March 16, 1965 A. E. BREWSTER ETAL 3,174,050

ELECTRIC PULSE DISTRIBUTORS

Filed Oct. 28, 1960 3 Sheets-Sheet 1

FIG.1.

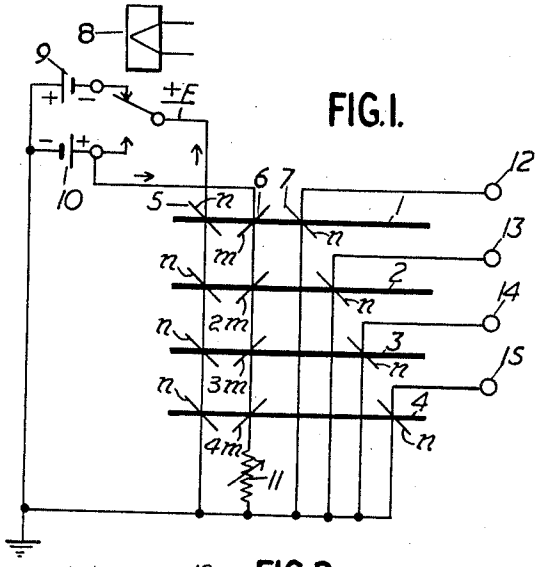


FIG.2.

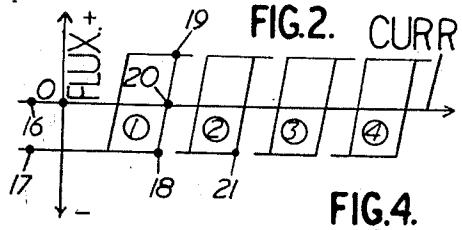


FIG.3.

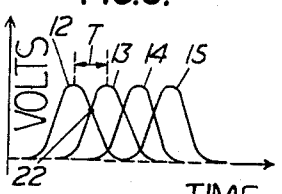
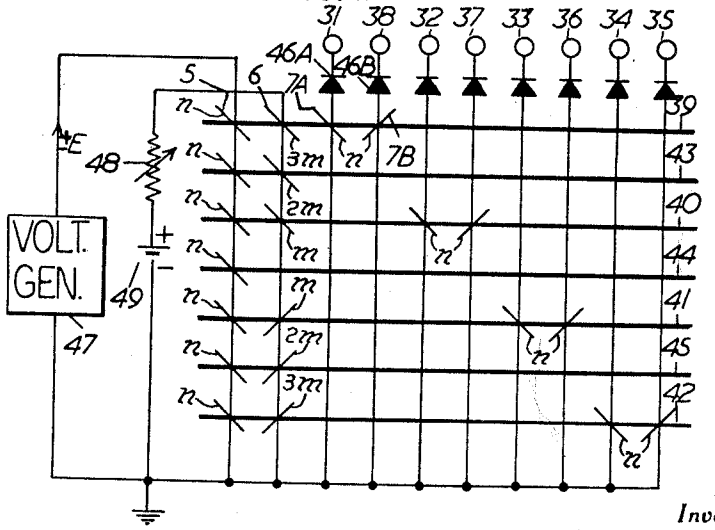


FIG.4.



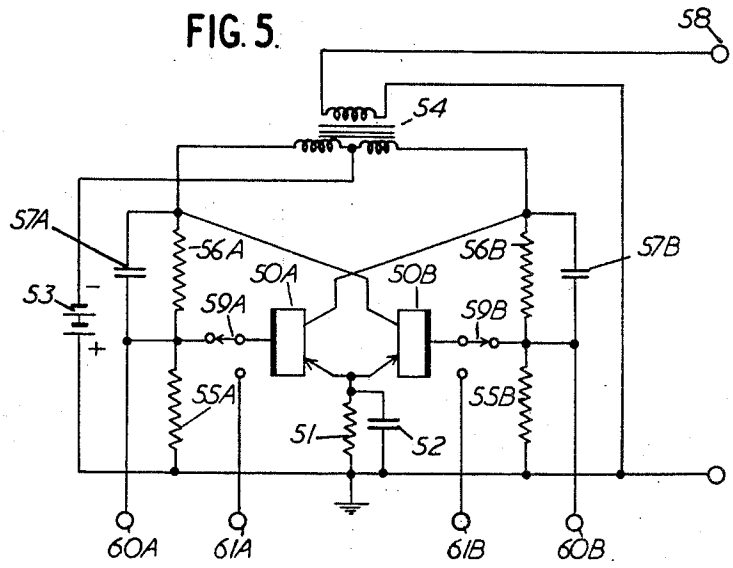
Inventors
ARTHUR E. BREWSTER
MICHAEL BEASLEY
By Philip M Bolton
Attorney

