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R. WARNECKE ET AL

2,543,213

HIGH-FREQUENCY PULSE PRODUCING APPARATUS

Filed May 14, 1947

2 Sheets-Sheet 1

Fig. 1

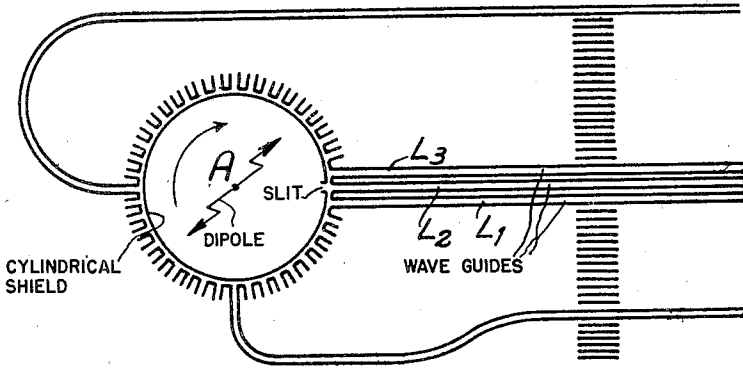


Fig. 2 a

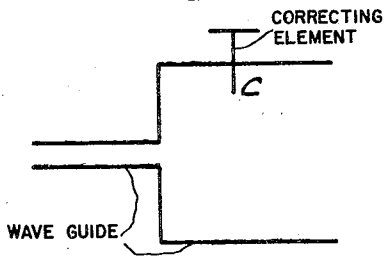
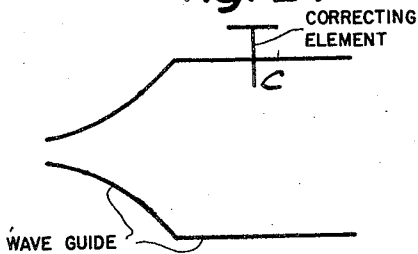


Fig. 2 b



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2 Sheets-Sheet 2

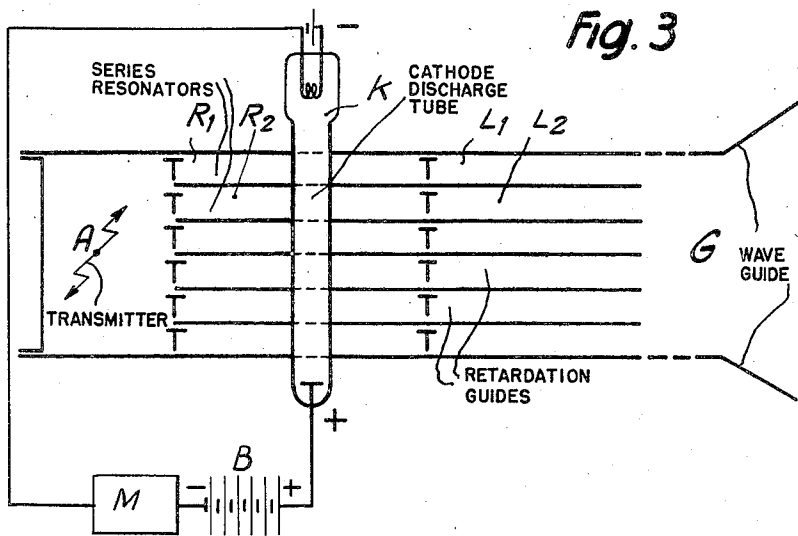


Fig. 4

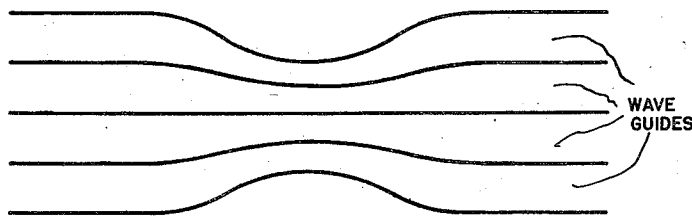
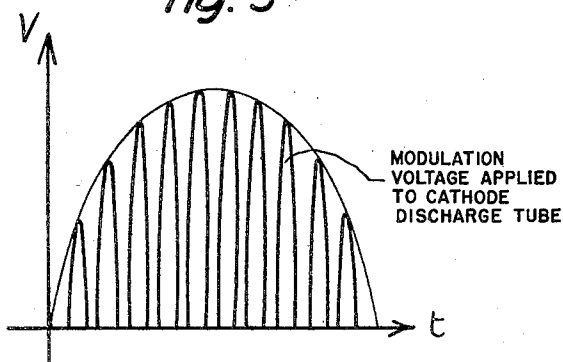


Fig. 5



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HIGH-FREQUENCY PULSE PRODUCING APPARATUS

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7 Claims. (Cl. 332-13)

1

This invention relates to apparatus for producing pulses or peaks of high frequency energy.

