is a pair of quarter wave concentric lines 77, 79, which are connected together and are grounded at their junction by a screw 81. The screw 81 acts as the common coupling between the two quarter wave circuits. In some arrangements, a single quarter wave line may be made common to both circuits, acting, for example, as an autotransformer. The inner conductor 83 of the concentric lines may be positioned within the outer conductor 85 by an insulated support 87. The lower 77 and upper 79 quarter wave lines may be tuned by trimmer capacitors 89, 91. The amplifier is coupled to the lower line 77 by the capacitor formed by the plate 59 and insulator 61 which may be fastened to the inner conductor 83 as shown. The input to the first detector 75 is made by connecting the grid lead 93 to the inner conductor 83 at a point of suitable impedance match. The input tuning may be adjusted by means similar to that shown for the input of amplifier 37 or by suitably choosing the length of a conductor 95 connected from the grid to the outer conductor 85. The former means is preferred if excessive overloading or blocking effects are present in the detector. The quarter wave lines 77, 79 and the conductor 95 are equivalent, respectively, to the circuits 17, 19 and the inductor 25 of Fig. 1.

The local oscillator 97 is coupled to the detector input circuit by adjusting the mutual coupling between the inner conductor 99 of the oscillator and the upper quarter wave line 79. The outer conductor 101 of the oscillator is slidably mounted on the conductor 85 and spaced therefrom by an insulating sleeve 103. The insulation is necessary in the instant arrangement because the outer conductor 101 is at oscillator anode potential while the conductor 85 is at ground potential.

A suitable construction for the oscillator is shown in Fig. 3. The inner and outer conductors 99 and 101 and the insulating sleeve 103 corre-

spond to the fragmentary showing in Fig. 2. The outer conductor 101 is divided by a ground plate 105. The inner conductor 99 is suitably fastened, by soldering, brazing, threading or the like, to the ground plate. The oscillator tube 107 is fastened to a socket 109 or the like which may be supported within the conductor 101. The grid electrode is coupled to the ground plate through a capacitor 110. The anode is connected by a lead 111 to the inner conductor 99 at a point of suitable impedance. The cathode is coupled to the inner conductor through lead 113 and a capacitor 114. The oscillator frequency may be adjusted over a small frequency range by a trimmer plate 115 located near the anode lead 111. This trimmer capacitor, and the quarter wave line trimmers 89, 91 have capacities which are very small compared to the total capacity of the asssociated lines, whereby the desirable characteristics of the concentric lines are retained.

Thus I have described an ultra high frequency device in which the input and output reactances of the associated thermionic tubes may be neutralized by adjustable elements of opposite reactance. Where the bypassing is critical, the capacitors have no leads of appreciable length. Means are disclosed for establishing points of high or low impedance as may be required. The arrangement shown is further characterized by the relative disposition of the component parts which are positioned to reduce the lengths of leads to a minimum. Finally, the component parts are largely concentric lines in which the losses are extremely low, temperature effects may be corrected, high frequency stability may be obtained and other desirable features, known to those skilled in the art, are present. It will be obvious that my invention may be applied to ultra high frequency transmitting and receiving devices. I have chosen to describe the latter merely by way of illustration.

I claim as my invention:

1. In an ultra high frequency device, a thermionic amplifier including an input circuit and an output circuit, an oscillator, a first detector including an input circuit, a coupling circuit; said coupling circuit including a pair of quarter wave concentric lines, coaxially joined and grounded at their junction, said amplifier having its output circuit coupled to one of said quarter wave lines, said detector having its input circuit effectively connected to the other of said quarter wave lines, said oscillator including a concentric line, means for mutually coupling the concentric line of said oscillator with one of said quarter wave lines, and further characerized by an arrangement of said amplifier and first detector which provide connecting leads of minimum length to their respective output and input circuits.

2. In an ultra high frequency device of the character of claim 1, means for tuning the input and output circuits of said thermionic amplifier.

3. In a device of the character of claim 1, means for tuning the input circuit of said amplifier including a rod, and a capacitor slidably mounted on said rod and slidably mounted within a grounded bushing.

4. In a device of the character of claim 1, means for tuning the output circuit of said amplifier comprising a conductor, and a capacitor slidably mounted on said conductor and slidably mounted within a grounded bushing.

5. In a device of the character of claim 1, means for neutralizing the reactance of the input circuit of said amplifier including a conductor connected directly to said input and to ground by a capacitor adjustably mounted on said conductor and slidably mounted within a grounded bushing, and means for making said ground impedance low.

6. In an ultra high frequency device, a thermionic amplifier including input and output circuits, an oscillator, a first detector including an input circuit, a quarter wave concentric line, said amplifier having its output circuit effectively coupled to said quarter wave line, said detector having its input circuit effectively coupled to said quarter wave line, said oscillator including a concentric line, means for mutually coupling the concentric line of said oscillator with said quarter wave line, and further characterized by an arrangement with said amplifier and said first detector which provides connecting leads of minimum length to the amplifier input and output circuits and to the detector input circuit.

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