

Sept. 24, 1946.

E. LABIN ET AL

2,408,078

CONSTANT WIDTH SYNCHRONIZED PULSE GENERATOR

Filed Feb. 3, 1942

2 Sheets-Sheet 1

FIG. 1.

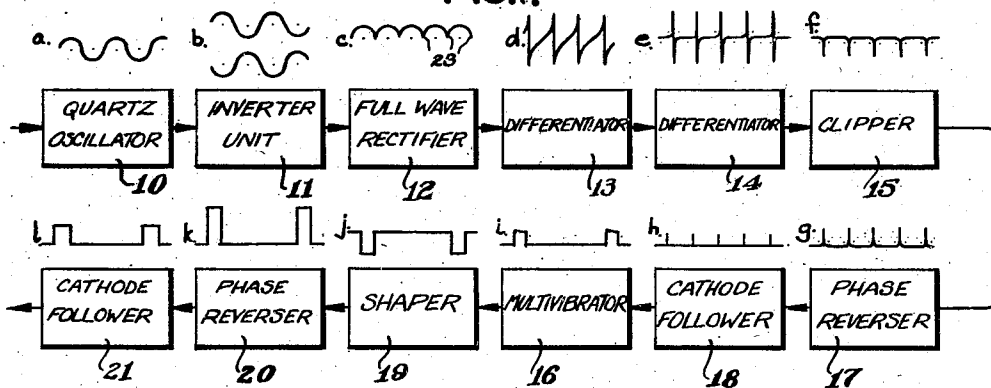
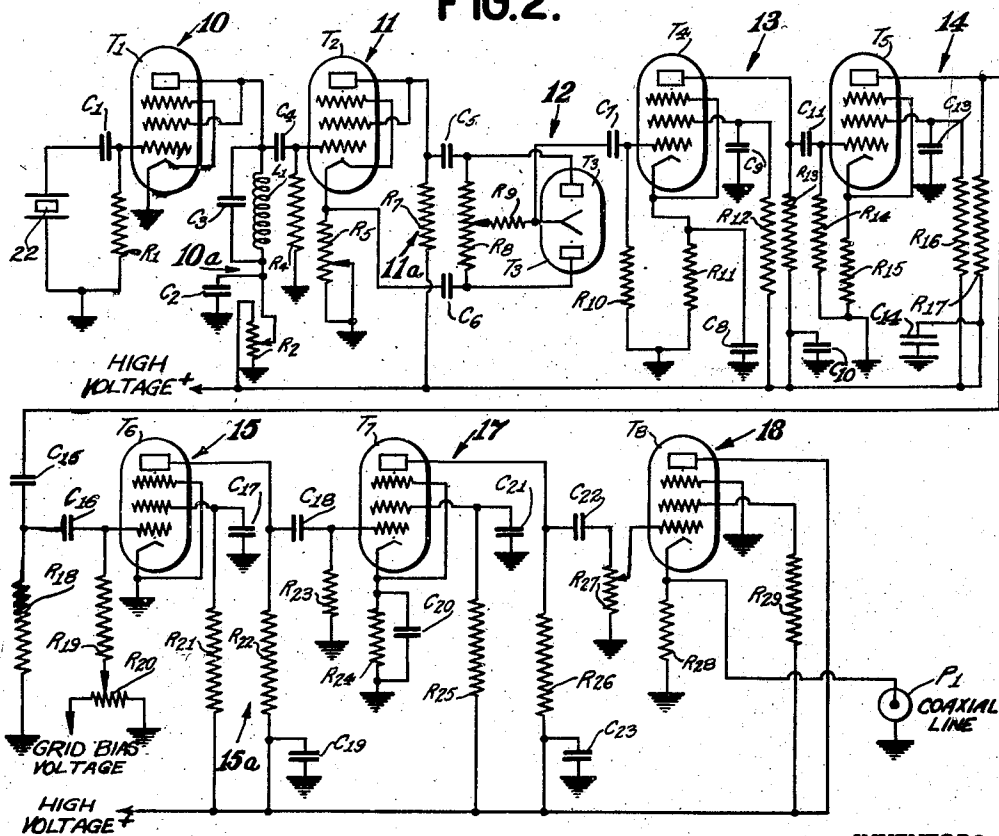


FIG. 2.



BY

INVENTORS
EMILE LABIN
DONALD D. GRIEG
R. P. Morris
ATTORNEY.

Sept. 24, 1946.

