

March 29, 1966

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3,243,494

TEMPO CONTROL FOR ELECTRICAL MUSICAL INSTRUMENTS

Filed Aug. 1, 1962

5 Sheets-Sheet 1

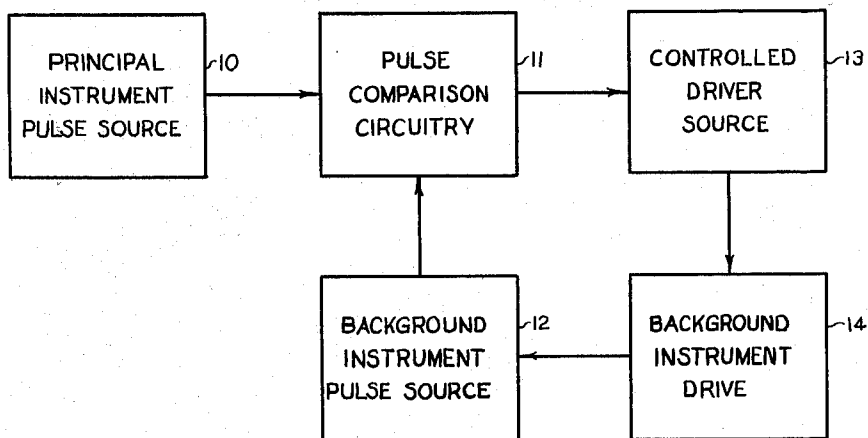


