Nov. 1, 1949. L. A. MEACHAM 2,486,491

GATE DISTRIBUTOR CIRCUITS

Filed Feb. 8, 1946 2 Sheets-Sheet 1

FIG. 1

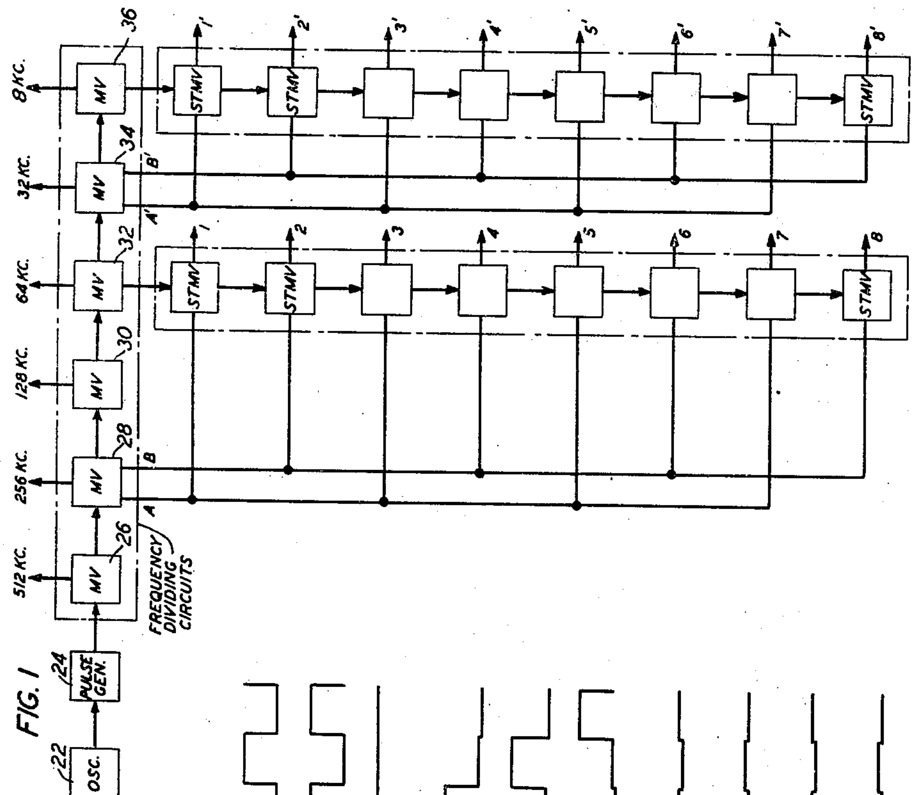
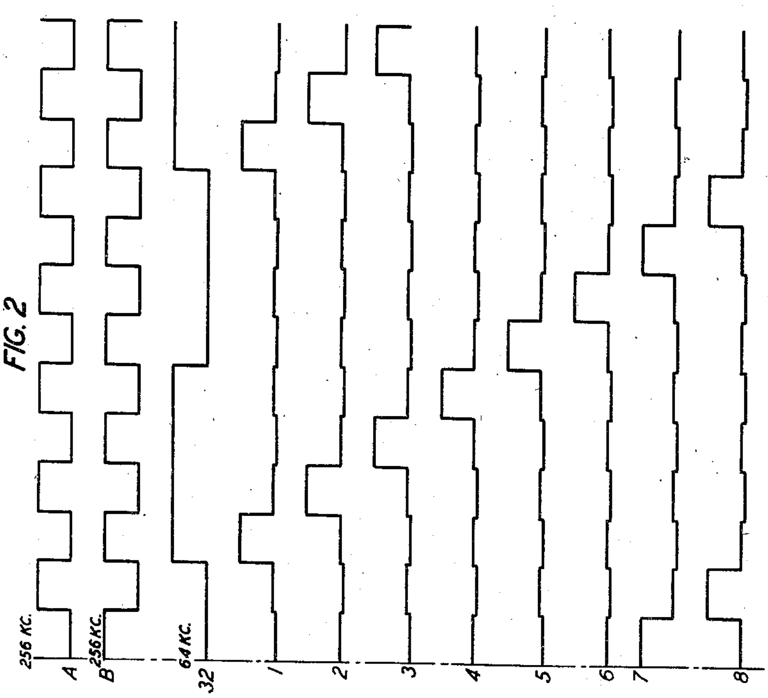