March 16, 1965 A. E. BREWSTER ETAL 3,174,050

ELECTRIC PULSE DISTRIBUTORS

Filed Oct. 28, 1960 3 Sheets-Sheet 2

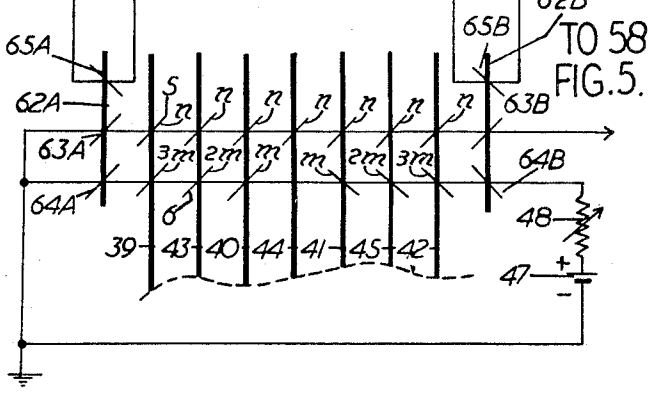
FIG. 5.



TO FIG. 5. 60A 61A

FIG. 6.

TO FIG. 5. 61B 60B



Inventors
ARTHUR E. BREWSTER
MICHAEL BEASLEY
By Philip M. Bolton
Attorney

March 16, 1965 A. E. BREWSTER ETAL 3,174,050

ELECTRIC PULSE DISTRIBUTORS

Filed Oct. 28, 1960 3 Sheets-Sheet 3

FIG.7.

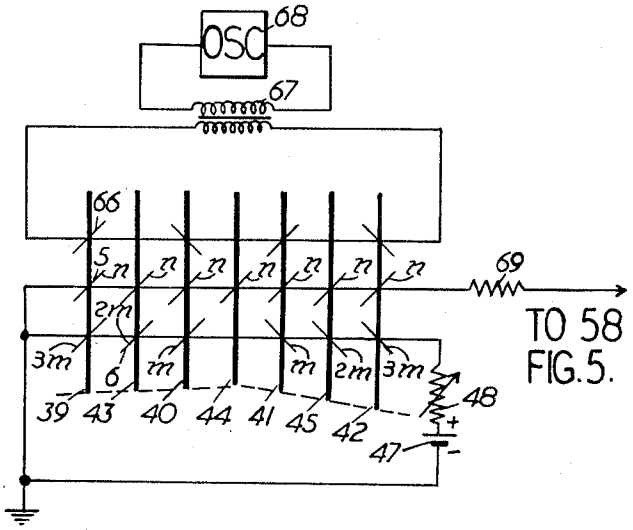
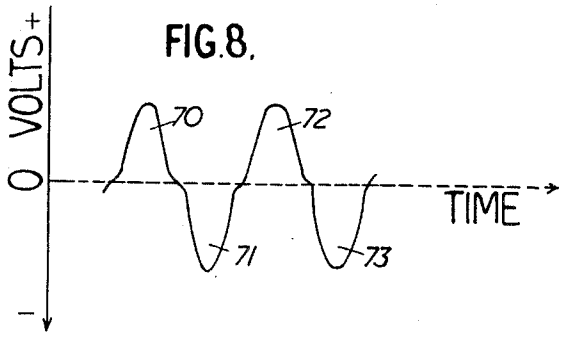


FIG.8.



Inventors
ARTHUR E. BREWSTER
MICHAEL BEASLEY
By Philip M. Botton
Attorney

United States Patent Office 3,174,050 Patented Mar. 16, 1965

3,174,050

ELECTRIC PULSE DISTRIBUTORS

Arthur Edward Brewster and Michael Beasley, London, England, assignors to International Standard Electric Corporation, New York, N.Y.

Filed Oct. 28, 1960, Ser. No. 65,708
Claims priority, application Great Britain, Nov. 9, 1959, 37,890/59
15 Claims. (Cl. 307—88)

The present invention relates to electric pulse distributors.

It has already been proposed to construct a pulse distributor from magnetic cores of ferrite or other suitable so-called "square loop" or saturable magnetic material. In this arrangement a number of similar cores are each provided with an input winding and a bias winding. The input windings all have the same number of turns and are connected in series to a source of a sawtooth or sinusoidal current wave. The bias windings all have different numbers of turns and are connected in series to a source of bias current, so that all the cores have different bias fields. Then, in response to each of the scanning strokes of the sawtooth or sinewave, the cores are triggered in turn, and corresponding output pulses can be obtained from output windings on the respective cores.

In this arrangement the accuracy of the timing of the output pulses depends on the straightness of the scanning stroke of the applied wave, and it may be difficult to obtain and maintain the necessary straightness.