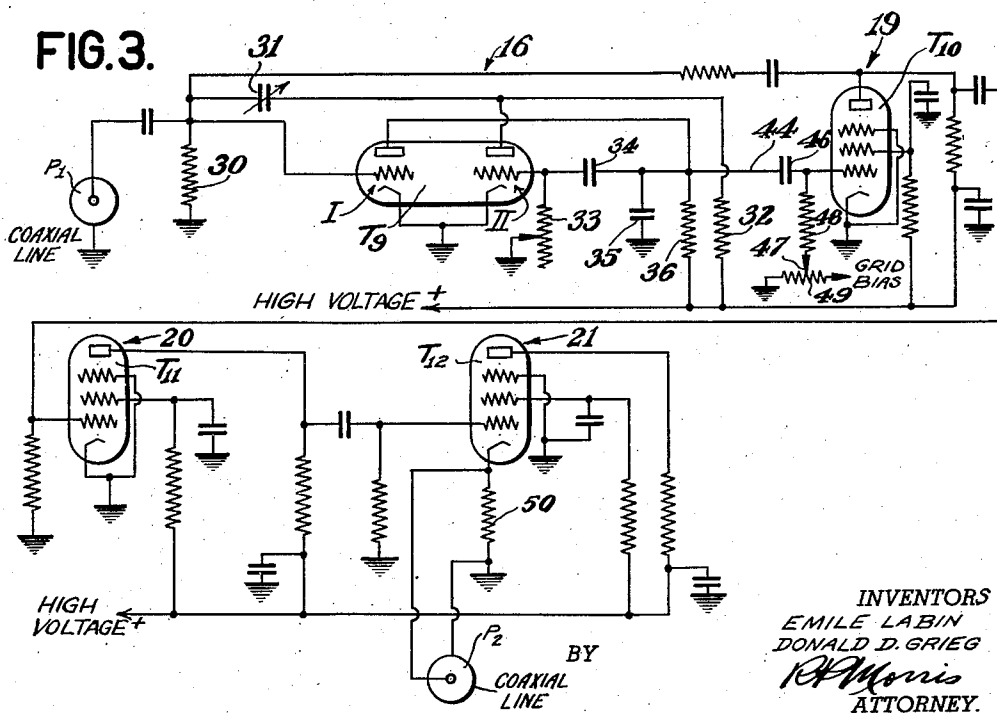
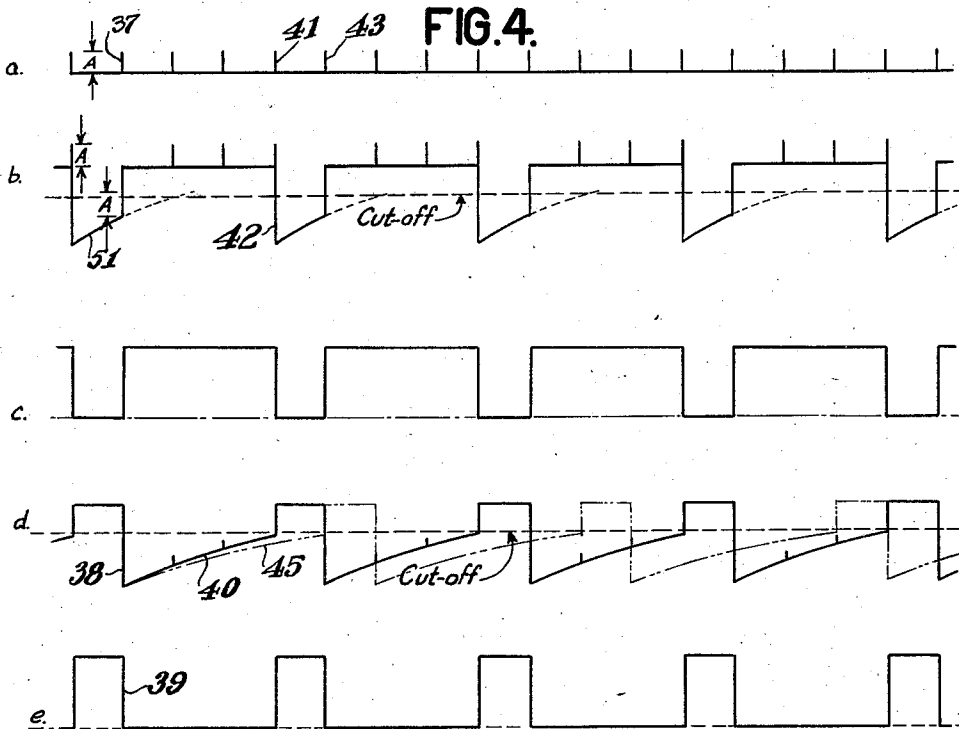
E. LABIN ET AL