FIG. 2



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2 Sheets-Sheet 2

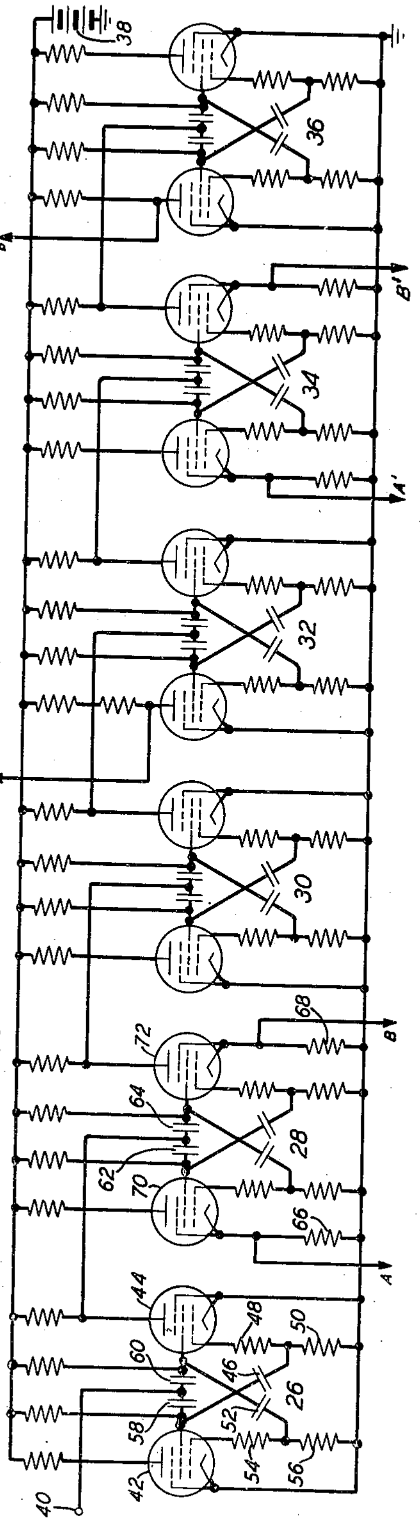

FIG. 3

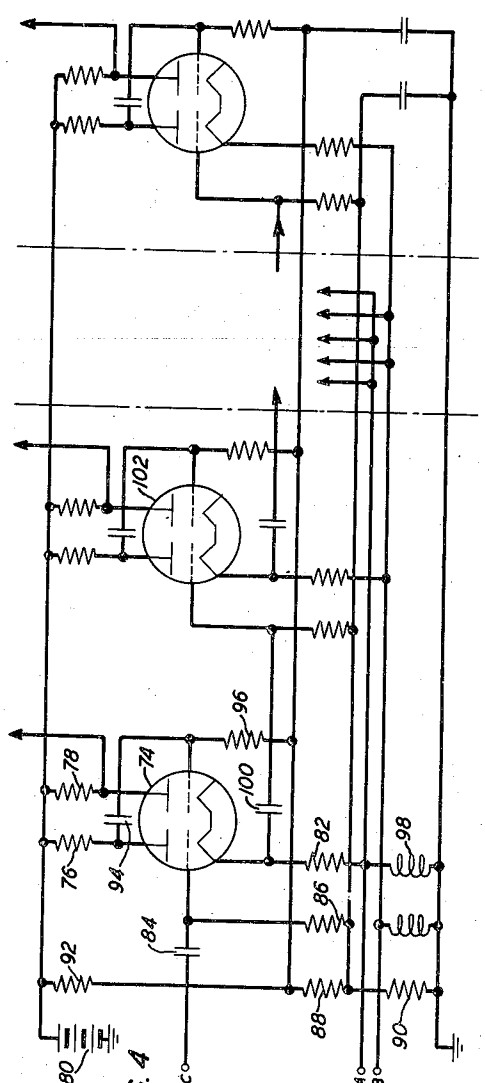

FIG. 4

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GATE DISTRIBUTOR CIRCUITS

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Application February 8, 1946, Serial No. 646,455

2 Claims. (Cl. 250—27)

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This invention relates to electronic switching or "gating" circuits. The invention particularly contemplates an electronic switching circuit of the so-called "chain" type.