FIG. 1

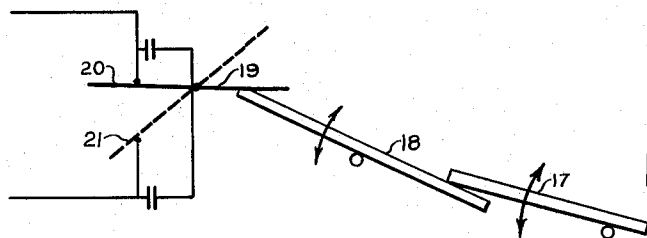


FIG. 3

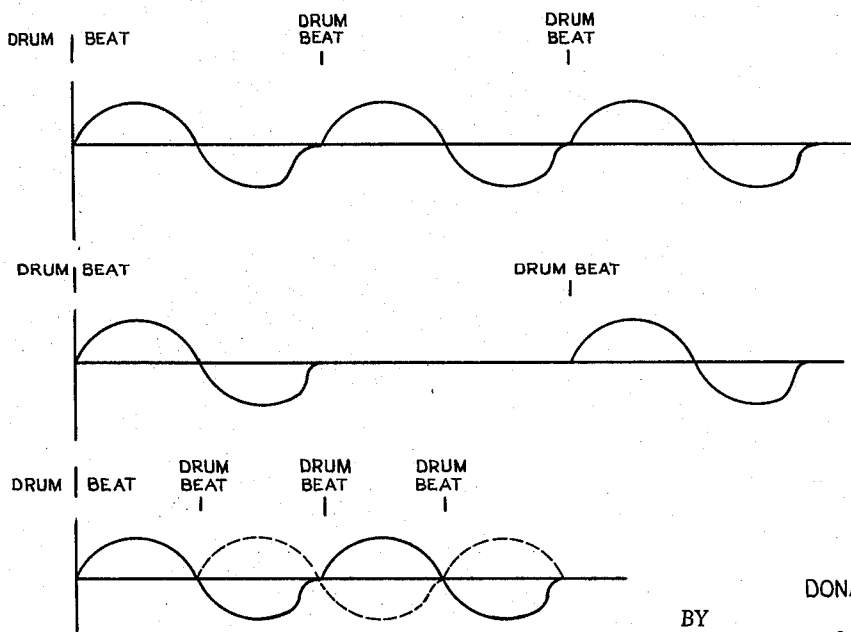


FIG. 4

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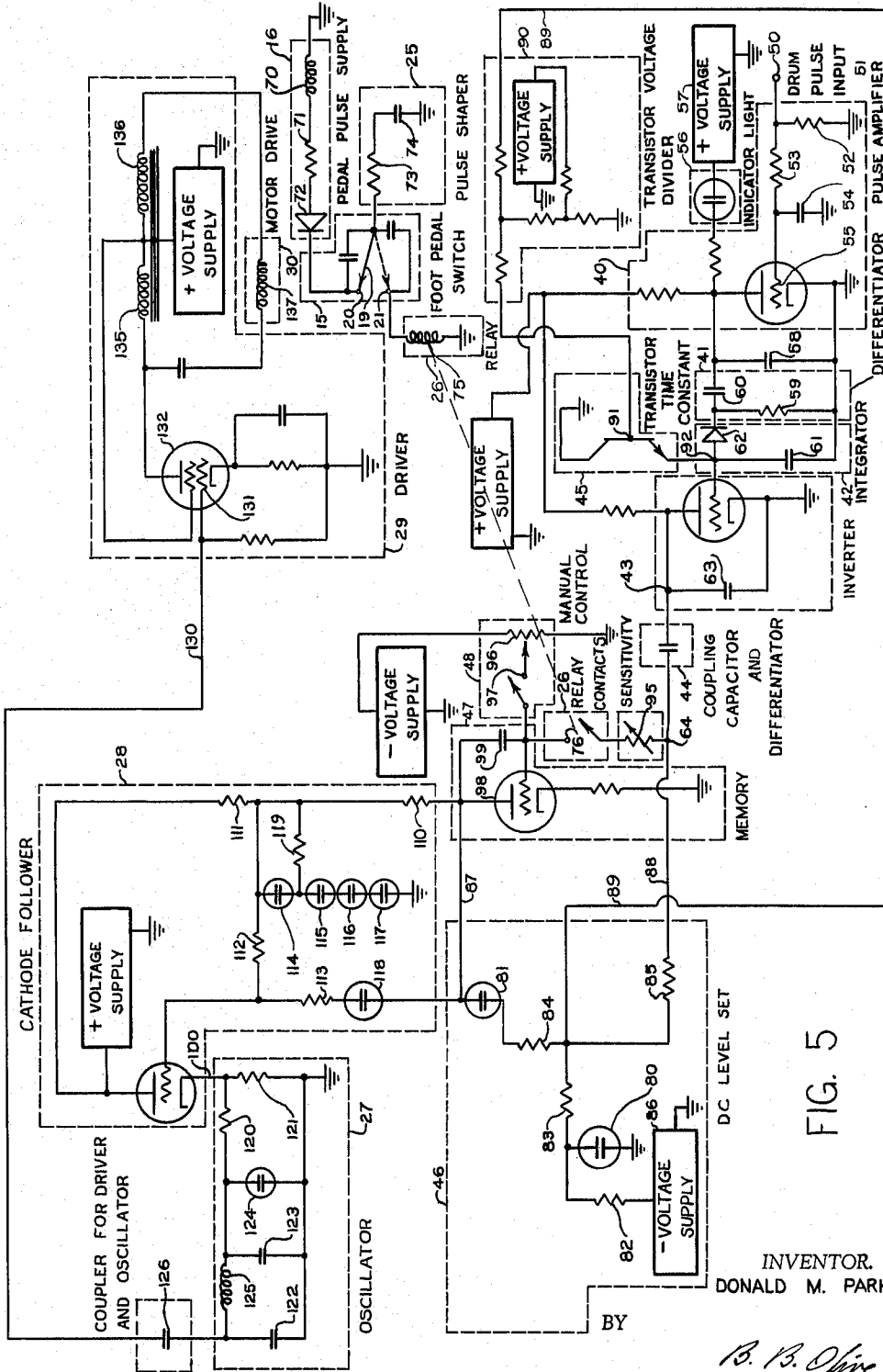