2,408,078

CONSTANT WIDTH SYNCHRONIZED PULSE GENERATOR

Filed Feb. 3, 1942

2 Sheets-Sheet 2



UNITED STATES PATENT OFFICE

2,408,078

CONSTANT WIDTH SYNCHRONIZED PULSE GENERATOR

Emile Labin and Donald D. Grieg, New York, N. Y., assignors to Federal Telephone and Radio Corporation, a corporation of Delaware

Application February 3, 1942, Serial No. 429,376

2 Claims. (Cl. 250-27)

1

This invention relates to impulse generating systems and in particular to an improved type of synchronized impulse generator for timing, calibrating, and other control purposes. The invention is considered particularly adaptable where a highly accurate timing interval is desired, as for example in aircraft identifier apparatus wherein small time intervals indicative of distance are observed on the screen of a cathode ray tube. Such apparatus has been disclosed, for example, in the copending applications Ser. Nos. 382,391, filed March 8, 1941, and Ser. No. 383,103, filed March 13, 1941, of E. Labin.

It is an object of the invention to provide a method and means for generating accurately synchronized impulses over a relatively wide range of desired impulse recurrent frequencies.

Another object is to provide an improved form of "constant-width" impulse generator wherein both the leading and trailing edges of impulses are defined thereby with high accuracy.

A further object is to provide a method and means for generating periodically recurrent impulse energy wherein each successive impulse is of very substantially the same duration for different frequencies of such periodic recurrence.

It is also an object to provide improved means for generating impulses of a desired controllable duration.

Other objects and various further features of novelty and invention will hereinafter be pointed out or will become apparent from a reading of the following specification in connection with the drawings included herewith. In said drawings,

Fig. 1 is a block diagram illustrating very schematically a preferred form of the invention, Figs. 1a, b . . . 1 indicate wave form treatment through the various elements of the circuit of Fig. 1;

Fig. 2 represents schematically and in more detail certain of the elements of Fig. 1;

Fig. 3 represents schematically and in more detail further elements of Fig. 1; and

Figs. 4a, b . . . e illustrate graphically certain circuit conditions occurring during a normal operation of the apparatus of Fig. 3.

Broadly speaking, the invention contemplates the use of a master oscillator of relatively high stability and having a generally sinusoidal wave form as the prime source of control energy. The periodicity of this wave form is related by a simple factor to the desired pulse "width" or duration in the output of the apparatus. This sinusoidal wave form may be employed in a known manner to generate a series of extremely

2

short synchronizing impulses having a periodicity equal or factorially related to the desired pulse width. The synchronizing impulses thus obtained are then supplied to a novel multi-vibrator circuit forming part of this invention, to generate impulses of the desired shape and duration, that is, impulses equal or factorially related in duration to the periodicity of the synchronizing, this relationship being dependent upon circuit adjustments. Thereafter, the output may be suitably shaped for whatever the required purposes.

For a more specific consideration, reference will now be made to Fig. 1, which shows in block diagram form, features of a preferred embodiment. As the master oscillator, we employ in the form shown, a quartz oscillator 10 to produce the required sinusoidal wave form. This wave is then suitably shaped in an inverter unit 11 for application to a full-wave rectifier 12 to give a balanced rectified output. Since the most accurately defined recurrent portion of the output of rectifier 12 is the cusp-shaped part where the wave hits zero voltage, we accentuate these cusps by applying the output of rectifier 12 to a pair of successive differentiator circuits 13 and 14, whereby in accordance with known principles, a series of extremely sharp alternately positive and negative impulses is produced. Since it is desired to use only one of these sets of impulses for synchronization, output of differentiator 14 is applied to a clipper or limiting device 15 to produce a series of uni-directional synchronizing impulses.

These synchronizing impulses, as above-indicated, may then be applied to a multi-vibrator circuit 16, which forms an important part of this invention. Since it is preferable that the impulses applied to the input of multi-vibrator 16 are positive and of a controllable magnitude, suitable networks 17 and 18, including a phase reverser and cathode follower, respectively, may be included in the circuit between clipper 15 and multi-vibrator 16. After the desired kind of impulse energy has been formed in multi-vibrator 16, the output may be appropriately shaped, phased, and amplified for the required purposes in networks 19, 20, and 21, respectively.

Turning now to a more detailed consideration of the various elements involved in the circuit of Fig. 1, reference is made to Fig. 2 in which oscillator 10 is seen to include a quartz crystal 22 and a pentode T_1 having certain resistance R_2 in its output circuit 10a. Since the stability of the entire system is seen to depend to a large extent on the inherent stability of the master oscillator stage 10, it is considered preferable that

certain precautions be taken to ensure the necessary stability. For this reason, the resistance R_2 may be included in the output of tube T_1 so that, should there be any impedance changes within tube T_1 under operating conditions, these changes will be of a negligible nature, as compared with the total impedance, including that added by resistor R_2 .