A fundamental process appearing frequently in electric circuits and devices is that in which the members of a group of similar circuits are operated in sequence at accurately prescribed times. Such instances arise, for example, in connection with timing and coordinating the operations of various portions of radar equipment; in the connection of a number of audio channels to transmission equipment used in common on a time-division basis; in the cyclic recognition of the presence or absence of charges upon storage condensers in certain forms of pulse signaling; in the sorting of received pulse signals into separate circuits; and in other timing, coordinating, and synchronizing circuits and systems.

Control of such sequential operation may be accomplished by means of timed pulses or "gates" generated or distributed in commutator fashion to a desired number of separate paths. The sequence of gates appearing in any one of these paths controls the operation of apparatus associated with the particular path. The gate distributor has the nature of common synchronizing equipment, and it can supply any number of groups of circuits requiring sequential control.

Conveniently, each of the gates required for the sequential operation of a desired number of circuits or devices may comprise a change, at the proper time, of the polarity or magnitude or both of a voltage or current applied to each circuit or device. The gate distributor may, therefore, comprise electronic switching means capable of effecting the required number of voltage or current changes in the proper timed relationship. There have heretofore been proposed a number of sequential electronic switching circuits of the co-called "chain" type which are in general capable of fulfilling these requirements. In such switching circuits, a control pulse initiates the operation by "firing" or triggering the first switching stage (a vacuum tube or combination of vacuum tubes). Thereafter, the remaining stages are fired successively along the chain, each by the action of the preceding stage. Such circuits, while possessing sufficient precision of timing for many purposes, may not be sufficiently precise for high speed switching in cases where each of the control circuits or devices is to be rendered operative for times of the order of microseconds.

Objects of this invention are to provide a gate

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distributor or electronic switch which will deliver accurately timed rectangular pulses in sequence to a number of separate outputs and to increase the precision of timing over that normally attainable through the use of chain type switching circuits of the type referred to above.

In view of the above objects and in accordance with the invention, a pulse distributor is provided which comprises means for precisely timing the operation of a chain-type electronic switching circuit. In general, such means include, in addition to one or more chains or trains of a single pulse generators, means for generating two or more control currents of substantially constant, harmonically related frequencies. One of these control currents is employed to initiate successive cycles of operation of the chain, while another, of higher frequency, is utilized precisely to time in turn the operation of each of the individual single pulse generators in the chain.

In an exemplary embodiment of the invention, the required single square pulses or gates are generated and distributed to a plurality of outputs in precisely timed relation by a system in which the output of a sine-wave oscillator having high frequency stability is applied to a square wave generator to obtain a square wave output of the same fundamental frequency as that of the oscillator. This square wave signal controls the operation of a series of multivibrators arranged in a frequency dividing network to obtain square wave outputs having fundamental frequencies which are submultiples of that of the sine wave oscillator. The square wave outputs from the frequency dividing network are used to control the operation of one or more pulse distributor chains each comprising a number of single square pulse generators of the type sometimes known as single trip multivibrators. It will be understood that the exact number of such single square pulse generators used in each pulse distributor chain depends upon the desired number of gates desired to be obtained.

Each of the single square pulse generators or single trip multivibrators comprises a vacuum tube switching circuit which may be triggered from a rest or normal condition to an actuated condition from which it automatically returns after an interval determined by the parameters of the circuit. The single square pulse generators forming a pulse distributor chain are so interconnected that the first generator of the chain may be triggered by an external signal to produce a single square pulse. The termination of this square pulse is then effective to trigger the next generator of the chain and this process is repeated to the end of the chain, each generator except the first being triggered by the preceding generator of the chain. The circuit constants of the single pulse generators are adjusted to obtain square pulses of equal periods but in accordance with the invention more precise timing both as to duration and time of occurrence of the pulses is obtained by introducing into each of the pulse generator circuits of the chain a square wave synchronizing signal derived from the frequency dividing network and having a higher frequency than that of the signal used to initiate the operation of the chain. More specifically, the synchronizing signal in the exemplary arrangement described in detail herein is chosen as a harmonic of the initiating signal and its period is made twice the desired pulse duration.

The above and other features of the invention will be better understood from the following detailed specification taken in connection with the drawings in which:

Fig. 1 is a block diagram of a pulse or gate distributing system in accordance with the invention;

Fig. 2 shows typical wave forms of the voltages and currents occurring at various points in the system of Fig. 1;

Fig. 3 is a circuit diagram of a frequency dividing network suitable for use in the system of Fig. 1; and

Fig. 4 is a circuit diagram of a chain of single trip multivibrators suitable for use as the pulse distributor of the system of Fig. 1.