The present invention proposes an alternative arrangement in which the timing of the output pulses is principally determined by the characteristics of the cores. Instead of supplying a current wave to the input windings of the cores, a fixed potential is applied, whose polarity is periodically reversedl; then in response to each cycle all the cores reverse in turn and produce output pulses whose spacing depends on the time taken for the flux of a core to be reversed.

This will be more fully explained with reference to the accompanying drawing, in which:

FIG. 1 shows a schematic circuit diagram of a theoretical form of a distributor according to the invention;

FIGS. 2 and 3 show diagrams used to explain the operation of FIG. 1;

FIG. 4 shows a schematic circuit diagram of a one practical embodiment of a distributor according to the invention;

FIG. 5 shows a schematic circuit diagram of a generator used in FIG. 4;

FIG. 6 shows a schematic circuit diagram of an arrangement for reversing the condition of the generator of FIG. 5;

FIG. 7 shows a modification of FIG. 4 to enable the distributor to be synchronised; and

FIG. 8 shows a diagram used to explain the operation of FIG. 7.

In the present specification, in order to simplify the circuits, a magnetic core will be shown diagrammatically as a thick horizontal line. A winding on a core will be shown as a short line inclined upwards to the left to indicate a winding wound "straight," and inclined upwards to the right to indicate one wound "reverse." A vertical line through the intersection of a winding line with the core line indicates a conductor with which the winding is in series. A current flowing downwards through a "straight" winding will be assumed to produce a flux from left to right in the core.

The circuit of FIG. 1 illustrates the principle of the invention. Four similar preferably toroidal cores 1, 2, 3, 4 of ferrite or other suitable saturable ferromagnetic material with a so-called "square" hysteresis loop are

provided. Each core is provided with an input or trigger winding 5 wound straight, a bias winding 6 wound reverse, and an output winding 7, wound straight. The trigger windings 5 all have the same number n of turns, and all the output windings 7 may also have the same number of turns. The bias windings 6, however, all have different numbers of turns. Thus for example, the windings 6 of cores 1 to 4 may have m, $2m$, $3m$ and $4m$ turns, respectively, in which m may be equal to 1.

A direct current source is provided, comprising a relay 8 and two batteries 9, 10 of opposite sign and constant potential E. The batteries are connected to ground, and to the change-over contacts of the relay 8 as shown. The movable spring of the contacts is connected to ground through all the trigger windings 5 of the cores 1 to 4 in series. The relay 8 is driven from some suitable alternating current source (not shown) in such manner that the potential E supplied to the trigger windings 5 is periodically reversed. Any other suitable arrangement may be used for providing the periodically reversed potential E.

The bias windings 6 are connected in series with an adjustable resistor 11 between the positive source 10 and ground. The output windings 7 are connected between ground and respective output terminals 12 to 15.

It will be seen that each of the cores has a bias magnetic field from right to left by virtue of the current in the bias winding. This field will be regarded as negative, and is of increasing magnitude for cores 1, 2, 3, 4. With the relay contact in the position shown, each core is also subjected to a negative field the same for all the cores, owing to the current in the trigger windings 5.

FIG. 2 shows the hysteresis curves of the four cores. The abscissae are the currents flowing in the winding 5 and the ordinates are the corresponding fluxes produced in the cores. The four hysteresis curves are numbered to correspond with the respective cores. They are spaced apart, as shown, because of the different bias fields applied by the bias windings. The spacing of the hysteresis curves can be changed by adjusting the resistor 11 (FIG. 1). With the contacts of relay 8 in the position shown, a negative current represented by the point 16 (FIG. 2) is applied to all the trigger windings, and the cores will all be negatively saturated and their condition will be represented by the point 17. Now suppose that the relay 8 changes over. The sign of E is changed from positive to negative, and a positive current is now supplied to the windings 5. Assuming that the windings have negligible resistance, then it is well known that the trigger windings 5 of the four cores must together produce a back E.M.F. equal to E, and that the current will adjust itself so that this condition is met. For any single core, the back E.M.F. is equal at any time to $n.df/dt$ where f is the flux, and t is time.

In FIG. 2 the hysteresis curves are shown in somewhat idealised form, the positive negative saturation being assumed to be absolutely complete, and no curvature at the corners of the loops. In this ideal case, immediately after the potential E has changed to the positive value, the current increases substantially instantaneously until the corner 18 of curve 1 is reached, and then core 1 supplies the whole of the back E.M.F. $e=n.df/dt$ while its saturation is reversed from negative at the point 18 to positive at the point 19, and the time T taken for this reversal to take place depends on the total flux change 2F. Thus in the ideal case shown in which df/dt is constant it follows that the time $T=2nF/E$. As soon as the flux reversal has taken place, core 1 can no longer supply the back E.M.F., and so the current increases practically instantaneously until core 2 is switched in like manner, and so on. Thus output pulses of duration T spaced by intervals also equal to T will be obtained from terminals 12 to 15 in turn.