Due to the method of pulse generation in accordance with the preferred form shown, the synchronizing pulse output forthcoming from clipper 15 is twice the frequency of the master oscillator. As will later appear, this relation means that for the minimum required pulse width in the output of multi-vibrator 16, the period of the master oscillator must be equal to twice the time width of these minimum-sized impulses. Expressing this relation between the master oscillator period T_0 and the minimum time width of desired pulses t_w , $T_0 = 2t_w$, and since the relationship between a period t and the frequency f to which it corresponds is—

$$\frac{1}{t} = f, F_0 = \frac{1}{2t_w}$$

where F_0 is the frequency of the master oscillator. Thus, by way of example, if a pulse width of 5 microseconds were required for a certain purpose in the output of multi-vibrator 16, the fundamental oscillator frequency would necessarily be:

$$F_0 = \frac{1}{2(5)} \cdot 10^6 = 100 \text{ kilocycles}$$

As above-indicated in the discussion of Fig. 1, an inverter circuit 11 is employed to produce two balanced sine waves for application to the full-wave rectifier 12. In the form shown, the inverter 11 includes an amplifier T_2 having an output 11a including a load resistor R_7 . It will be noted that the output is taken directly across the cathode and plate circuits of tube T_2 , and that therefore balance with respect to ground may be regulated by a variable resistor R_5 included in the cathode circuit to ground. By adjusting cathode resistor R_5 to equal in magnitude the load resistor R_7 , zero amplification results in tube T_2 and maximum balance may be obtained. In the form shown, load resistor R_7 directly supplies input energy to the full-wave rectifier. This rectifier may include a double diode T_3 symmetrically fed across a resistor R_8 , and the cathode circuit may be connected through a resistor R_9 to substantially the midpoint of input resistor R_8 .

As above-indicated in general language, we consider it preferable for increased timing accuracy that the timing of the pulses appearing in the output of differentiator 14 be determined solely by the time at which the sinusoidal wave from oscillator 10 crosses the zero axis, that is, by the cusp portions 23 of the rectified wave; see Fig. 1c. Since the cusp timing is independent of voltage variations (the cusp representing zero voltage), a high order of pulse timing or frequency stability is possible by utilizing this portion of the rectified wave. In order to achieve maximum pulse stability, however, the sharpness of the cusp wave form must be maintained. This latter requirement necessitates that high-frequency discrimination and distortion at the wave cusps be kept at a minimum, that is, that the circuit be as evenly responsive as feasible to a relatively wide band of frequencies. To this end, potentiometer R_8 is connected as shown, and the resistor R_9 is made small in order to minimize

the shunting effect of the input coupling to the following stage (differentiator 13).

The two differentiator circuits 13 and 14 are of essentially similar and known form, and include amplifier tubes T_4 and T_5 having coupling circuits which constitute the differentiating networks. These coupling circuits may be of the simple resistance-capacitance type, and in the form shown, include condenser C_{11} and resistor R_{14} for the output of the tube T_4 of differentiator 13, and condenser C_{15} and resistor R_{18} for the output of the tube T_5 of differentiator 14. The wave-form treatment, as energy from the rectifier 12 passes through differentiators 13 and 14 successively, is indicated graphically in Figs. 1d and 1e. It will be seen therefrom that the output of differentiator 14 as appearing across resistor R_{18} comprises a series of extremely short impulses of successively positive and negative sense.

Since the form of the multi-vibrator 16 shown requires positive synchronization impulses for operation, the output of differentiator 14 is next limited through a clipping device 15 so as to produce a series of uni-directional synchronizing impulses. In the form shown, clipper 15 includes a class C amplifier employing tube T_6 . As is well-known, in this form of amplifier negative excursions of the input voltage past cutoff cannot be reproduced in the plate circuit, and a limiting action thus results. Inherent in the operation of tube T_6 is the fact that a phase reversal occurs. Accordingly, the result of cutting out the negative pulses in the output of differentiator 14 is to produce a series of negative pulses in the output 15a of clipper 15. Passage of this energy through another vacuum tube device is therefore necessary in order to reverse the pulse phase and to produce the positive impulses required for the multi-vibrator 16. In the form shown, this latter stage is a simple class A amplifier T_7 . Now, since the input to this stage will be relatively high, tube T_7 may be additionally employed for shaping purposes, that is, to limit the magnitude of output pulses due to saturation in tube T_7 . The resulting pulses in the output of this stage are thus at proper polarity for synchronization, but present the undesirable feature that they are delivered at a relatively high impedance, as presented by the plate circuit of tube T_7 .