In the block diagram of Fig. 1, there is shown a gate distributor arranged for purposes of illustration and in accordance with the invention to provide two sets of gates, each set being capable of controlling the operation of or supplying pulses to eight channels or paths. For this example it has been assumed that the gate frequency is to be 64 kilocycles per second for the eight channels of one set and 8 kilocycles per second for the eight channels of the other set.

Accordingly, two gate distributor chains are provided, that for operation at 64 kilocycles comprising single trip multivibrators **1** through **8** and that for operation at 8 kilocycles comprising single trip multivibrators **1'** through **8'**. The required 8- and 64-kilocycle square wave control signals and the synchronizing signals are provided by a frequency dividing network comprising six multivibrators **26** through **36** controlled in tandem by a sine-wave master oscillator **22** operating at 1,024 kilocycles and driving a square wave generator **24** arranged to produce a square wave output of the same fundamental frequency. Multivibrators **26**, **28**, **30**, **32** and **34** are arranged in a well-known manner as frequency dividers to obtain submultiple frequencies at a 2:1 ratio while the final multivibrator **36** is arranged to obtain a submultiple output at a 4:1 frequency ratio. Thus, there are provided square wave outputs of 512, 256, 128, 64, 32 and 8 kilocycles, respectively. It will be understood that the sine wave oscillator, the pulse generator, and the frequency dividing circuit may each be of any well-known type. For example, United States Patent 2,022,969, Meacham, December 3, 1935, shows a suitable type of frequency changing circuit. The disclosure of this Meacham patent is hereby made a part of this application as if fully included herein. The sine wave oscillator may, for example, comprise a crystal-controlled vacuum tube oscillator delivering a substantially pure sine wave output of high frequency stability. Suitable types of oscillators are disclosed in United States Patents 1,788,533, Marrison, January 13, 1931; 1,931,873, Marrison, October 24, 1933; 2,087,326, Marrison, July 20, 1937; 2,163,403, Meacham, June 20, 1939; and 2,275,452, Meacham, March 10, 1942. The square wave generator may conveniently comprise one or more vacuum tubes operated as overloaded amplifiers which are driven alternately into saturation and beyond cutoff by the sine wave output of the master oscillator to obtain an output of fundamental frequency, having a substantially square wave form. In the system of Fig. 1 all of the single trip multivibrators comprising each of the chains are arranged to produce single square pulses or gates of equal duration and circuit constants are so chosen that the distributor chains are not triggered for a second cycle of operation until the last gate of the preceding cycle has been completed. Under these conditions in the exemplary system described herein, the pulse duration in the chain controlled by the 64-kilocycle multivibrator is approximately 2 microseconds while that for the chain controlled by the 8-kilocycle multivibrator is approximately 16 microseconds.

Inasmuch as the two pulse distributing chains of the exemplary system operate in substantially identical fashion but at different frequencies, only the distributor controlled by 64-kilocycle multivibrator **32** and comprising single trip multivibrators **1** through **8** will be described in detail. As pointed out above, the first single pulse generator of the distributor chain is triggered by the 64-kilocycle square wave output from multivibrator **32** and the circuit parameters of the pulse generator are so chosen that a single square top pulse is generated having a period equal to approximately one-eighth the period of the 64-kilocycle control signal or approximately 2 microseconds. The termination of this square top pulse is used to trigger the next generator **2** of the chain and this process is repeated until the eighth generator has been operated.

In the operation of the circuit thus far described, the duration of each of the single square pulses or gates is controlled approximately by adjustment of the RC elements determining the time constant of the single trip multivibrators. For high speed switching, however, greater precision of timing than that so obtained is often necessary. For this purpose and in accordance with the invention, the output of that multivibrator of the frequency dividing network which has a fundamental frequency of 256-kilocycles is utilized to control precisely the ending of each of the gate pulses and the initiation of the succeeding gate pulse of the chain. Recalling that the gates are to be generated in each path or channel at a gate frequency of 64-kilocycles, it will be recognized that the half period of this 256-kilocycle synchronizing signal is precisely the desired gate length. It should be understood that a 512-kilocycle synchronizing signal could be used, the whole period of this signal being equal to the desired pulse length, and that other synchronizing frequencies might also be used.

