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Fig. 1

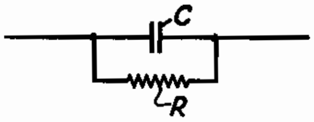


Fig. 2

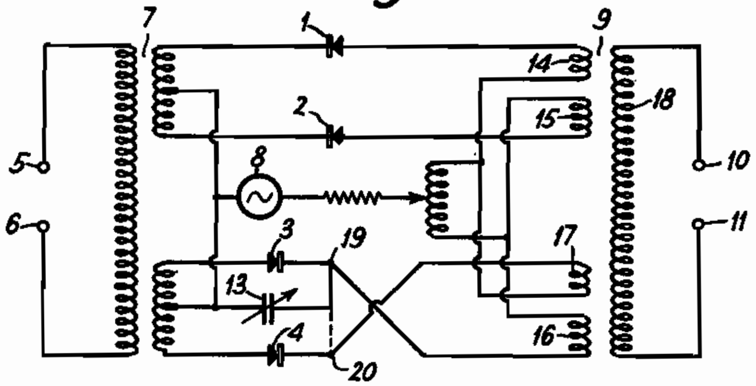
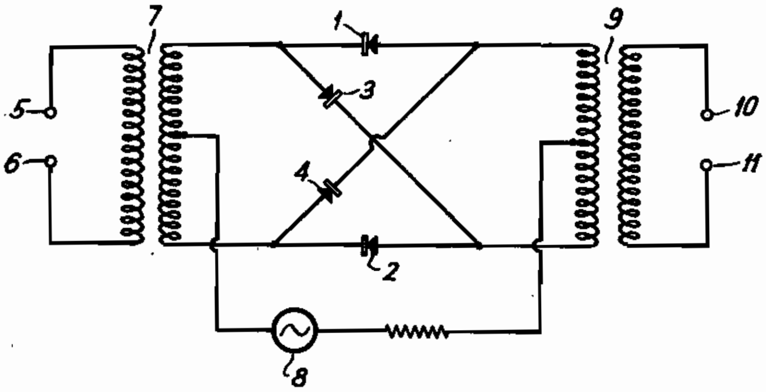


Fig. 3



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MODULATOR AND DEMODULATOR SYSTEMS

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This invention relates to arrangements respectively for modulating and demodulating electric oscillators, comprising a bridge circuit or a double balanced circuit of four rectifiers.

Such arrangements are used inter alia in carrier wave telephony systems, in this case the condition being imposed that in the output circuit the carrier wave must be suppressed as completely as possible.

It is customary for the rectifiers to use dry-metal or metal-oxide rectifiers. The electric substitution diagram for such a rectifier is mainly a capacity C shunted by a resistance R (see Fig. 1), the capacity and the resistance being a function of the voltage applied. The values of the capacity C and of the resistance R for various rectifiers of the same type are generally unequal for one and the same voltage, due to which a certain carrier-wave voltage, the so-called carrier-wave leakage, will occur notwithstanding in the output circuit.

In order to attain a lowest possible carrier-wave leakage, it is known to balance the circuit used; this means that the impedances of the various branches of the circuit are adjusted or chosen, for example, by means of adjustable resistances or condensers, in such manner that no carrier-wave leakage or substantially no carrier-wave leakage occur. Now the capacity C is a function of the carrier-wave voltage applied so that, if the capacity is C at a carrier-wave voltage having an effective value E, the capacity will be $C+\Delta C$ at a voltage $E+\Delta E$. This ΔC is in general also unequal for various rectifiers of the same type. This results in the circuit, if balanced for a certain value E_m of the carrier-wave voltage, being in general no longer balanced for a carrier-wave voltage differing from E_m, due to which the carrier-wave leakage becomes inadmissibly high.

By choosing rectifiers exhibiting an at least substantially equal E—C characteristic curve, it is possible to maintain the carrier-wave leakage low even with the practically occurring differences from the carrier-wave voltage E_m prescribed. This method, however, is cumbersome and gives many rejects.

According to the invention, in an arrangement for modulating and demodulating electric oscillations comprising a bridge circuit, a double push-pull circuit of four rectifiers exhibiting substantially balanced rectifier characteristics and rectifier capacities with a prescribed value of the carrier-wave voltage supplied to the circuit, the four rectifiers are grouped in such manner that the resulting capacity variation which is decisive for the carrier-wave leakage is a minimum with the occurring differences from the prescribed value of the carrier-wave voltage. In modulators and demodulators such as used in the carrier-wave telephony systems, an admissibly low carrier-wave leakage for carrier-wave frequencies up to 100 kilocycles is obtained if the resulting capacity variation is inferior to 50 micromicrofarads.