In order for these synchronized impulses to be delivered to the multi-vibrator circuit at low impedance, we choose to employ a known type of cathode follower device 18, which in the form shown, includes tube T_8 from which the low impedance impulses are derived across resistor R_{28} in the cathode circuit. The cathode follower circuit may also serve additional functions should the magnitude of impulse energy applied to the input thereof be too great for proper synchronization of the multi-vibrator. To these ends and due to the step-down impedance transformation from the input circuit to the output, voltage may be reduced with a minimum of distortion. Tube T_8 may serve a further function should the input be of unduly large magnitude, in that, due to plate saturation and grid-current flow, amplitude limiting and further shaping may result. It will be clear from the above-described circuit that the output of this stage, as applied to a load through a co-axial line P_1 , is a series of regular synchronizing pulses of short duration and occurring at a frequency equal to twice that of the master oscillator 10.

The multi-vibrator used may be considered to

5

be of a dissymmetrical type, that is, the time-constant decay circuits of the input section are dissimilar to those used in the output or alternate section. One of these time-constant circuits is employed to control output pulse width, and the other to determine the recurrent frequency of the pulses whose width is being controlled by the first of said circuits, as will later be clear.

Referring to Fig. 3, the multi-vibrator 16 is shown to include a double triode T9 comprising a triode section indicated generally by I and another indicated by II. A resistance 30, capacitance 31, and a further resistance 32, between the output circuit of tube section II and ground are included in the time-constant circuit which will be seen to be determinative of the width of the desired pulse; and a resistance 33, capacitances 34, 35, and a further resistance 36, between the output circuit of tube section I and ground are included in the time-constant circuit which will hereinafter be seen to be determinative of the frequency of recurrence of pulses derived from the multi-vibrator.

A better understanding of the operation of the multi-vibrator may be had by reference to the various curves shown in Fig. 4. In this figure, curve *a* represents the series of synchronizing impulses supplied from the cathode follower 18 over the co-axial line P₁, Figs. 2 and 3; curve *b* represents the instantaneous voltage appearing on the grid of tube section I; curve *c* represents plate current for tube section I; curve *d* represents instantaneous voltage appearing on the grid of tube section II, and curve *e* represents output current for tube section II. All five of these curves have been drawn against time, and for the sake of a better understanding, corresponding abscissae on all curves represent the same instant of time.

Assume initially the instant at which a positive synchronizing impulse 37 is applied to the grid of tube section I. This impulse will be of sufficient amplitude to render tube section I conductive, whereby this impulse is amplified and at the same time its phase is reversed to make it in effect an amplified negative impulse. Instantaneously this large negative voltage is applied to the grid of tube section II to bias the latter below cutoff, whereby tube section II is rendered non-conductive. On the curves of Fig. 4, this reaction is illustrated on curve *d* by a large swing 38 of grid voltage on tube section II below cutoff, and the resultant subsidence of output current in this tube section to zero is indicated by the wall 39 dropping to zero current in curve *e*.

As tube section I continues to conduct a large quantity of current, a relatively high voltage drop persists across resistance 36; and, as a result of the circuit values of condensers 34 and 35 and resistance 33, a voltage begins to build up across resistor 33 so that the grid voltage of tube section II builds up in a sense approaching cutoff. In Fig. 4, this increase in grid voltage toward cutoff is shown by the portion 40 of the curve of Fig. 4*d*. Now, as the grid voltage in tube section II is thus building up towards cutoff, the synchronizing impulses applied to the multi-vibrator circuit continue and are necessarily impressed upon the voltage appearing across resistor 33. As the synchronization impulses are thus applied across resistor 33, they will be of reduced magnitude, due to the fact that they have had to traverse certain circuit impedance represented by condensers 31, 34, and various leakage resistance paths. Thus, on curve

6

d they have been represented as of reduced magnitude. The synchronizing impulses reaching the grid of tube section II will be of a positive sense, however, due to the fact that they have reached this point directly, rather than by passing through a vacuum tube device. They are accordingly shown positively superimposed upon curve portion 40.

Now, the magnitude of the synchronizing impulses when superimposed upon the voltage that is building up across resistance 33 (as represented by curve portion 40) is at first insufficient to carry the grid of tube section II to a point greater than cutoff; but, as this grid voltage builds up, there will become a time when the superposition of a synchronizing impulse upon a voltage that has built up across resistor 33 will be great enough to apply a potential greater than cutoff potential to the grid of tube section II. In the assumed illustration, this time occurs with the third synchronizing impulse after the grid of tube section II was placed below cutoff, as will be clear from Fig. 4*d*.

