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COMPLETE SPECIFICATION

Circuit Arrangement for the Demodulation of Electric Oscillations Modulated in Frequency or in Phase

We, EGYESÜLT IZZÓLÁMPA ÉS VILLAMOSSÁGI RÉSZVÉNYTARSASÁG, a Body Corporate organized under the Laws of Hungary, of 77, Váci-ut, Budapest IV, Hungary, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a circuit arrangement for the demodulation of electric oscillations or electro-magnetic waves modulated in frequency or modulated in phase. The circuit arrangement according to the invention is provided with means, which are suitable for the damping of modulations possibly occurring in the amplitude, that is for the production of an outgoing electric oscillation, the amplitude of which is independent of the amplitude of the ingoing electric oscillation or wave.

Circuit arrangements for the solution of this problem are known. Such an arrangement is, for example, the so-called "ratio detector", in which the damping of the amplitude modulation is effected by two diodes together with a condenser of correspondingly large capacity. The satisfactory operation of the ratio detector, however, presupposes the fulfilment of several conditions difficult to adhere to. One of these consists in the strict symmetry of the two diodes, in respect to their capacity as well as in regard to their inner resistance, without which symmetry a satisfactory operation of the ratio detector cannot be achieved.

Another known circuit arrangement serving the same purpose is the so-called frequency modulation discriminator, which is damped by a diode. This contains, in addition to the two diodes effecting the frequency demodulation, a third diode, which is connected in parallel with the oscillation circuit of the last intermediate frequency stage and the damping of the amplitude modulation is effected by means of an RC member, as in the case of the ratio detector. The third diode may be employed either in the form of a separate valve, by which the device becomes more expensive, or a valve is used, in which three diodes with small inner resistance are combined. This type of valve is rare and therefore expensive and in addition has also the further disadvantage, that for each diode a separate cathode must be provided, as the full anode voltage of the last intermediate frequency stage (generally of a pentode) occurs on the diode situated in parallel with the oscillation circuit, and therefore the cathode of this diode may not lie on earth, that is may not be grounded.

Applicants have already proposed for the purpose of avoiding the above disadvantages, a circuit arrangement for the demodulation of electro-magnetic waves modulated in frequency or modulated in phase, which circuit arrangement has a first tuned circuit in the anode circuit of the last intermediate frequency stage, which tuned circuit contains a primary coil and a secondary coil inductively and capacitively connected with this primary coil, which secondary coil forms a part of a second tuned circuit which together with two diodes, of which the cathode of the one diode is preferably connected to earth or earth potential, represents a discriminator circuit. This circuit arrangement is characterized by a third coil, which is inductively coupled with the primary coil and is insulated directly from said coil and also by a current circuit, which contains the said third coil, an RC member and a diode connected in series, in which case the cathode of the last-mentioned diode lies on the common potential with the cathode of that discriminator diode, the cathode of which advantageously is grounded. In this circuit arrangement the primary and

tertiary coils are preferably bifilar coils and the three diodes are disposed preferably in the same envelope, so that they form one single combined valve.

This circuit arrangement proposed by us has indeed appreciable advantages, but is, however, still burdened by the relatively small disadvantage that, for the purpose of obtaining a suitable operation it is advisable to wind the primary and tertiary coils very carefully bifilarly, which means on the one hand a source of error and on the other hand causes extra costs.

The object of the present invention is the production of such a circuit arrangement, which is free even from the above-mentioned small disadvantage and is in addition considerably simpler and cheaper than all hitherto known circuit arrangements of similar purpose and similar character.

A further object of the invention is the construction of the above-mentioned circuit arrangement from such known constructional parts, which are usually used already in such circuit arrangements and are therefore cheap, and in addition that a relatively cheap multiple readily available valve on the market, as, for example a valve of the type EABC 80 can be used in the circuit arrangement, the triode part of which valve also remains free for other purposes, owing to which circumstance the whole circuit arrangement is considerably cheapened.

The present invention thus consists of a circuit arrangement for the demodulation of electric oscillations modulated in frequency or modulated in phase, which has a first tuned circuit situated in the anode circuit of the last intermediate frequency stage, which circuit contains a primary coil, and a secondary coil inductively coupled with said primary coil, which secondary coil is a component part of a second tuned circuit, which, together with two diodes, in which the cathode of the one diode is preferably applied to earth or earth potential, represents a known discriminator circuit arrangement, but the circuit arrangement according to the invention also further contains a tertiary coil which is, by one of its ends, connected directly with the centre of the secondary coil and inductively coupled with the primary coil, and the other end of which, not connected to the secondary coil, is directly connected to the connection series-connecting with each other two resistances and also to the connection series-connecting with each other two capacitors, each of said resistances being connected parallel with one of said capacitors, and the pairs of said series-connected resistances and capacitors interconnecting with each other the cathodes of the already mentioned two discriminator diodes, the circuit arrangement also further containing a third diode, the cathode of which is connected to earth that is, is grounded and the circuit arrangement according to the invention being characterized by the feature that the said third diode, together with a fourth coil acting as choke coil, a resistance and capacitors, all of which are situated in the anode circuit of the said third diode, form a damping circuit which is coupled through a capacitor and the anode of said third diode to the primary coil.