FIG. 5

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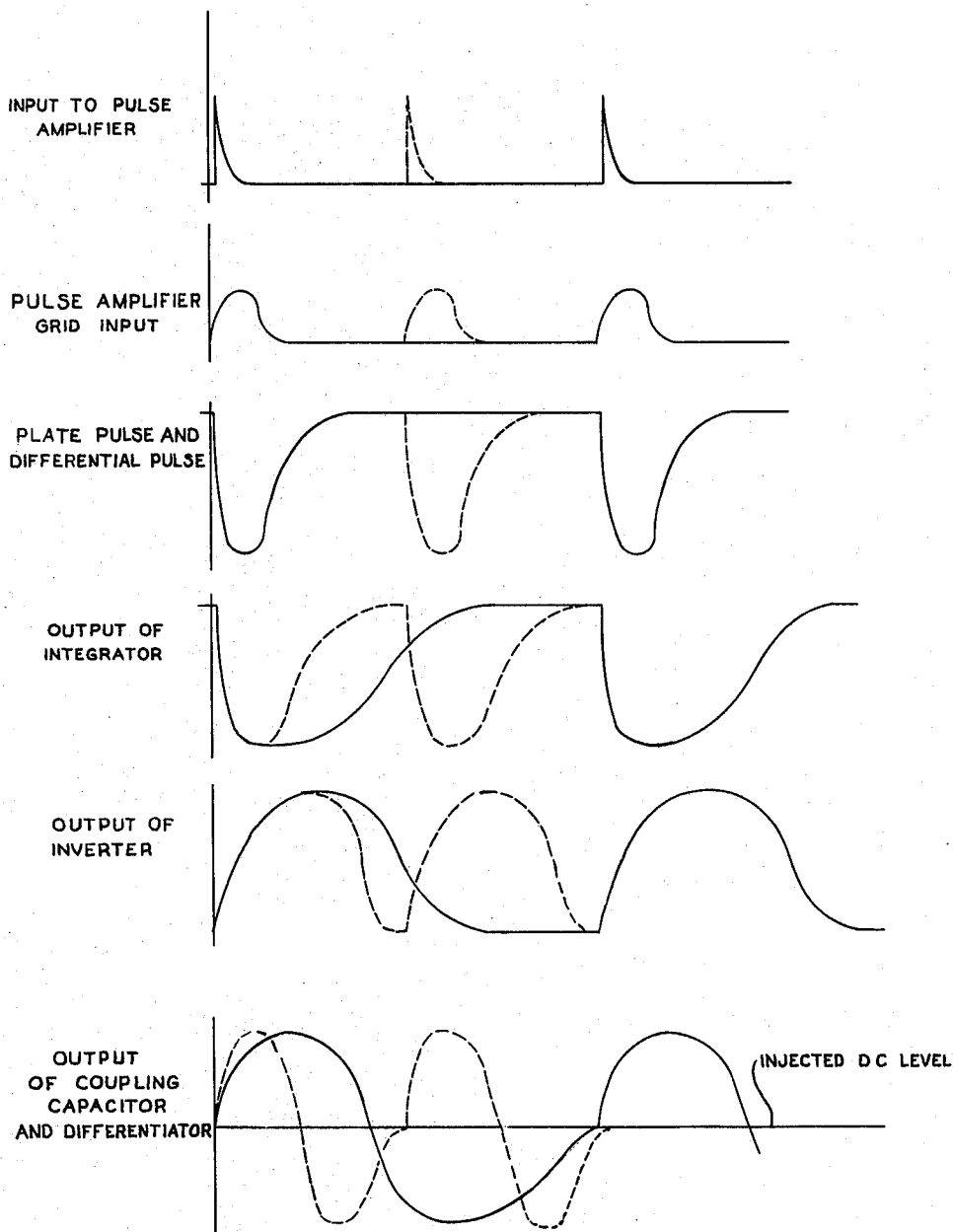