Once tube section II is thus rendered conductive, the applied synchronizing impulse, which in the assumed case will be that indicated as 41, may be greatly amplified by tube section II. This large output may then be instantaneously applied to the grid of tube section I as a large negative impulse. The magnitude of this negative voltage applied across the grid of tube section I may thus be great enough to cut off conductivity of tube section I, as indicated by the sharp downward swing of grid voltage in tube section I (see the portion 42 of curve *b* of Fig. 4). Once tube section II has thus been rendered conductive, it will remain so until the large negative voltage across the grid of tube section I builds up in a positive sense to cutoff. The rate of this build-up, it will be clear, is governed by the particular time constant of the circuit defined by resistor 30, capacitance 31, and resistor 32, as will be clear. Now, due to the fact that synchronizing impulses are being continuously applied to the grid of tube section I with their full magnitude A, tube section I may be rendered prematurely conductive, owing to the superposition of impulses of magnitude A upon the positively increasing negative voltage across resistor 33. This phenomenon is shown to occur in Fig. 4*b* with the synchronizing impulse which next succeeds the impulse 41 which caused the grid of tube section I to be biased well below cutoff. Once tube section I again becomes conductive, the grid of tube section II is immediately biased beyond cutoff and the above-described cycle of operation repeats itself.

It will be noted that, in the form shown, output from the multi-vibrator is taken in line 44 from across resistor 36; in other words, output is taken from tube section I. It follows from the above discussion of multi-vibrator action that this output current will have the form shown in Fig. 4*c*, that is, it will be characterized by relatively long-duration impulses with small intervals between them. If it were desired to obtain small impulses with relatively large intervals therebetween, output should be taken across the plate circuit of tube section II, that is, by connecting line 44 across resistor 32 instead of across resistor 36 as shown. Multi-vibrator output would then present the wave form shown in Fig. 4*e*, as will be clear.

Presuming that multi-vibrator output is derived across resistor 32 to yield a series of regularly spaced relatively short-duration impulses,

7

it may readily be seen how in accordance with the invention the periodicity of impulse recurrence may be varied while maintaining impulse duration constant. This extension of impulse separation may be obtained, for example, by increasing the resistance 33 across which voltage applied to the grid of tube section II builds up. Such an increase in the resistance 33 will have the effect of changing the slope of the curve portion 40 of Fig. 4d so as to correspond, for example, with the line 45. Now, when the synchronizing impulses are superimposed upon this alternate curve portion 45, it will be clear that the third synchronizing impulse after the grid of tube section II has swung below cutoff will be of insufficient magnitude when superimposed upon curve section 45 to render tube section II conductive. In the form shown, however, the next succeeding, that is, the fourth impulse, will be of sufficient magnitude to render tube section II conductive and thus immediately to cut off the conductivity of tube section I, as will be clear. Operation thereafter will be of an analogous nature to that above described in connection with the full-line showings of curves 4b through 4e. This alternate operation is shown, for example, in dot-dot-dash lines to be distinguishable from the other full-line showings.

It will be clear from the above discussion that appropriate change in magnitude of any of the parameters affecting the voltage build up across resistor 33 may have the effect of changing the recurrent frequency of output impulses. It is further to be noted in this connection that the width of pulses in the multi-vibrator output may if desired be maintained precisely the same regardless of how the periodicity of recurrence varies. This feature follows from an appreciation of the fact that the time-constant circuit controlling output pulse width may always be maintained substantially the same, so that pulse width may always be determined by two synchronizing impulses of the same accurate time spacing.

In an analogous manner, the width of output impulse may also be controlled to be any desired multiple of the synchronization impulse repetition frequency $2F_0$. To this end, a variation in the capacitance 31 may have the effect of increasing the build-up time of bias voltage impressed on the grid of tube section I as tube section II is conductive. This build-up time may be increased so much that when the synchronizing impulse which succeeds the one which rendered tube section I nonconductive comes along, the magnitude of this succeeding impulse will be insufficient when superimposed upon the voltage that has by that time been built up across resistor 20 to render tube section I conductive. It will thus remain for the next succeeding, or perhaps a still later, impulse to render tube section I conductive. It is accordingly clear that impulse width may be controlled to be equal to any integer multiple of the synchronizing impulse repetition frequency.

An alternate method of controlling either pulse repetition frequency or the width of output pulses from the multi-vibrator may be to control the magnitude of synchronization impulses applied to the grid of tube section I. Such control may be included within the circuit of cathode follower 18, as will be clear, and may for example be in the nature of a variable tap on the input resistor R_{27} of tube T_8 . Should this control be effective to reduce the magnitude of applied synchroniza-

8

tion impulses to a great enough extent, tube section I may fail to go conductive after an interval equal to the period between synchronization impulses and may thus go conductive after one or more synchronizing impulses have been impressed on this grid.