The above-mentioned damping circuit is preferably arranged, according to the invention, so that in the circuit of the said third diode the said choke coil and the said resistance are connected in series with each other, and one of the said capacitors is preferably an electrolytic capacitor of great capacity, whereas another of the said capacitors is a capacitor of smaller capacity, and all of the said capacitors lying in the anode circuit of the third diode are connected with each other and with the said resistance in parallel. The three diodes present in the circuit arrangement are situated preferably in the common envelope of a multiple valve, which also contains other electrodes and can be a multiple valve readily available on the market.

An essential feature of the invention accordingly consists of the fact that the damping of the eventual modulations of the amplitude of the incoming oscillations is effected by the damping circuit connected to the primary coil containing the third diode. The direct current circuit of this diode is, according to what has been said above, closed by the choke coil connected in the circuit of the diode in series with the resistance. For the high frequency, however, this choke coil is an interruption of the high frequency circuit and therefore this circuit containing the third diode can in respect to the high frequency be considered as regards to its effect, as a series connected diode circuit. This ensures the advantage that the damping resistance caused by the whole damping circuit containing the third diode amounts to one half of the resistance lying in the current circuit of the diode, and accordingly the damping dependent on amplitude is more energetic than that attainable with a diode connected in parallel. It is preferable to use as damping diode (third diode) a diode of small inner resistance, but providing such type of diode as third diode causes no difficulties in the case of multiple valves.

The invention is described in detail below in two forms of embodiment with reference to the accompanying drawing. In the drawing Figure 1 shows the circuit arrangement according to the invention in using three separate diodes, whereas Figure 2 shows the same circuit arrangement in using a multiple valve containing the three diodes. Identically acting component parts are marked on the two Figures with identical reference numbers.

In Figure 1, 10 is the last intermediate frequency pentode, in the anode circuit of

which is situated the tuned circuit 11. This contains the capacitor 12 and the primary coil 13. The secondary coil 14 is inductively coupled with the primary coil 13. The secondary coil 14 is positioned in a tuned circuit 15 in parallel with a capacitor 16. There are connected to this tuned circuit 15 at the point 17 the anode 19 of a diode 18 and at the point 20 the anode 22 of a diode 21. The cathode 28 of the diode 21 is directly grounded, that is lies directly on earth. An ohmic resistance 29 is connected in the circuit of the diode 21. The resistance 24 connected to the cathode 23 of the diode 18 together with the capacitor 25 forms a low pass filter known per se. The resistance 26 and the capacitor 27 are situated in the current circuit of the cathode 23 of the diode 18 and the resistance 29 and the capacitor 30 in the current circuit of the cathode 28 of the diode 21. The one end of the tertiary coil 31 is connected to the centre of the secondary coil 14 and is thus directly connected with it. The tertiary coil 31 is also inductively coupled with the primary coil 13. The other end of the tertiary coil 31 is directly connected to the points 32 and 33 respectively between the two resistances 26 and 29 and thereby between the two capacitors 27 and 30 respectively. The cathode 28 of the diode lies, as already mentioned on earth and is therefore grounded.

The part of the circuit arrangement described up to now forms a discriminator circuit known per se.

Now, according to the invention the damping circuit 35 is connected to the primary coil 13 through the capacitor 34. This circuit consists of the third diode 36, of the choke coil 37, of the resistance 38 and of the capacitors 39 and 40 connected in parallel with the resistance 38. The cathode 41 of the diode 36 is earthed.

In the form of embodiment according to Figure 1 the damping circuit 35 is grounded in such a manner that the one end of the choke coil 37 is connected to the anode 42 of the diode 36 and its other end to one end of the resistance 38, so that the resistance 38 connected in series with the coil 37 is situated in the current circuit of the diode 36 and the capacitors, that is the capacitor of greater capacity 39 together with the capacitor of smaller capacity 40 are connected with each other and in parallel with the resistance 38. The capacitor 39 advantageously constructed as an electrolytic capacitor, has advantageously a capacity, for example about 5μF (microfarad), whereas the capacity of the capacitor 40 constructed, for example, as a mica capacitor can amount to, for example, 10^{-9}F (one nanofarad). The inner resistance of the diode should be small, that is have the order of magnitude of about 100 ohms, for example 200 ohms. The inner-resistances of the diodes 18 and 21 are unimportant and therefore can be as desired. One can, therefore, use, for example, even a diode 18 of small and a diode 21 of high resistance. This is however important from the point of view of being able to use multiple valves, as their use is made possible practically by this fact.

In the arrangement shown in Figure 2 the electrodes of the diodes 18, 21 and 36 are disposed in the envelope of the multiple valve 43. In this valve the cathode 44 is a common one for two diode systems and therefore the cathode 44 replaces the two cathodes 28 and 41 of Figure 1. The triode part 45 of the valve, which valve 43 can, for example, be a valve of the type EABC 80 now on the market, does not come into use in the present circuit arrangement, and therefore remains free for other purposes.

