Oct. 7, 1941. E. BRÜCHE ET AL 2,258,129

DIAPHRAGM FOR ELECTRONIC-OPTICAL PHASE LENSES

Filed Oct. 26, 1938

Fig. 1

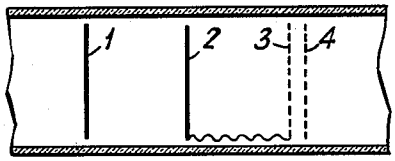


Fig. 2

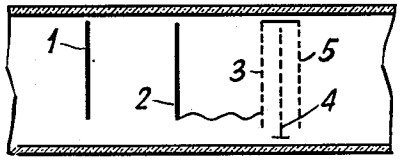


Fig. 3

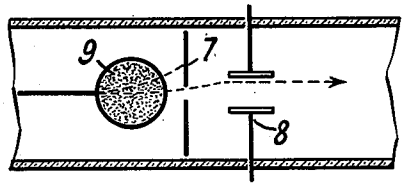


Fig. 4

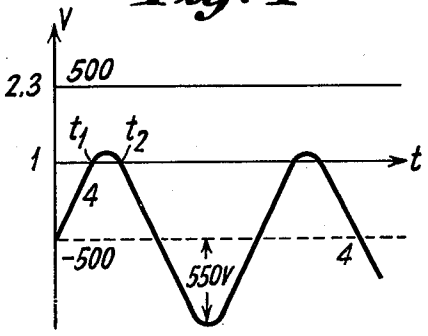


Fig. 5

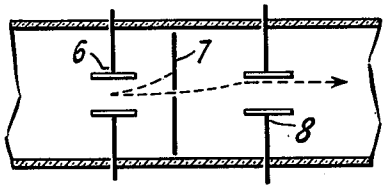
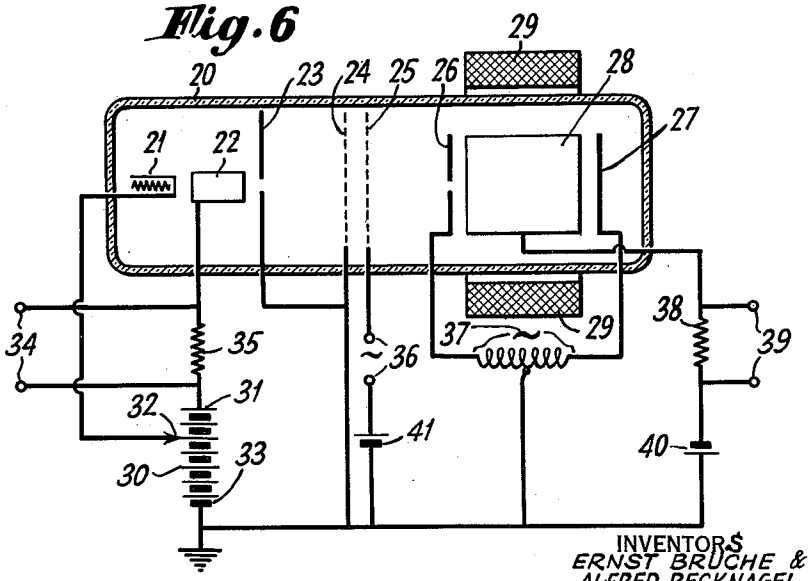


Fig. 6



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DIAPHRAGM FOR ELECTRONIC-OPTICAL PHASE LENSES

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Application October 26, 1938, Serial No. 237,140
In Germany October 26, 1937

6 Claims. (Cl. 250—27)

This invention relates to electronic devices, and in particular, to transit time electron tubes in which there is provided a phase diaphragm for increasing the operational efficiency of such tubes.

There are known electronic tubes in which the charge carriers (electrons or ions) are moved under the action of electric or magnetic alternating fields in such a manner that their transit time plays an important part in the operation of the device. This is the case, for instance, if the time spent by the electron or ion passing through the tube is comparable with the time of oscillation of the alternating field or is long in comparison thereto.