It will be noted in Fig. 1 that multivibrators **28** and **34** utilized to provide the synchronizing signals for the two pulse distributor chains are each provided with two output terminals labeled A and B, and A' and B', respectively. Conveniently each of these multivibrators is provided with means for generating two outputs 180 degrees out of phase with each other and alternate generators of the associated pulse distributor chains are respectively connected to the two outputs as shown in the drawing. This arrangement places a symmetrical load on the synchronizing signal multivibrators and in addition has certain advantages which will appear below in connection with the triggering and turning off of the individual generators forming the pulse distributor chains.

The 64-kilocycle control signal, the 256-kilocycle synchronizing signal and the square pulse output signals of the eight single pulse generators of the chain are shown in time relationship in Fig. 2, the numbers assigned to the several curves or discontinuous lines of Fig. 2 corresponding to those assigned the various circuit elements of Fig. 1.

From a consideration of the above, it will be seen that the relationship between the frequencies of the initiating and synchronizing signals supplied by the frequency dividing network to any one of the pulse distributor chains depends upon the number of individual pulse generators in the chain and upon whether one or more sets of gates are to be traveling through the distributor simultaneously. In the example chosen and illustrated in Figs. 1 and 2, provision is made for the generation of eight individual single square pulse outputs and it is assumed that the pulse distributor chain will complete a full cycle of operation before it is again triggered by the initiating signal. In this instance, the frequency of the initiating signal is so chosen that the period of the applied voltage is at least equal to eight times the desired pulse or gate length and the frequency of the synchronizing signal is advantageously so chosen that one-half the period of the applied synchronizing voltage is equal to the desired pulse length. Thus, if the initiating signal has a frequency of 64 kilocycles, as in the example, the synchronizing signal may have a frequency of 256 kilocycles. If, as in the case of the distributor chain comprising single pulse generators 1′ through 8′, the initiating frequency is 8 kilocycles, the synchronizing signal may have a frequency of 32 kilocycles. It will be apparent that the initiating signal frequency may be increased without changing the synchronizing signal frequency thereby to trigger the pulse distributor in such fashion that more than one set of pulses are traveling through it simultaneously. Also the initiating signal frequency may be decreased without changing the synchronizing signal frequency thereby to provide a rest period between operations of the pulse distributor. In either event it is usually desirable that the frequencies of the initiating and synchronizing signals be harmonically related so that the proper phase relationships for the operation of the pulse distributor are maintained between the initiating and synchronizing signals.

Frequency dividing network

As shown in the detailed circuit schematic of Fig. 3, the frequency dividing network shown in block form in Fig. 1 comprises six multivibrators indicated generally at **26**, **28**, **30**, **32**, **34** and **36** connected between the positive terminal of battery **38** and ground, the negative terminal of battery **38** also being connected to ground. The six multivibrators are arranged for operation in tandem in response to a control signal applied at input terminal **40**, the first multivibrator functioning to trigger the second, the second the third, etc. Since the six multivibrators are substantially identical with the exception of minor differences in the output connections, only one of them will be described in detail. Thus multivibrator **26** comprises a pair of pentode type vacuum tubes **42** and **44**, the screen grids and grids of which are cross-connected in a multivibrator circuit, the screen grid of vacuum tube **42** being connected through capacitor **46** to the junction of resistors **48** and **50** connected in series in the grid circuit of vacuum tube **44** and the screen grid of vaccum tube **44** being similarly connected through capacitor **52** to the junction of resistors **54** and **56** in the grid circuit of vacuum tube **42**. This method of connection leaves the plates of the two vacuum tubes **42** and **44** forming the multivibrator free for use in output circuits in such fashion that there can be little or no interaction between the multivibrator itself and the devices to which the output is applied. The input square wave signal at terminal **40** is applied through capacitors **58** and **60**, respectively, to the screens of multivibrator tubes **42** and **44** and serves accurately to determine the operating frequency of the multivibrator. The RC combinations of capacitor **46** and resistor **50**, and capacitor **52** and resistor **56** have suitable values for operation at the desired frequency.