It will be clear that, in order to facilitate an understanding of the operation of the multi-vibrator in accordance with features of the invention, the showings in Fig. 4 have been greatly exaggerated, that is, the impulses present in the output of the multi-vibrator have been shown to be excessively large with respect to the intervals separating them. In actual practice, it is contemplated that greater separation intervals may be employed merely by appropriate selection of the circuit constants and current magnitudes present in the multi-vibrator circuit. For example, in an actual embodiment of the invention, we have been able to obtain output impulse recurrent frequencies of from 500 to 6000 cycles while maintaining the pulse width constant over this entire range. This result, it may be noted, was obtained when a quartz crystal oscillating at 200 kilocycles was employed.

Although the current output wave form from the multi-vibrator has been shown in Fig. 4 to be very regular, that is, zero current for a while followed by a constant maximum, conceivably such regularity may not be a fact. Accordingly, in order to assure that a better square-wave output will be obtained, we propose to use appropriate wave-shaping elements.

In the form shown the multi-vibrator output is applied to shaper stage 19 by way of a capacity coupling 45. Referring to Fig. 3, shaper 19 is seen to comprise an ordinary amplifier tube T_{10} . The input circuit of tube T_{10} is provided with adjustable biasing means 47 whereby the tube may be preferably biased beyond cut-off, thus performing a clipping action to eliminate any circuit noise or transient phenomena occurring near the base of square-waves generated by the multi-vibrator. Tube T_{10} also preferably has a high- μ characteristic so that further shaping may be obtained due to saturation effects limiting the top of the square waves to a substantially uniform magnitude.

In the form shown the adjustable biasing means 47 includes a fixed resistor 48 adjustably tapped to a potentiometer 49, which is connected across the biasing source (not shown). It will be noted that in actuality then coupling condenser 46, resistor 48 and potentiometer 49 form part of the time-constant circuit which in the assumed illustrative case controls the longer of the two recurrent intervals defined by multi-vibrator action. If adjustment is contemplated in the magnitude of the bias voltage for tube T_{10} , it is considered preferable that such adjustment be effected with a minimum of change in the overall impedance of elements 46, 48, and 49. Accordingly, resistor 48 is preferably large compared with the impedance of potentiometer 49.

As shown output from the shaper stage 19 is taken from the anode circuit of tube T_{10} . There is thus a reversal in phase (polarity) of resultant squared pulse energy, and in order to obtain positive wave-forms a phase reverser 20 similar to phase reverser 17 may be employed. As in the case of phase reverser 17, phase reverser 20 may include an ordinary amplifier tube T_{11} capacitance-coupled to the output of tube T_{10} . At this stage it may be observed that further shaping of the squared-waves may be effected by taking ad-

vantage of the fact that the input wave form is negative. By operating tube T₁₁ at substantially zero bias and applying relatively large values of input voltage, clipping of the negative maxima may take place at cutoff, whereby both the bases and the crests of the resultant positive squared-waves are defined by clipping (cut-off) action.

Next and in order that the squared-waves may be supplied for any desired purpose at relatively low impedance, a cathode follower 21, similar to cathode follower 13 may be employed. The circuit for cathode follower 21 may thus comprise a conventional amplifier tube T₁₂ capacity-coupled to tube T₁₁, and output for a desired load P₂ may be derived without reversal of phase across resistor 59 common to the input and output circuits of tube T₁₂, as will be clear.

Many useful applications of the above-described device will doubtless occur to those skilled in the art. These applications may include receiver blocking, wave-blanking, differential delay circuits, and the like. One significant application will be briefly described.

As indicated at the outset, the invention is contemplated to have particular utility in the field of obstacle, particularly aircraft, locating apparatus. According to this type of device, as fully described in the above-mentioned copending patent applications of Messrs. Busignies and Labin, an impulse transmitter is employed periodically to radiate impulse energy. For each impulse transmitted, provided there is a reflecting object within range of the apparatus, a reflection of this impulse may be detected at an instant of time later than the instant of transmission by an amount proportional to the distance from the equipment to the reflecting object. The receiving equipment includes means for detecting the reflected impulses and an indicating device, preferably a cathode ray tube having at least two electron beam control systems. One of these control systems may be a conventional deflection system to which sweeping voltages, synchronized with the periodic recurrence of transmitted impulses, may be applied. The other of these control systems may be another deflection system to which energy from detected received signals may be applied.