To these so-called transit time devices belong, for instance, the dynamic multipliers as used for the amplification of a quantity of electrons with the aid of the secondary emission of electrons; the multiple accelerator for the generation of high velocity charge carriers, and the arrangements for inducing high-frequency oscillations. To the last-but-one group pertains, among other devices, the cyclotron, and to the last group the oscillation generators of Barkhausen-Kurz and the magnetron.

All these devices are based on the principle that in high-frequency alternating fields electrons are partly accelerated and partly retarded and that their energy of motion is, therefore, in mutual relation to the energy of the oscillatory circuit connected up thereto.

Now, it has been discovered that the high-frequency fields with the electrons passing through them can be conceived similar to a lens with a beam of rays radiating through it, and that in this way simple points of view for treating the problems can be taken. In the same manner in which, the beam or ray is focused or dispersed by a lens, so focusing or dispersion of electrons can be accomplished in an alternating field. This focusing or dispersion does not relate, however, first of all to the directions, but to the temporal succession of the electrons which can be assembled in time sequence at one point by means of such a "phase-lens." The alternating field as used in the transit time devices constitutes, according to the theory, such a phase-lens with variable focal length which oscillates between a collecting lens across a planoparallel plate and a dispersing lens and back again. The focal length depends upon the variation speed of the field strength. Thus, a phase lens may be defined as an "electron lens having a sinusoidal varying focal length."

The present invention relates to a device termed "phase diaphragm" and intended for the periodic interruption of the electron current entering into the phase lens. In this connection a phase diaphragm may be defined as an "electron diaphragm having a variable aperture." There is used as phase diaphragm, according to this invention, a control device able to interrupt the electron current synchronously with respect to the alternating potential of the phase-lens.

It is, for instance, possible to attain with the aid of such a phase-diaphragm, a phase-lens which exerts its action only at a certain definite focal length. Under this circumstance the action on the electron ray is similar to an optical "apertured diaphragm," being such that the interruptions cause the ray to fall onto the lens only within such intervals of time at which the focal length of the lens oscillates only slightly around a predetermined value. In general, the phase-diaphragm when employed in connection with transit time devices causes the electron ray to be interrupted synchonously with respect to the frequency of the alternating potential exciting the field and is brought, in this manner, into a phase suited to the alternating potential, whereby the efficiency of the transit time device will be increased.

The invention is illustrated diagramatically and by way of example on the accompanying drawing, in which Fig. 1 shows in schematic form one arrangement of electrodes in accordance with the invention to provide a phase diaphragm; Fig. 2 shows a modification of the electrode structure shown in Fig. 1 which permits variation of the applied alternating potential; Fig. 3 shows a further modification of the embodiment of a phase lens shown in Fig. 1 in which electromagnetic fields are used; Fig. 4 shows a graphical representation of the potentials of the various electrodes under operating conditions of the structure shown in Fig. 1; Fig. 5 shows a modification of the embodiment of the structure shown in Fig. 3 in which the electromagnetic field is replaced by an electrostatic control field; while Fig. 6 shows an electronic device embodying the invention and including both a phase diaphragm and a phase lens used in a dynamic multiplier in accordance with the invention.

Referring to Fig. 1, 1 denotes the cathode emitting the electrons, 2 the anode, and 3 and 4 denote the grid electrodes, constituting the diaphragm proper. The electrodes 2 and 3 have the same potential (for instance 500 volts) relatively

to the cathode 1. The grid 4 lies on a negative potential (for instance 1000 volts) relatively to the grid 3, and besides an alternating potential having an amplitude of, for instance, 550 volts is connected up to the electrodes 3 and 4.

Fig. 4 serves to illustrate the manner of action of the diaphragm. In this figure the potentials of all electrodes are represented relatively to the cathodes as functions of the time. The electron ray can pass through the grid 4 only if this latter has a positive potential relatively to the cathode 1. This is the case, during the entire period of the alternating potential, only in the interval of time from t_1 to t_2 in which the alternating potential passes through its upper crest value. In other words, the interruption of the electron beam takes place synchronously with respect to the alternating potential. In connection therewith it is desirable to keep the amplitude of the alternating potential constant.