In practice, of course, the ideal performance just described does not occur. Actually, since the upper and lower portions of the hysteresis curves are not horizontal as shown, all of the cores besides that which is switched will contribute small portions to the back E.M.F. However, a larger effect is produced by the curves at the corners of the hysteresis loops. The pulses delivered to terminals 12 to 16 by the cores, instead of being substantially rectangular, are shaped somewhat in the manner shown in FIG. 3 which shows the pulse amplitudes in volts in relation to time. The pulse 12 produced by core 1 has its maximum amplitude corresponding to the maximum value of df/dt at point 20 of the hysteresis loop 1, of FIG. 2, and the major part of the back E.M.F. E is then produced by the core 1. However, above the point 20, df/dt progressively becomes less, so that an increasing proportion of the back E.M.F. E is produced by core 2, in the neighborhood of the point 21 of the hysteresis loop 2, FIG. 2. It is clear, therefore, that as the amplitude of the pulse 12 declines, following the trailing edge, the amplitude of the pulse 13 produced by core 2 is beginning to grow at the leading edge. At the time corresponding to the point 22 where the pulses 12 and 13 intersect, cores 1 and 2 will each be providing about half of the back E.M.F. Thus it will be evident that the four pulses 12 to 15 overlap in the manner indicated.

It will be noted that the time spacing T of the crests of adjacent pulses is determined by E and n, and by the hysteresis curve of the magnetic material of which the cores are made, and if all the cores are alike in material and dimensions, then T will be the same for each core. Approximately $T=2nF/E$ where 2F is the total change in flux due to a reversal of the condition of the core.

When the relay 8 (FIG. 1) changes back to the position shown, it will be clear that a group of four negative pulses similar to those shown in FIG. 3 will be produced, but in this case the first pulse is produced by core 4 and the last by core 1.

It should be pointed out that after all the four cores have been switched, the current supplied by the source 10 will tend to increase to a very large value because none of the cores can now produce any appreciable flux change. The current will in practice be limited by the resistance of the windings 5. As will be explained below, this increase in current may be employed automatically to reverse the potential E when all the cores have been switched.

While the hysteresis curves are shown well separated in FIG. 2 for clearness, in practice they could be much closer so that they overlap, but the current corresponding to the point 21 should preferably be higher than that corresponding to the point 19 in each case. The curves can be brought closer together, for example, by increasing the resistor 11 in FIG. 1.

It will be evident that although only four cores are shown in FIG. 1, the circuit may be extended to include any number of such cores provided only that they are all differently biased.

It may be mentioned that if the rather close overlapping of the pulses indicated in FIG. 3 is inconvenient, the number of cores may be increased, and the output winding 7 may be omitted from alternate cores. This will have the effect of eliminating alternate pulses in FIG. 3 so that the overlapping of adjacent pulses is now much less significant.

A practical example of a pulse distributor operating according to the principles explained with reference to FIGS. 1 to 3 is shown in FIG. 4. It provides cycles of eight distributor pulses which appear at eight corresponding output terminals 31 to 38, which are numbered in the order in which the output pulses appear. Four output magnetic cores 39 to 42 are arranged alternately with three spacer cores 43 to 45. Each of the cores has a trigger winding 5 wound straight with n turns. Each of the cores except 44 has a bias winding 6 wound straight on cores 39, 43 and 40 and reverse on cores 41, 45 and 42. The bias windings on cores 40 and 41 have m turns, those on cores 43 and 45 have $2m$ turns, and those on cores 39 and 42 have $3m$ turns.

Core 39 has two output windings 7A and 7B wound straight and reverse, respectively, and connected to terminals 31 and 38 through respective rectifiers 46A and 46B both of which are directed to pass positive pulses to the corresponding terminals. Cores 40, 41 and 42 have similar pairs of output windings connected to corresponding output terminals through rectifiers in like manner. No output windings are provided for the spacer cores 43, 44 and 45.

The trigger windings 5 of the seven cores are connected in series to a voltage generator 47 which generates a constant voltage E which is periodically reversed. A suitable generator is shown in FIG. 5. The six bias windings 6 are connected in series with an adjustable resistor 48 to a direct current bias source 49.

The arrangement is similar to FIG. 1 with three extra spacer cores arranged alternately with the four output cores, but instead of biasing all the cores in the same direction by different amounts one of the cores (44) has no bias while the bias of cores 40, 43 and 39 is opposite to that of cores 41, 45 and 42.