The teachings of this invention may be applied to obstacle detection systems of the above-described character in substantially the following manner. Energy characterizing the synchronizing impulses which render tube section I of multivibrator non-conductive and simultaneously make tube section II conduct may be employed also to synchronize or energize the impulse transmitted so that impulse energy is transmitted only at these particular instants of time. Such a synchronizing signal could be obtained, for example, by sending output energy from either tube section (I or II) through a differentiator circuit, whereby sharp alternately positive then negative impulses would result, and then clipping so that whichever of these sets of impulses characterized the above-noted instants of time may remain for application to the transmitter unit.

Concurrently with the use of multi-vibrator output energy just noted, the periods of non-conductivity of tube section I (i. e. the shorter intervals) could be employed accurately to define a "distance" scale on the cathode ray indicator tube. To this end it is suggested that sweeping energy proportional to the change in voltage represented by the solid line voltage build-up curve

51 of Fig. 4b, as obtained for example by a high impedance connection across the input of tube section I, be amplified, appropriately polarized, and applied to the first-mentioned deflecting system of the cathode ray tube. In this manner it is clear that the cathode ray could be periodically swept across the screen of the indicator tube, and that the length of this sweep on the screen would be an accurate indication of the time interval represented by the interval of non-conductivity of tube section I. Accordingly, if received reflections of transmitted impulses be detected within the interval of time during which tube section I is non-conductive, there will be observed on the screen a needle-like indication transverse to the "distance" or "time interval" sweep scale; and the lateral disposition of this needle-like indication with respect to ends of the "distance" scale may be indicative of distance to the reflecting object, as will be clear.

If it should happen that the reflecting object is relatively far away, the interval between successive synchronizing impulses may not allow sufficient time for transmitted impulses to reach the object, be reflected, and then be detected by the receiving equipment. In such an assumed case the transverse needle-like deflection representing the reflecting object will appear at one end of the "distance" scale, and adjustment will be necessary before the distance to the object may be correctly determined. Such adjustment may be made very simply by making any of the above-noted adjustments to change the period of non-conductivity of tube section I. A simple expedient would be to increase the time constant of the circuit defined by elements 30, 31, and 32 so that instead of the period of non-conductivity of tube section I being merely the period between synchronizing impulses, it may be precisely the period of every two, three, four, etc. of these synchronizing impulses, as will be clear. In this manner, it would be possible effectively to magnify or enlarge the range of the obstacle-detection apparatus as desired, and at the same time always to have a precisely calibrated "distance" scale on the cathode ray screen, due to the high accuracy of the stable timing source, quartz oscillator 10.

It will be appreciated that we have disclosed means and methods for generating synchronizing impulses having a high order of stability and accuracy of recurrence. These pulses may be highly useful for accurate synchronization of sawtooth generators, multi-vibrators, timers, and other devices. In a specific embodiment these synchronizing impulses are employed to produce other pulses of highly precise constant width, adjustable as desired to an integer multiple of the synchronizing impulse period. These other pulses have the further feature of recurring at an easily adjusted sub-multiple frequency of the frequency of the synchronizing impulse recurrence, and have been shown to have utility in specific application to obstacle-detection apparatus.

Although the above specification has dealt with specific preferred embodiments of the invention in considerable detail, it is to be understood that these embodiments are purely illustrative and that many additions, adaptations, and omissions may be made fully within the scope of the invention.

What we claim is:

1. A device for generating periodically recurrent impulse energy characterized by impulses of

11

accurately defined duration comprising: means for generating a regular series of relatively short accurately timed synchronized pulses, a multivibrator having two discharge sections, each having an input circuit, means to apply said synchronized pulses to one of the input circuits, first, to render in response to a synchronized pulse one of the sections conductive and the other non-conductive, and second, to effect in response to a later synchronized pulse the reverse operation, means providing a time constant for the input circuit of said one section to terminate the conduction therein upon the occurrence of a synchronized pulse a predetermined interval after initiation of conduction thereby generating an impulse of given duration, means providing a time constant for the input circuit of said other section to terminate conduction therein upon the occurrence of a synchronized pulse a selected interval after initiation of conduction to determine the frequency of the generated impulses, means

12

to independently vary the value of said time constant means, and means to withdraw the resulting periodically recurrent accurately timed impulse energy from said multivibrator circuit.

2. An impulse generating device according to claim 1 in which said synchronized pulse generating means includes: a stabilized sine wave oscillator means, a full wave rectifier means coupled to said oscillator to produce a series of accurately and equally time spaced cusps, a first differentiator circuit coupled to the output of said full wave rectifier means, a second differentiator circuit coupled to said first differentiator circuit said differentiator circuits sharpening the cusps of the rectified sine wave, and clipping means coupled to the output of said second differentiator circuit for producing a unidirectional train of accurately and equally time spaced instantaneous pulses.

EMILE LABIN.
DONALD D. GRIEG.