The circuit arrangement according to the invention operates as follows:

The damping of the whole band pass filter situated in the anode circuit of the amplifier valve 10, which advantageously is a pentode, is effected through the diode 36, which maintains the amplitude of the oscillation on the primary coil 13 of the band pass filter at a constant value even in the case of alterations of the amplitude of the incoming oscillation. The diode 36 acts as rectifier and the direct current voltage appearing on the working resistance of the same is stabilized by the capacitor 39. The time constant of the members 38, 39 is so great that the voltage of the capacitor 39 can alter appreciably only after the expiration of a relatively long time, for example of some tenths of a second. The capacitor 39 therefore plays a similar part as the stabilizing capacitors usual in the ratio detectors. As already mentioned, the damping circuit containing the diode 36 represents in the circuit according to the invention a load resistance value $\frac{R}{2}$ for the primary coil of the band pass filter, R being the value of the resistance 38. The value R must be so selected that the primary circuit will be already greatly loaded by a resistance $\frac{R}{2}$. The degree of that amplitude modulation, which can be damped by the circuit arrangement, depends on the value R of the resistance 38. This resistance value R can in practice lie, for example, between about 20 and 30 kilo ohms. Now, if the amplitude of the ingoing oscillation increases, the diode 36 receives higher voltage, and as the initial voltage of this diode is constant, the current flowing through the diode increases considerably, owing to which the load effect of the diode exerted on the primary coil is increased. This considerable load increase has the effect that the voltage on the primary coil 13 remains practically constant. If the amplitude of the ingoing oscillation decreases, then the load effect of the diode 36

decreases in such a manner that the voltage on the primary coil 13 also remains approximately constant. In the case of the decrease of the input level, that is the decrease of the amplitude of the ingoing oscillations, this damping or limiting effect of the diode 36 is effective until the load effect drops to nil. In the case of a further decrease of the amplitude the diode or the damping circuit is thus no longer in a position to exert a decreased damping. It depends accordingly on the value of the resistance 38 which degree of the decrease of the amplitude the circuit arrangement is still able to compensate.

The particular advantage of the circuit arrangement according to the invention consists, in addition to the simplicity of the same, in the fact that the same can be used in the case of the known and conventional band pass filters without any difficulties, that is without special modification and without the use of special, new component parts difficulty accessible. A further important advantage consists of the fact that, in contradiction to the ratio detector circuit, the circuit arrangement according to the invention is comparatively insensitive to asymmetries of the diodes and the construction of the circuit arrangement is therefore easier to carry out.

The use of the term "directly connected" or "connected directly" implies that the parts are directly connected with each other by a metallic connection other than a resistance, a coil or a capacitor, for example.

WHAT WE CLAIM IS:—

1. Circuit arrangement for the demodulation of electric oscillations modulated in frequency or modulated in phase, which has a first tuned circuit situated in the anode circuit of the last intermediate frequency stage, which tuned circuit contains a primary coil and a secondary coil inductively coupled with said primary coil, which secondary coil forms a component part of a second tuned circuit which, together with two diodes, of which the cathode of the one diode has preferably earth potential, forms a known discriminator circuit arrangement, the circuit arrangement however also containing a tertiary coil, which is, by one of its ends, connected directly with the centre of said secondary coil and inductively coupled with said primary coil and the other end of which, not connected to the secondary coil, is directly connected to the connection series-connecting with each other two resistances and also to the connection series-connecting with each other two capacitors, each of said resistances being connected in parallel with one of said capacitors, and the pairs of said series-connected resistances and capacitors interconnecting with each other the cathodes of the said two discriminator diodes, the circuit arrangement also containing a third diode, the cathode of which is earthed, characterised by the feature that this third diode, together with a fourth coil acting as a choke coil, a resistance and capacitors, all of which are situated in the anode circuit of the said third diode, forms a damping circuit, which is coupled through a capacitor and the anode of the third diode to the primary coil.

2. Circuit arrangement according to claim 1, characterised by the feature that the damping circuit containing the third diode is so constructed that there are situated in the current circuit of this diode the choke coil connected to the anode of the diode and the resistance being connected in series with the same and a capacitor of large capacity, advantageously an electrolytic capacitor, being connected in parallel with the resistance and a capacitor of smaller capacity connected in parallel with the same.

3. Circuit arrangement according to claim 1 or 2, characterised by the feature that the three diodes are built into one single thermionic valve, whereby in this valve the cathodes of the damping diode and of one discriminator diode are preferably formed by one single, common cathode.

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decreases in such a manner that the voltage on the primary coil 13 also remains approximately constant. In the case of the decrease of the input level, that is the decrease of the amplitude of the ingoing oscillations, this damping or limiting effect of the diode 36 is effective until the load effect drops to nil. In the case of a further decrease of the amplitude the diode or the damping circuit is thus no longer in a position to exert a decreased damping. It depends accordingly on the value of the resistance 38 which degree of the decrease of the amplitude the circuit arrangement is still able to compensate.

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