When the voltage applied by the source 47 changes to +E, the seven cores will be switched in turn downwards from 39 to 42. In the case of core 39, the positive pulse generated by the winding 7A passes through the rectifier 46A and is delivered to terminal 31, while the negative pulse generated by the winding 7B is stopped by the rectifier 46B. The cores 40, 41 and 42 behave similarly, so that positive pulses are delivered in turn to terminals 31, 32, 33 and 34. When core 42 has been switched, the current supplied by the generator 47 to the windings 5 increases to a large value and causes the generator 47 to supply a voltage of −E instead of +E. The seven cores now switch back again, upwards from core 42 to core 39, and it will be clear that now positive output pulses are delivered in turn to terminals 35, 36, 37 and 38.

It should be noted that when the applied voltage E is reversed after the core 42 has been switched, so that, as explained, core 42 is switched back again, the two successive pulses generated by the core 42 will substantially not overlap because the back E.M.F. generated must pass through zero before reversing. These two pulses can be spaced substantially by the time 2T so that spacing core is not needed. Similar considerations apply when the voltage E is reversed after core 39 has been switched. Thus it will be seen that in the general case the number of spacer cores required is one less than the number of output cores.

FIG. 5 shows the circuit of one possible form of the voltage generator 47 of FIG. 4. It is a known type of two-condition bistable device comprising two similar transistors 50A, 50B, assumed to be of the usual P-N-P type, the emitter electrodes of which are connected to ground through a common resistor 51 shunted by a capacitor 52. A direct current operating source 53 has its positive terminal connected to ground, and its negative terminal connected to the centre tap of the primary winding of an output transformer 54, which should be designed so that it does not exhibit any saturation effects. The base electrode of transistor 50A is connected to ground through a switch 59A, when in the position shown, and resistor 55A, and to the source 53 through the switch and a resistor 56A and half the primary winding of the transformer 54. The resistor 56A is shunted by a capacitor 57A. Terminals 60A and 61A are connected respectively to the capacitor 57A and to the disconnected contact of the switch 59A. Similar elements are associated with transistor 50B and are given the same designation numbers with the letter B instead of the letter A, the circuit being symmetrical. The collector electrode of the transistor 50A is connected to the upper end of resistor 56B

and that of transistor 50B to the upper end of resistor 56A, as shown. The secondary winding of the transformer 54 is connected between ground and an output terminal 58.

The terminals 60A, 61A and 60B, 61B are used in connection with a modified arrangement to be described with reference to FIG. 6, and for the present they will be disregarded, and it will be assumed that the switches 59A and 59B are in the positions shown.

The circuit has two stable states, in one of which the transistor 50A is cut off, and in the other, the transistor 50B is cut off, the other transistor being conducting in each case. Let it be assumed that the circuit has just changed over so that transistor 50A is cut off, and that the cores shown in FIG. 4 are being switched in order downwards (which will be called the forward direction). Then since transistor 50B is conducting, substantially all of the current from the source 53 flows through the left-hand half of the primary winding of the transformer 54. The value of this current is automatically adjusted so that the switching of the cores is maintained. Since transistor 50B is conducting, its collector potential V1 will be practically equal to its emitter potential and not far from ground potential, so that the voltage across the left-hand half of the primary winding of the transformer 54 will be constant and a little less than the voltage of the source 53, and in opposition thereto. An equal voltage will appear across the right-hand half of the primary winding, but aiding the voltage of the source 53. The potential V2 applied to the upper terminal of resistor 56B is thus nearly double the potential of the source 53.

The maximum current which the transistor 50B is capable of providing depends on the base current and on the current gain of the transistor. The base current flows through the resistor 56B and depends on the larger voltage V2.

The time constant of the resistors 56 and capacitors 57 is chosen to be small compared with a half-period of the multivibrator, so that towards the end of the switching cycle the capacitors 57A and 57B will be charged respectively to potentials V1 and V2. By a suitable choice of values of resistors 55 and 56 the base electrode of the transistor 50A is arranged to be slightly positive to the emitter electrode in this condition so that this transistor is cut off.

At the end of the switching cycle, when all the cores have been switched, a large value of current will be demanded from the transistor 50B to maintain the back E.M.F. across the halves of the primary winding of the transformer 54, and as this current is not forthcoming, the back E.M.F. collapses so that the potential of the upper terminal of resistor 56B suddenly rises (becomes less negative) and that of the upper terminal of resistor 56A falls (becomes more negative). The result is that the base potential of the transistor 50B is driven positively until the transistor is cut off, and the base potential of transistor 50A is driven negatively until the transistor is rendered conducting, and the condition of the multivibrator sharply reverses. The back E.M.F. is again established in the reverse direction and the cores then begin to switch in the reverse direction.