Assuming for purposes of illustration that tube **42** is initially conducting or turned on and tube **44** is non-conducting, the charge on capacitor **46** steadily decreases, allowing the grid of tube **44** to approach ground potential approximately exponentially with time, while simultaneously the charge on capacitor **52** increases, allowing the screen of tube **44** to approach the potential of the positive terminal of the battery **38**. When, however, the grid of tube **44** reaches the potential at which that tube begins to conduct, the screen of tube **44** suddenly drops in potential, carrying the grid of tube **42** negative, and thereby causing the tubes to exchange their states of conduction, tube **44** becoming conducting and tube **42** non-conducting. Thereupon the charge on capacitor **46** increases and that on capacitor **52** decreases, until another transient occurs restoring the conditions initially assumed.

Thus far the square wave applied to terminal **40** has not been considered. When this wave becomes negative, a negative pulse is applied to the screens of tubes **42** and **44** through the respective capacitors **58** and **60**, and thence to the grids of tubes **44** and **42** through the respective capacitors **46** and **52**. This pulse is amplified by whichever of the tubes **42**, **44** is conducting at the time of the particular pulse, and thereby a larger pulse, of positive sign, is applied to the grid of the opposite or non-conducting tube. This positive pulse, overriding the smaller negative pulse at said grid, carries it above the "cut-off potential" of the tube and thus initiates conduction. In similar fashion each transient of the multivibrator wave form is precisely controlled by the potential or current applied to terminal **40**. The output taken from the plate of vacuum tube **44** is applied through capacitors **62** and **64** to the screen grids of the second multivibrator **28** of the network.

In the case of the example, the circuit parameters of the first multivibrator **26** are adjusted to provide a square wave output having a fundamental frequency of 512 kilocycles per second while the circuit parameters of the second multivibrator **28** are adjusted for a fundamental output frequency of 256 kilocycles per second. Multivibrator **26** is thus controlled by the 1024-kilocycle square wave generator **24** (Fig. 1) at a 2:1 ratio while multivibrator **28** is controlled at the same ratio by the 512-kilocycle output of multivibrator **26**.

Similarly, multivibrators **30**, **32** and **34** are each respectively controlled by the preceding multivibrators of the network at a 2:1 ratio giving fundamental output frequencies of 128, 64 and 32 kilocycles per second, respectively, while multivibrator **36** is controlled by multivibrator **34** at a 4:1 ratio to produce a fundamental output frequency of 8 kilocycles. Control signals at 8 and 64 kilocycles per second are obtained from the plate circuits of multivibrators **36** and **32**, respectively. Multivibrators **28** and **34** are slightly modified to provide two outputs which are in phase opposition of 180 degrees out of phase, for the synchronizing signals which are advantageously employed in the operation of the pulse distributor circuits as will be explained hereinafter. Thus, for example, in multivibrator **28**, resistors **66** and **68**, respectively, are connected in the cathode circuits of multivibrator tubes **70** and **72** and 180 degrees out of phase outputs are obtained at terminals A and B, respectively.

It will be understood that the number of multivibrators in the frequency dividing network and the ratios at which they are controlled may be varied as required to provide output signals of the frequencies necessary for control and synchronization purposes. It will be recognized, for example, that when two or more pulse distributor chains are included in the system, the control signals for one chain and the synchronizing signals for another may be obtained from the plate and cathode, respectively, of a single multivibrator operating at the proper frequency.

Pulse distributor circuits

Circuit details of an exemplary pulse distributor chain are shown in Fig. 4 to which reference is now made. Each of these chains in the system of the example comprises eight single square pulse generators of the type sometimes referred to as single trip multivibrators because, like multivibrators, the circuits have two conditions of stability, acquired alternately. But whereas the two conditions are both only temporarily stable in the case of the ordinary multivibrator, the present circuits have a normal condition of permanent stability in which they remain until actuated to the other condition. These circuits will remain in this other or activated condition for only a short interval of time after which they automatically return to the normal condition even in the absence of applied control currents. Three of these generators are shown in detail in Fig. 4.

The first single trip multivibrator of the pulse distributor chain is typical of all eight and comprises two triodes or in this case a dual-triode type vacuum tube **74** and associated circuit elements. The plates of the left and right-hand sections of this tube are respectively connected through load resistors **76** and **78** to the positive terminal of battery **80**, the negative terminal of which is connected to ground. The cathodes of the two sections are connected together and through resistor **82** to input terminal A which in turn is connected to output terminal A of multivibrator **28** (Fig. 3). The grid of the left-hand section of vacuum tube **74** is connected through capacitor **84** to input terminal C which is connected to output terminal *a* of multivibrator **32** (Fig. 3), the grid return being through resistor **86** to the junction of voltage divider resistors **88** and **90** which are connected together and in series with resistor **92** between the positive potential at **80** and ground. The plate of the left-hand section of vacuum tube **74** is connected through capacitor **94** to the grid of the right-hand section and grid return resistor **96** is connected to the junction of voltage divider resistors **88** and **92** described above. Inductor **98** is so connected that it by-passes cathode resistor **66** of multivibrator **28** (Fig. 3) to reduce the flow of direct current through resistor **66** and thus to reduce changes in bias or operating conditions of tubes **70**, **72**, **74** and the other tubes in the chain which, like tube **74**, are associated with terminal A.