While Fig. 1 shows a phase-diaphragm, in which the electrons in general leave the grid 4 with a potential energy which is small relatively to the amplitude of the alternating potential, Fig. 2 shows a modification in which the emission speed can have any desired magnitude. There are in this example, the three grid electrodes 3, 4 and 5, of which 3 and 5 are conductively connected with one another. The potentials of the electrodes are the same as has been stated with respect to Fig. 4. The interrupted electron beam has in this case an energy of 500 volts.

In Fig. 5 is shown how the interruption of an electron current by means of a phase-diaphragm can be effected also by a change of the direction of said current. In this diagram 6 denotes a pair of deflecting plates, 7 is a diaphragm, and 8 another pair of plates arranged therebehind.

An alternating potential connected up to the plates 6 causes the electron beam to oscillate in front of the diaphragm. The beam can pass through the diaphragm only if the absolute amount of the alternating potential lies below a certain limit. The frequency of the interruption is, therefore, twice the frequency of the alternating potential. As the direction of the beam permitted to pass has, in general, been changed, the pair of deflection plates 8 has been provided which brings the beam back into its former direction.

Fig. 3 shows a phase-diaphragm, the manner of operation is the same as the manner of operation of the phase-diaphragm shown in Fig. 4, but instead of the pair of deflection plates 6 a pair of deflection coils 9 is provided which causes the change of the direction of the electron beam and thereby the periodic interruption of the same.

In the arrangements, shown in Figs. 5 and 3, the deflection member 6 or 9 and the diaphragm 7 can, furthermore, be so arranged with respect to one another that an electron current can pass through the apertured diaphram only if the alternating potential of the phase diaphragm passes through one of the crest values thereof. In this case an interruption would be brought about by a change of the direction synchronously with respect to the alternating potential of the phase-diaphragm.

Fig. 6 illustrates how the phase-diaphragm may be used in connection with a dynamic multiplier. The multiplier by way of example, is connected for operation as an amplifier. In the glass-vessel 20 an indirectly heated cathode emits electrons, which, through a cylindrically shaped control electrode 22 enter the phase-diaphragm formed by three electrodes 23, 24, 25. The construction of this phase-diaphragm corresponds to that described in Fig. 1. Electrode 23 is formed as a diaphragm and at the same time serves as anode, while electrodes 24 and 25 consist of grid structures. After the electrons have passed through the phase-diaphragm they impinge on one of the known dynamic multipliers, which in this case consists of electrodes 26, 27, 28 and a surrounding electromagnetic coil 29. The latter serves for the generation of a magnetic field in the direction of the axis of the glass-vessel.

The cathode 21 is connected with the tap 32 of a direct current source 30, while cylinder 22 is connected with tap 31 of the same direct current source and thus is negatively biased with respect to the cathode.

The control-voltage to be amplified is impressed on the control-cylinder 22 from the input terminals 34 and by means of the impedance 35. The anode 23 and the grid-like electrode 24 both are connected with tap 33 of the direct-current source 30 and are grounded. They receive a positive potential with respect to the cathode of, by way of example, some 100 volts. The alternating voltage of the phase-diaphragm, as represented in Fig. 4 for instance, is impressed on the phase-diaphragm by the source 36. A battery 41 is provided as a negative bias for electrode 25 with respect to electrode 24. The phase-diaphragm and its connection herewith in every detail correspond to those represented in Figs. 1 and 4.

In the electron multiplier, as well known in the art, there are arranged two cathodes 26, 27, the cylindrical electrode 28 and an electromagnetic coil 29. On the cathodes 26, 27 by means of terminals 37, is impressed an alternating voltage of high frequency. The terminals 37 being symmetrical with respect to ground, their mean potential is that of ground. The alternating potential on electrodes 26 and 27 causes an alternating field between these electrodes, which as already described forms a phase-lens with temporally variable focal-distance. The magnetic field of coil 29 serves for the concentration of the electrons traversing within the swinging multiplier.