The instant of reversal depends on the peak current which can be drawn from the transistor, and this can be adjusted by suitable choice of the value of resistors 56A and 56B which determine the base current when the transistor is conducting. If this peak current is permitted to be too large, there will be too great a separation of the last pulse of the forward cycle and the first pulse of the reverse cycle, and appreciable "sneak" pulses may appear from all cores simultaneously.

In the case of the circuit of FIG. 5 the reversal of the multivibrator depends on what amounts to a momentary overload of one of the transistors.

This can be avoided by the arrangement illustrated in FIG. 6, which shows part of the cores 39 to 44 of FIG. 4 with only the trigger and bias windings 5 and 6 shown. It will be understood that the output windings 7A and 7B and the rectifiers 46A and 46B which are not shown in FIG. 6 will be provided in the manner indicated in FIG. 4. The bias source 47 and the variable resistor 48 of FIG. 4 are shown in FIG. 6 connected to the bias windings.

The trigger windings are connected to terminal 58 of FIG. 5 as indicated.

In FIG. 6 there are shown two additional reversing cores 62A and 62B having respective trigger windings 63A and 63B, wound straight, and connected in series with the other trigger windings 5, and bias windings 64A and 64B wound straight and reverse, respectively, and connected in series with the other bias windings 6. The cores 62A and 62B are further provided with output windings 65A and 65B respectively, both wound reverse. Winding 65A is connected to terminals 60A and 61A of FIG. 5, and winding 65B to terminals 60B and 61B as indicated. In FIG. 5, each of the switches 59A and 59B should be operated to the position opposite to that shown, so that the effect will be to insert the windings 65A and 65B of FIG. 6 in series with the base electrodes of transistors 50A and 50B, respectively, of FIG. 5.

The number of turns of the bias windings 64A and 64B should be chosen so that the cores 62A and 62B have a slightly greater bias than cores 39 and 42 respectively. If it be assumed that transistor 50B (FIG. 5) is conducting so that the cores are being switched in the forward direction (that is from core 39 to core 42), it will be seen that the reversing core 62B will be switched slightly later than the last of the output cores 42. When core 62B is switched, a reversing pulse is generated by the winding 65B in such a direction that the base electrode of the transistor 50B is driven positively, thus cutting off the transistor and causing the multivibrator to change over, so that switching of the output cores now begins in the reverse direction. A reversing pulse of opposite polarity will be generated by the winding 65B on the reversing core 62B which would tend to switch the multivibrator immediately back again, but this does not occur because at the moment of reversal of the multivibrator the charge in the capacitor 57B drives the base electrode so far in the positive direction that the reversing pulse from the winding 65B has no effect.

It will be seen that when the reverse switching cycle of the output cores is completed, the reversing core 62A will be switched slightly after the core 39 and the pulse generated by the winding 65A will switch the multivibrator back again, and so on.

It will be seen that by this arrangement the reversal of the multivibrator does not now depend on either transistor being driven to overload.

The bias of the switching cores 62A and 62B should be adjusted so that the time interval between the last pulse of one switching cycle and the first pulse of the next is substantially equal to 2T. If necessary, the bias windings 64A and 64B may be connected to the bias source 47 in an independent circuit with a separate resistor (not shown) corresponding to 48 to enable the proper bias to be obtained.

It should be pointed out that to minimise the effect of the reversing cores 62A and 62B on the pulses from the output cores, the reversing cores should preferably be designed so that the total flux change 2F produced by the switching of the core is a fraction of the corresponding flux change in an output core, for example, 10%.

It may also be mentioned that in some cases it may be possible to omit the extra reversing cores 62A and 62B and to put the reversing windings 65A and 65B on the output cores 39 and 42 respectively, so that each of these cores would then have two output windings. There may be a tendency with this arrangement for the multivibrator to be reversed too quickly after each switching cycle, and this could be overcome by introducing an appropriate

small delay between the windings 65A and 65B and the base electrodes of the transistors 50A and 50B.

It has already been explained that the time spacing T of the pulses shown in FIG. 3 depends on the value of E, on the number of turns n of the trigger windings 5, and on the magnetic characteristics of the cores. The latter depend on the material and dimensions of the cores, and in practice can only be approximately predicted. Thus, in order to be able to obtain accurately a desired value of T, some means of conveniently adjusting the value of E should be available, for example, by connecting the centre point of the primary winding of the transformer 54 to the moveable contact of an adjustable potentiometer (not shown), shunting the source 53. Any other convenient means for effectively adjusting the potential of the source could be used. Alternatively an equivalent result would be obtained by making the resistor 51 adjustable.

It is also necessary to relate the period of reversal of the two-condition device to the value of T. If, for example, the arrangement of FIG. 4 is to provide distribution pulses for $2r$ channels, for example, then the period between successive reversals should be adjusted to $2Tr$.