The invention will be more clearly understood by reference to the accompanying drawing in which Fig. 2 shows a double push-pull circuit of four rectifiers, 1, 2, 3 and 4 which are connected respectively to input terminals 5, 6 and to output terminals 10, 11 by means of double push-pull transformers 7 and 9. A carrier-wave generator 8 is connected in the indicated manner to the two push-pull circuits. The modulated oscillations are supplied to the input terminals 5, 6, while the side-bands without carrier wave can be taken from the output terminals 10 and 11. An adjustable potentiometer 12 is provided to make the resistances equal in each of the double branches, while the resulting capacity of the branches for a certain prescribed voltage of the carrier-wave generator 8 can be balanced out by means of an adjustable condenser 13.

In order to be able to find which grouping gives the least carrier-wave leakage with a certain voltage variation, the following argumentation can be made up. Assuming the circuit not yet to be balanced exclusively as regards the capacity of the rectifiers, a carrier-wave component is still present in the voltage derived from the terminals 10 and 11, which component originates from the resulting voltage of the four carrier-wave voltages induced by windings 14, 15, 16 and 17 in the winding 18 of the transformer 9.

In the case assumed the carrier-wave voltage induced by the winding 14 is a function of the capacity C_1 of rectifier 1 and is opposite to the carrier-wave voltage induced by the winding 16 which is a function of C_2. The carrier-wave voltages induced by the windings 16 and 17 are dependent respectively on C_3 and C_4 and are also opposite to each other.

Since the circuit, except the capacities, is balanced, the resulting voltage induced in the winding 18, i. e. the carrier-wave leakage L consequently is a function of $f(C_1+C_4-C_2-C_3)$. If a condenser 13 is provided, as is shown in Fig. 2, $L=f(C_1+C_4-C_2-C_3-C_{13})$. By adjustment of this condenser the circuit for a certain carrier-wave voltage E_n may also be balanced according to the capacities, in which case one end must be connected to point 19 or 20, according as the one or the other double branch exhibits too small a capacity, and $C_1+C_4-C_2-C_3-C_{13}$ can be made equal to 0, in which case no carrier-wave leakage occurs. If now the carrier-wave voltage E_n varies to a value E_n ΔE, then carrier-wave leakage ΔL_1 will occur again which is given by:

$$\Delta L_1=f(C_1+\Delta C_1+C_4+\Delta C_4-C_2-\Delta C_2-C_3-\Delta C_3-C_{13}$$
$$=f(\Delta C_1+\Delta C_4-\Delta C_2-\Delta C_3)$$

Two other groupings of the four rectifiers are still possible, in which case the rectifiers 2 and 4, and 2 and 3 respectively have changed their places, said groupings each involving another carrier-wave leakage which is then given respectively by:

$$\Delta L_2=f[\Delta C_1+\Delta C_2-(\Delta C_3+\Delta C_4)]$$

and

$$\Delta L_3=f[\Delta C_1+\Delta C_3-(\Delta C_2+\Delta C_4)]$$

In order to attain the lowest carrier-wave leakage with a variation in the carrier-wave voltage, according to the invention that grouping is chosen for which the ΔL has the smallest absolute value.

If the corresponding carrier-wave leakage still remains above the value considered admissible, the desired improvement can be attained by replacing at least one of the rectifiers by another rectifier so that the absolute value of the expression $\Delta C_1+\Delta C_4-(\Delta C_2+\Delta C_3)$ decreases so that the desired small value of ΔL is obtained. At the same time the condenser 13 is to be readjusted so that the circuit for the voltage E_n is brought again in push-pull. This is necessary because the replacing rectifier or rectifiers will have another ΔC and also another C. It has been found in practice that for carrier-wave telephony purposes the term $\Delta C_1+\Delta C_4-(\Delta C_2+\Delta C_3)$ must not exceed any more the value 50 micromicrofarads.

By measuring on a number of rectifiers the ΔC corresponding to the ΔE which is to be taken into account and by dividing these rectifiers in groups, each comprising only rectifiers of which the ΔC's are not farther away from one another than 50 $\mu\mu F$ so that the limits of the capacity variations of each group are equally far away from one another, it is always possible by means of four rectifiers forming part of one group to compose a modulator or demodulator circuit so that

$$[\Delta C_1+\Delta C_4-(\Delta C_2+\Delta C_3)]$$

is <50 micromicrofarads.

In fact, the most disadvantageous position arises when the ΔC of one of the rectifiers is greater or smaller to the extent of 50 $\mu\mu F$ than the ΔC of the three other rectifiers and in this case the resulting capacity variation of the whole circuit is also but 50 $\mu\mu F$.

It is evident that the invention does not exclusively apply to circuits according to Fig. 2 but to all modulation and demodulation circuits comprising a number of rectifiers in bridge or push-pull connection and that corresponding conditions can be derived therefor.

Thus, Fig. 3 represents a so-called ring modulator for which, considering the numbering of the rectifiers, the carrier-wave leakage is determined by the expression $\Delta C_1+\Delta C_4-(\Delta C_2+\Delta C_3)$ for a minimum carrier-wave leakage at a voltage $E_n+\Delta E$, E_n in this case being the value of the carrier voltage for which the push-pull is adjusted.

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