The operation of single trip multivibrator **74** will now be considered with reference to the wave forms of applied voltage shown in Fig. 2. Let it be assumed that in the rest condition the right-hand section of single trip multivibrator tube **74** is conducting a current determined by the bias voltage derived from voltage divider resistors **92**, **88** and **90** while the left-hand section of that tube is cut off by a more negative bias also derived from the divider. At the beginning of a cycle of pulse distributor operation the positive half cycle of a 64-kilocycle square wave control signal (shown at **32** in Fig. 2) is applied to the left-hand section of single trip multivibrator **74** through input terminal C. At the same time a negative square pulse of a synchronizing signal having a frequency of 256 kilocycles as shown in trace A (Fig. 2) is applied through terminal A and cathode resistor **82** to the cathodes of vacuum tube **74**. The control grid of the left-hand section of this tube is thus made positive relative to the cathode thereof and this section of the tube begins to conduct current. The voltage drop thus produced across load resistor **76** causes capacitor **94** to discharge applying a negative voltage to the control grid of the right-hand section of the same tube to cut off that section. As capacitor **94** discharges and after a period predetermined by the values of capacitor **94** and resistor **96** the potential on the control grid of the right-hand section rises, in the absence of a synchronizing signal or pulse, to such a value that this section of tube again becomes conducting. The large increase in total current through cathode resistor **82** then increases the cathode potential relative to the grid of the left-hand section of the tube to such a value that this section is again cut off, capacitor **94** is recharged, carrying the grid of the right-hand section momentarily strongly positive, and the cycle of operation of the single trip multivibrator is completed.

The grid bias applied to the right-hand section of multivibrator tube **74** is so chosen that this section of the tube operates as a cathode follower which is not overloaded during the rest portion of the cycle. This assures uniformity of cathode potential at the rest condition and thus contributes to accuracy of triggering despite reasonable tube and circuit changes.

From the above, it is apparent that in the absence of any controlling or synchronizing signals, the multivibrator circuit comprising both sections of tube **74** has an activated or temporarily stable condition and a normal condition. When the anode current of any of these tubes is changed from the normal condition, it will be returned to the normal condition automatically after a predetermined interval of time.

It has been discovered, however, that the time required to return to the normal condition varies depending upon many factors including characteristics of individual tubes, potentials applied thereto, ambient temperature, and temperature of circuit components, as well as other factors.

In order to more accurately and with greater precision control the time at which the circuits are restored to their normal condition, synchronizing or control pulses are applied to all the so-called single trip multivibrators in such a manner that any circuits which are in the activated condition are returned to their normal condition and the succeeding ones switched to their opposite or activated condition.

At a time prior to the time at which the circuits of tube 74 would normally revert to their normal condition as described above, synchronizing or control pulses are applied to control leads A or B. At this time lead A is made more positive and lead B more negative. When lead A becomes more positive the cathode of both sections of tube 74 are likewise made more positive. This change in the cathode potential is sufficient to cause the anode current of the left-hand section of tube 74 to be decreased. The anode of the left-hand section, therefore, will rise in potential or voltage and cause the grid of the right-hand section likewise to rise in voltage due to the coupling capacitor 94. As a result the right-hand section of tube 74 starts to conduct current and causes the two cathodes to rise to a relatively high positive value, thus completely interrupting conduction in the left-hand section of tube 74, and restoring this circuit to its normal condition. When the cathodes of tube 74 rise in potential they cause a positive potential to be applied to the grid of the left-hand section of tube 102 of the next single trip multivibrator through capacitor 100. Simultaneously with the application of the positive synchronizing potential to lead A a more negative potential is applied to the synchronizing lead B. Synchronizing leads A and B extend respectively to the cathodes of the tubes of alternate pulse generators or single trip multivibrator circuits. In making lead B more negative, therefore, the effective grid-to-cathode potential of the left-hand section of the tube 102 of the second single trip multivibrator is made more positive. However, this change in voltage is not sufficient to cause current to flow through the left-hand section of this tube or those of any of the tubes to which lead B extends.