For a number of applications of very short electromagnetic waves, for example in radar, radio distance measurement or ranging, and radio altimeters, it is required to produce very short, very powerful signals (pips), having for instance peak powers of a few tens or hundreds of kilowatts for periods of the order of a micro-second.

This is usually done, by providing the feed circuit of a generating tube with pulses or peaks. Such an arrangement is satisfactory for relatively low power transmitters using maintained voltages of fairly low value for it is then practical, by considerably increasing the maintained or normal feed voltage for very short periods, to produce "pips" with very high peak power, whilst at the same time retaining a relatively low mean power in the generator tube. The method is, however, obviously not practical with generator tubes using fairly high maintained voltages, or with tubes which require voltages of critical values.

This invention seeks to avoid these limitations and to provide improved means for producing very short waves (for example decimetre or centimetre waves) in pulses of very considerable peak powers, without modifying the values of the feed voltages of the tubes of the system.

The principle of the invention resides in dividing a maintained normal emission into several successive periods of duration equal to the duration of a pip, during an interval of time which is the pip period. These partial emissions obtained are fed to retardation guides, the retardation due to each guide relatively to the previous guide being equal to the interval of time separating each pip. These guides all end in a single guide which thus collects during a period of partial emission, all the mean power, which is thus peak-multiplied by the number of said partial emissions.

In other words, if the mean maintained power of the tube is W , and there are n suitably adjusted retardation guides the peak power will be $n \times W$ for a period $1/n$.

This principle of the invention, of a far-extending scope, may be applied in numerous different ways, some of which are illustrated in the accompanying drawings, in an absolutely non-limitative manner in which:

Figure 1 illustrates the system of our invention in which the pips, excited in a cavity reso-

2

nator, are transmitted successively to the different delay guides by purely mechanical means;

Figs. 2a and 2b indicate two modes of connection capable of being employed for joining the said cavity with each of the delay guides;

Fig. 3 discloses a form of our invention in which the successive transmission of the pips is obtained with the use of a cathode ray tube inserted in the unit of the lines connecting the cavity with the delay guides;

Fig. 4 illustrating a form of our invention applicable to the unit shown in Fig. 3; and

Fig. 5 represents a curve showing the anodic voltage applied to the cathode ray tube as a function of time.

Referring to Fig. 1 which illustrates one embodiment of my invention a transmitting antenna A (a dipole, for instance) radiates within a shield constituting a cylindrical cavity provided with a slit, parallel to the axis of the cylinder and rotated very rapidly round its axis, the period of rotation being equal to the pip period. Round the single slitted cylindrical shield is another fixed shield of a very nearly the same shape, but provided with fixed slits of the same width as that in the rotating shield. These fixed slits are the inner ends of rectangular wave guides L_1, L_2, L_3 , of height (by height, in this connection, is meant the dimension perpendicular to the electric vector) slightly greater than $\lambda/2$ where λ is the wave length of the emission. The guide comprises two parts:

(a) A first part consisting of a guide element having the same width as the fixed slit and leading into a wider guide, either abruptly as in Fig. 2a or smoothly through a funnel-shaped length as in Fig. 2b. A correcting element placed in the wider guide portion renders it possible for the whole power to pass between the fixed slit and the interior of said wider guide portion.

(b) A second part consisting of a retardation guide proper terminated by an opening into a large collecting wave guide. The retardation guide can take any of several forms e. g.:

1. A wave guide of height approaching $\lambda/2$ for which the propagation speed of the energy tends towards zero when the height tends towards $\lambda/2$.

2. A wave guide with a dielectric other than air within it. Such dielectrics introduce a wave length much smaller than in air, in dependence on the value of the dielectric constant, and consequently they can introduce an appreciable delay with less length of guide than would be required were an air dielectric used.

The wave reflections due to the opening can

be prevented by any suitable means. Since such means form per se no part of this invention they will not be described herein.

In the embodiment shown in Fig. 3 a transmitter A (Fig. 3) sends a transmission into a large collecting guide G, via several rectangular retardation guides L_1, L_2 , each preceded by a series resonator $R_1, R_2 \dots$. A glass tube K in which a cathode discharge is set up, passes transversely through all these resonators, use being made, if necessary, of a very much narrower guide section as indicated in Fig. 4, where the tube passes. The system of the resonators is first adjusted in such way that each resonator is turned to the frequency of the transmission for a given (different) value of the feed voltage to the discharge tube, and be out of tune for all other values. The discharge tube is modulated, for example by applying to its anode a modulated voltage provided by a biasing battery B and a modulating device M, of any known type, suitable for giving a voltage, shaped as indicated in Fig. 5, which represents the applied voltage plotted against the time, this voltage being applied in pulses or peaks of a number corresponding to the number of guides $L_1, L_2 \dots$ the maximum voltage being itself modulation at the frequency desired.