It may be pointed out that the timing of the output pulses does not depend on the accuracy of reproduction of any waveform, but only on the constancy of the potential E which is not difficult to maintain. It will be noted that since the transistors 50A and 50B in FIG. 5 are used only as switches, the curvature of their characteristics has negligible effect on the performance of the device.

It should be mentioned that N-P-N type transistors could be used in FIG. 5, in which case the polarity of the source 53 should be reversed. No alteration in FIG. 6 would be necessary.

The distributor shown in FIG. 4 may be synchronized by a stable oscillator by the arrangement shown in FIG. 7, which shows part of the cores 39 and 44 including the trigger windings 5 and the bias windings 6. The output windings 7 and rectifiers 46 are not shown but will be provided as indicated in FIG. 4. Elements 47 and 48 of FIG. 4 are also shown in FIG. 7. Each of the output cores 39, 40, 41 and 42 is provided with a synchronizing winding 66 wound straight on cores 39 and 41 and reverse on cores 40 and 42 as shown. All the synchronizing windings have the same number of turns. These synchronizing windings are connected in series through a suitable transformer 67 to a stable synchronizing oscillator 68 which is preferably crystal-controlled. The frequency of the oscillator 68 should be ¼T. The trigger windings 5 are connected in series to terminal 58 of the generator 47 shown in FIG. 5 through a resistor 69. The resistance of the synchronizing windings 66 should be as low as possible so that the coupling between the oscillator 68 and the cores is tight. The resistor 69 is introduced to reduce the coupling between the generator 47 and the trigger windings 5, and could be omitted if the resistance of the windings 5 is suitably increased.

The oscillator 68 then substantially determines the times at which the output cores are switched. This will be understood from FIG. 8. Let it first be supposed that the oscillator 68 (FIG. 7) is disconnected from the transformer 67. Then it will be seen that since the synchronizing windings 66 on the cores 40 and 42 are wound reverse, the pulses 70 to 73 shown in FIG. 8 will be delivered to the transformer 67 when the cores are switched in the forward direction. Pulses 70 and 72 are positive and 71 and 73 are negative. It will be seen that pulses 70 and 71 correspond to the pulses 12 and 14 of FIG. 3, the pulse 71 having been inverted because the corresponding synchronizing winding is wound reverse. It will be seen that the pulses 70 to 73 form a wave which is not very different from a sinewave.

When the oscillator 68 is connected to the transformer 67, it supplies to the synchronizing windings 66 a sinewave of the same period as the wave constituted by the pulses 70 to 73, namely 4T, and since it is tightly coupled to the cores, while the generator 47 is loosely coupled, the oscillator determines the switching times of the cores. If at any instant the voltage applied to the transformer 67 by the cores tends to be less than that of the controlling sinewave, current will flow from the oscillator 68 to increase the rate of switching, while in the opposite case current flows from the synchronizing windings 66 to the oscillator 68 which then acts as an additional load which reduces the switching rate. Thus the time spacing 2T (FIG. 3) of the output pulses from the cores is substantially determined by the oscillator 68.

The voltage supplied by the generator 47 (FIG. 4) should be about 10% higher than the value E necessary to produce the spacing 2T when unsynchronized, and the resistor 69 (FIG. 7) should be so chosen that the voltage applied to the trigger windings is about 10% below E when maximum current is drawn from the generator 47. The current increment required to switch a core is then obtained from the oscillator 68, while the balance of current necessary to maintain the progressive switching of the cores is obtained from the generator 47.

It will be understood that the extra cores 62A and 62B shown in FIG. 6 for reversing the multivibrator may be added to FIG. 7 if desired.

While the principles of the invention have been described above in connection with specific embodiments, and particular modifications thereof, it is to be clearly understood that this description is made only by way of example and not as a limitation on the scope of the invention.

What we claim is:

1. An electric pulse distributor comprising:
- a first odd numbered plurality of similar cores of saturable ferromagnetic material;
- a second odd numbered plurality of similar cores of saturable ferromagnetic material;
- an additional core of saturable ferromagnetic material disposed between said first and second plurality of cores;
- an input winding wound in a given direction on each of said cores of said first and second plurality of cores and said additional core;
- a first circuit connecting all of said input windings in series;
- a bias winding wound in said given direction on each of said first plurality of cores, each of said bias windings having a different number of turns;
- a bias winding wound in a direction opposite to said given direction on each core of said second plurality of cores, each of said bias windings having a different number of turns;
- a second circuit connecting all said bias windings in series;
- a first generator coupled to said first circuit to apply thereto a first direct current potential having a constant magnitude, said first generator comprising:
  - a bistable device to generate a first potential of given magnitude and given polarity in one condition and a second potential of said given magnitude and a polarity opposite to said given polarity in its other condition;
  - means responsive to the disappearance of the back electromotive force from said input windings when the condition of saturation of all the magnetic cores have been reversed for periodically reversing the condition of said device;
- a second generator coupled to said second circuit to apply a second direct current potential thereto and a different bias magnetic field to each of said cores of said first and second plurality of cores; and
- output means coupled to alternate cores of said

first and second plurality of cores for deriving accurately timed output pulses from associated ones of said alternate cores in response to the reversal of the condition of saturation of said alternate cores.