However, the grid of the left-hand section of tube 102 in the second single trip multivibrator will have applied to it a positive pulse from the cathode of the previous tube through the capacitor 100 as described above. Consequently, tube 102 which is thus conditioned by the application of a positive potential to its grid in addition to the negative synchronizing potential applied to its cathode through lead B will be changed from its normal condition to its activated condition thus causing current to flow in its output circuit. When it is desired to terminate this current, the synchronizing potentials applied to the leads A and B are again reversed and the multivibrator circuit in its activated condition is returned to its normal condition. In this maner each one of the tubes or pulse generaton circuits causes a succeeding tube or pulse generating circuit to be conditioned so that it will be actuated to its activated condition in response to the next control condition applied to synchronizing or control leads A and B.

Thus, after one-half cycle of the synchronizing signal, at which time the first single trip multivibrator has completed a full cycle of operation, a negative signal is applied to the cathode of vacuum tube 102 simultaneously with the application of the positive voltage appearing at the cathode output of vacuum tube 74 to the control grid of the left-hand section of vacuum tube 102. This section of the tube is then triggered on and this single trip multivibrator operates in the same fashion as that of the preceding pulse generator to produce a second square pulse as shown in trace 2 of Fig. 2 in accurately timed relationship to that produced by the first multivibrator of the chain and shown at trace 1 of Fig. 2. The remaining single trip multivibrators of the chain operate in identical fashion, the two out-of-phase outputs A and B of the synchronizing multivibrator being applied to alternate single trip multivibrators as shown precisely to time the initiation and completion of the gate pulses in the eight channels.

In an alternative arrangement, the two leads A and B of Fig. 4 may be effectively connected together to form a single synchronizing lead, this single lead being supplied with a synchronizing square wave of twice the frequency, that is to say, of a period equal to the period of each single trip multivibrator. Such a square wave may, for example, be obtained from the preceding stage of the multivibrator frequency dividing network.

By providing two separate synchronizing leads A and B, however, and connecting them to alternate ones of the pulse generating circuits and then applying synchronizing or controlling potentials to these leads in phase opposition, more time is provided to permit the currents to establish themselves in the manner described above, and greater protection is secured against causing more than one tube to change from its normal to its temporarily activated condition. Furthermore, the change from the normal to the activated condition and vice versa is more accurately and stably controlled by the synchronizing signals and is thus more completely independent of variations of the type referred to above.

While there has been described above one embodiment of the invention it will be understood that changes in the particular circuit arrangements, in the types of vacuum tubes used, and in circuit parameters may be made within wide limits. For example, each of the single trip multivibrators may comprise two separate triodes while the multivibrators of the frequency dividing network may each comprise two sections of a dual triode. The multivibrators of the frequency dividing network may be of the common triode type in which the control grids and plates of a pair of triodes are cross-connected through appropriate resistors and capacitors in the well-known multivibrator circuit. Changes may also be made in the number of pulse generators in each gate distributor chains and in the number of chains provided.

What is claimed is:

1. A gate distributor comprising a substantially constant frequency oscillator, a series of frequency-dividing multivibrators driven thereby, a train of single pulse generators, the end of a pulse in one generator being effective to trigger the next generator of the train, means for applying the output of one of the frequency-dividing multivibrators to trigger the first generator of the train, connections for obtaining two 180 degrees out-of-phase outputs from a frequency-dividing multivibrator of higher frequency and means for

applying these two outputs respectively to alternate single pulse generators of the train.

2. A pulse distributor comprising a plurality of sources of control current of harmonically related frequencies, a train of single pulse generators each adapted to be triggered by the end of a pulse from the preceding generator of said train, means for applying one control current to initiate the operation of the first generator of the train, the period of said one control current being at least equal to the duration of a single pulse produced by said generators multiplied by the number of generators in the train, and apparatus for applying control currents of higher frequency to terminate the operation of each of said generators, including means for applying control currents of equal frequency but opposite phase respectively to alternate generators of said train, the frequency of the last-mentioned control currents being equal to the frequency of said one control current multiplied by one-half the number of single pulse generators in said train.

LARNED A. MEACHAM.

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