As well known to those skilled in the art, the principle of the multiplier is that primary electrons which enter the multiplier through diaphragm 26 impinge on cathode 27 at a suitable phase of the alternating field, emit there secondary electrons, which now on their part in suitable phase impinge on the other cathode 26, emit there secondary electrons and so forth. Thus the primary electrons are multiplied and the electron stream may be taken off on the auxiliary electrode 28.

It is known that when primary electrons enter the multiplier through the diaphragm 26 in a continuous stream, only a fraction of the electrons impinge on cathode 27 at such a phase of the alternating potential that this fraction effectively takes part at the multiplying process. The other electrons have been brought into the multiplier without any use; they are superfluous and only withdraw energy from the oscillating field which energy cannot be employed.

According to the invention with the phase-diaphragm there is accomplished that the electrons impinge on the cathode 27 only at suitable phases of the alternating voltage that only such

electrons occur which effectively take part in the multiplying process.

The multiplied electrons reach the auxiliary anode **28**, which is positively biased by direct current source **40**, and appear on impedance **38** as the amplified control potential, provided that the control potential is of substantial lower frequency than the alternating voltage of high frequency of the multiplier and the phase-diaphragm. The amplified voltage may be taken off at terminals **39**.

Of course, instead of the phase-diaphragm **23**, **24** any other phase-diaphragm as represented in Figs. 2, 3 and 5 may be used.

It is advantageous for the purpose in view to supply the phase-diaphragm and the phase-lens with alternating potential from the same source. In that case, the phase-diaphragm interrupts the electron current with double the frequency of the diaphragm potential, it is, however, necessary to make use of means for doubling the frequency or for dividing it into halves, in order to insure that the interruption takes place synchronously with the lens potential.

While in the above description, the effect of the phase-diaphragm upon electrons has been emphasized, it is a matter of fact that a diaphragm of the said type can serve also for the control of ion currents and can be used, for instance, in connection with a cyclotron operating with ions.

We claim:

1. A transit time electron device comprising means for producing a concentrated beam of electrons, electrode means for controlling the intensity of the produced beam of electrons by electrical signals, an electron phase lens, and an electron phase diaphragm interposed between said beam producing means and said phase lens.

2. A transit time electron device comprising means for producing a concentrated beam of electrons, electrode means for controlling the intensity of the produced beam of electrons by electrical signals, an electron phase lens, and an electromagnetic phase diaphragm interposed between said beam producing means and said phase lens.

3. A transit time electron device comprising means for producing a concentrated beam of electrons, electrode means for controlling the intensity of the produced beam of electrons by electrical signals, an electron phase lens, and an electrostatic phase diaphragm interposed between said beam producing means and said phase lens.

4. An electron device comprising means for producing a concentrated beam of electrons, electrode means for controlling the intensity of the produced beam of electrons by electrical signals, a dynamic secondary electron multiplier incorporating an electron phase lens positioned in register with said beam producing means, and an electron phase diaphragm interposed between said beam producing means and said multiplier.

5. An electron device comprising means for producing a concentrated beam of electrons, electrode means for controlling the intensity of the produced beam of electrons by electrical signals, a dynamic secondary electron multiplier incorporating an electron phase lens positioned in register with said beam producing means, an electrostatic electron phase diaphragm interposed between said beam producing means and said multiplier, and connection means adapted to supply electrons from said multiplier to an output circuit under the joint control of said phase lens and said phase diaphragm.

6. An electron device comprising means for producing a concentrated beam of electrons, electrode means for controlling the intensity of the produced beam of electrons by electrical signals, a dynamic secondary electron multiplier incorporating an electron phase lens and an output electrode positioned in register with said beam producing means, an electron phase diaphragm interposed between said beam producing means and said multiplier, an impedance connected to said output electrode, and means to derive output energy from across said impedance.

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