2. A distributor according to claim 1 further comprising: a stable synchronizing source, and synchronizing windings connected in series with said stable source and wound about selected one of said first and second plurality of cores to couple the output of said stable source to said first and second plurality of cores to determine the time interval between said output pulses.

3. A distributor according to claim 2, wherein said output means includes: a pair of output windings oppositely wound on alternate cores of said first and second plurality of cores; and an output arrangement coupled to each of said output windings.

4. A distributor according to claim 3, wherein each of said output arrangements include: an output terminal; and means coupled between its associated one of said output terminals and its associated one of said output windings to suppress pulses of a given polarity.

5. A distributor according to claim 2, wherein said selected cores include said alternate cores of said first and second plurality of cores; and said synchronizing windings coupled to said alternate cores of each of said plurality of cores are oppositely wound.

6. A distributor according to claim 2, wherein said stable source includes means to generate periodic waves having a period equal to twice said time interval.

7. A distributor according to claim 5, wherein said stable source includes means to generate periodic waves having a period equal to twice said time interval.

8. A distributor according to claim 1, wherein said means for periodically reversing the condition of said device comprise:

a second additional core having a first additional input winding connected in series with the others of said input windings,

a first additional bias winding connected in series with the others of said bias windings,

said first additional input winding and said first additional bias winding cooperating to reverse the condition of saturation of said second additional core prior to the reversal of the condition of saturation of any of the others of said cores, and

a first additional output winding connected to said device to reverse the condition thereof when the saturation condition of said second additional core is reversed; and

a third additional core having a second additional input winding connected in series with the others of said input windings,

a second additional bias winding connected in series with the others of said bias windings,

said second additional input winding and said second additional bias winding cooperating to reverse the condition of saturation of said third additional core after the reversal of the condition of saturation of all the others of said cores, and

a second additional output winding connected to said device to reverse the condition thereof when the saturation condition of said third additional core is reversed.

9. A distributor according to claim 2, wherein said means for periodically reversing the condition of said device comprise:

a second additional core having a first additional input winding connected in series with the others of said input windings,

a first additional bias winding connected in series with the others of said bias windings,

said first additional input winding and said first additional bias winding cooperating to reverse the condition of saturation of said second additional core prior to the reversal of the condition of saturation of any of the others of said cores, and

a first additional output winding connected to said device to reverse the condition thereof when the saturation condition of said second additional core is reversed; and

a third additional core having a second additional input winding connected in series with the others of said input windings,

a second additional bias winding connected in series with the others of said bias windings,

said second additional input winding and said second additional bias winding cooperating to reverse the condition of saturation of said third additional core after the reversal of the condition of saturation of all the others of said cores, and

a second additional output winding connected to said device to reverse the condition thereof when the saturation condition of said third additional core is reversed.

10. A distributor according to claim 1, wherein said output means includes:

a pair of output windings oppositely wound on alternate cores of said first and second plurality of cores; and

an output arrangement coupled to each of said output windings.

11. A distributor according to claim 10, wherein each of said output arrangements include:

an output terminal; and

means coupled between its associated one of said output terminals and its associated one of said output windings to suppress pules of a given polarity.

12. A distributor according to claim 11, further comprising:

a stable synchronizing source; and

synchronizing windings connected in series with said stable source and wound about selected ones of said first and second plurality of cores to couple the output of said stable source to said first and second plurality of cores to determine the time interval between said output pulses.

13. A distributor according to claim 12, wherein

said selected cores include said alternate cores of said first and second plurality of cores; and

said synchronizing windings coupled to said alternate cores of each of said plurality of cores are oppositely wound.

14. A distributor according to claim 12, wherein said stable source generates periodic waves having a period equal to twice said time interval.

15. A distributor according to claim 13, wherein said stable source generates periodic waves having a period equal to twice said time interval.

References Cited in the file of this patent

UNITED STATES PATENTS

2,691,153	Rajchman et al.	Oct. 5, 1954
2,722,565	Ridler et al.	Nov. 1, 1955
2,733,860	Rajchman	Feb. 7, 1956
2,734,185	Warren	Feb. 7, 1956
2,937,285	Olsen	May 17, 1960
2,962,704	Buser	Nov. 24, 1960
3,085,161	Guanella	Apr. 9, 1963
3,103,593	Woodland	Sept. 10, 1963