If each resonator is tuned in connection with the voltage of the corresponding pip, the transmission itself is chopped in the same manner, the maxima of the transmission pips being equal and corresponding with the mean power of the transmitter. After passing through the retardation guides, into the common rectangular collecting guide G, the transmission will again be of pip form, that is, one pulse the peak power of which is equal to the mean power multiplied by the number of guides $L_1, L_2 \dots$. The duration of the one pulse will be the mean duration of the voltage pips. The pulse frequency will be equal to the frequency of modulation of the voltage applied to the discharge tube.

What we claim is:

1. A system for increasing the peak value of the current furnished by a pulse generator having a transient-state response and fed by periodic waves of a relatively low strength produced in steady-state condition, comprising in combination, a resonant unit employing at least one electromagnetic resonator excited from a pulse generator, a plurality of electromagnetic wave delaying guides, means for transmitting successively to these different guides during a time period equal for each guide to the duration of a pulse, the current pulses produced in the resonant unit, and in the course of the duration of a pulse-repetition cycle, and a collector guide communicating simultaneously with all of the different delaying guides, the delays of propagation imparted by the latter to the pulses which traverse them being determined so as to bring about the addition of the effects of the pulses arriving at the same time, at a given instant, in the collector guide.

2. A system for increasing the peak value of the current furnished by a pulse generator having a transient-state response and fed by periodic waves of a relatively low strength produced in steady-state condition, comprising in combination, an electromagnetic resonator with a cylindrical cavity intended to be excited from a pulse generator, said resonator being equipped with a slot parallel to its axis and adapted to rotate about this axis with a period of rotation

equal to the duration of one pulse-repetition cycle, a plurality of electromagnetic wave delaying guides whose respective entrances are disposed about the cylindrical cavity in such a way that the slot in said resonator in the course of the rotation of said resonator is placed successively in the extension of each of said wave delaying guides for a time equal to the duration of a pulse, and a collector guide into which the exits of the delaying guides open, the delays of propagation imparted by the latter to the pulses which traverse them being determined so as to bring about the addition of the effects of the pulses arriving at the same time at a given instant in the collector guide.

3. A system for increasing the peak value of the current furnished by a pulse generator having a transient-state response and fed by periodic waves of relatively low strength, comprising in combination, an electromagnetic cavity resonator intended to be excited from a pulse generator, a plurality of electromagnetic wave delaying guides, means for transmitting successively to these different guides, during a time equal for each guide to the duration of a pulse, the current pulses produced in the cavity resonator, and a guide collector into which there opens the exits of the delaying guides, the latter being adapted in such a way that the delays which they impart to the pulses traversing them bring about the addition of the effects of the pulses arriving at the same time at a given instant in the collector guide, the said means of transmission comprising connection resonators in a number equal to that of the delay guides in order to join the cavity resonator with the entrances of the respective delaying guides, and a tube having an electronic beam traversing the connection resonators transversely and whose anodic feed voltage is modulated in amplitude to the frequency of repetition of the said pulses, the connection resonators being adjusted in such a way that in the course of a pulse-repetition cycle, under the effect of this variable anodic voltage, successively each of these resonators is tuned on the said frequency of repetition, the others being de-tuned.

4. A system for increasing the peak value of the current furnished by a pulse generator having a transient-state response and fed by periodic waves of relatively low strength, as set forth in claim 3, wherein the anodic voltage applied to the electronic tube is in the form of pips, the number of these pips during the duration of one pulse-repetition cycle being selected equal to that of the connection resonators.

5. A system for increasing the peak value of the current furnished by a pulse generator having a transient-state response and fed by periodic waves of relatively low strength as set forth in claim 1, wherein the electromagnetic wave delaying guides are of substantially rectangular section, and wherein the larger side of each substantially rectangular section has a length greater than half the wave length to be transmitted, that is, greater than half the time interval of the transmitted pulse.

6. A system for increasing the peak value of the current furnished by a pulse generator having a transient-state response and fed by periodic waves of relatively low strength, as set forth in claim 1, wherein the electromagnetic wave delaying guides contain dielectrics other than air.

7. A system for increasing the peak value of

the current furnished by a pulse generator having a transient state response and fed by periodic waves of relatively low strength, comprising, in combination, an electromagnetic cavity resonator, intended to be excited from a pulse generator, a plurality of electromagnetic wave delaying guides, means for transmitting successively to these different guides during a time interval, for each guide, to the duration of a pulse, the current pulses produced in the cavity resonator, and a guide collector into which the exits of the delaying guides open, the latter being adapted in such a way that the delays which they impart to the impulses traversing them bring about the addition of the effects of the pulses arriving at the same time, at a given instant, in the collector guide, the said means comprising connection resonators in a number equal to that of the delay guides, in order to join the

cavity resonator with the entrances of the respective delaying guides and means to detune the said connection resonators and tune them successively on the frequency of repetition of the said pulses.

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