FIG. 6

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5 Sheets-Sheet 5

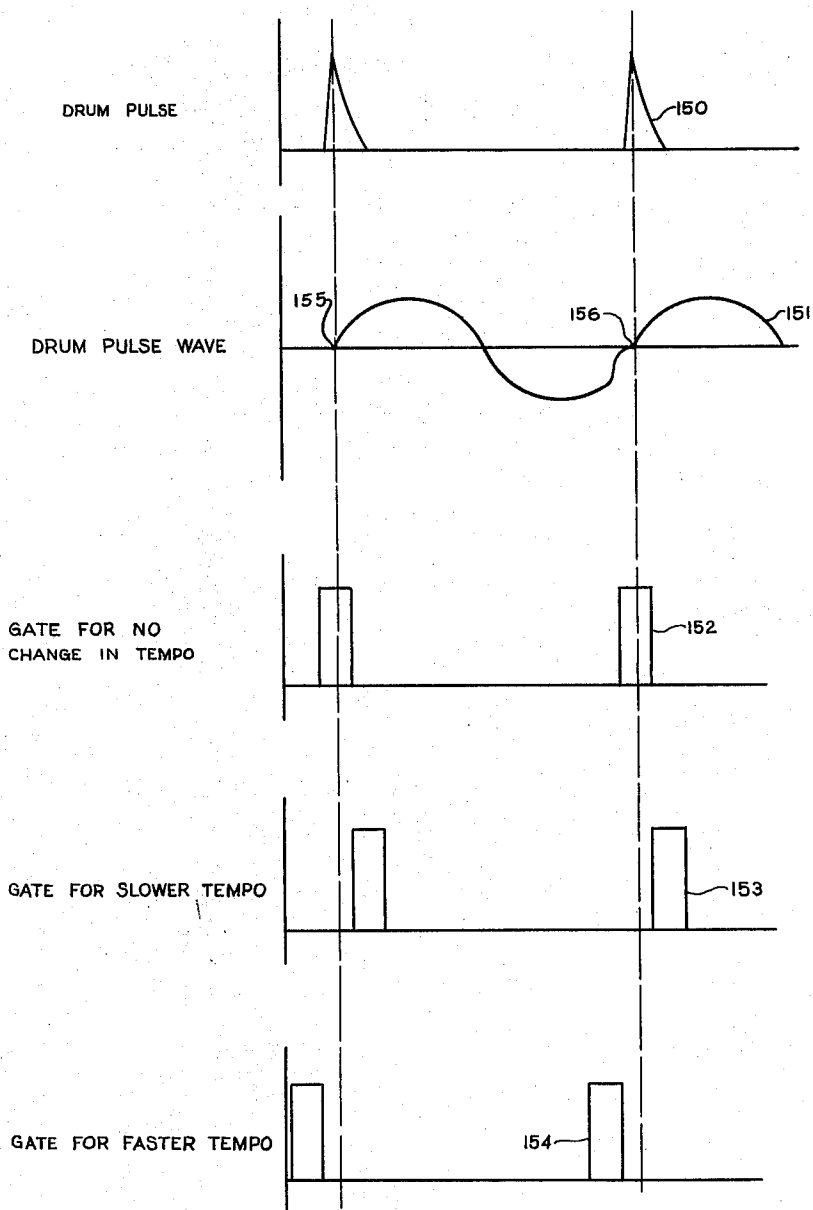


FIG. 7

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## TEMPO CONTROL FOR ELECTRICAL MUSICAL INSTRUMENTS

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17 Claims. (Cl. 84-1.03)

This invention is concerned with the relatively recently developed electrical musical instrument systems of the type in which a manually played instrument is accompanied by a separate electrical instrument that automatically produces repetitive background sounds for the first instrument. A manually played electrical organ accompanied by an electrical percussion instrument such as that sold under the mark "Rhythm King" by the Kinsman Company of Laconia, New Hampshire, is an example of the environment suitable to the invention. More particularly, the invention is concerned with providing means whereby the tempo of the accompanying background instrument can be kept or brought in step with the tempo of the principal instrument.

Reference is made to my copending application, Serial No. 166,159, filed January 15, 1962, entitled "Gaseous Glow Tube Controlled Musical Instrument," over which this invention represents an improvement and in which is given more detailed information concerning the circuitry employed in the type of background instrument referred to above.

The conventional percussion background instrument which is used to accompany an electric organ as musical background is generally provided with some type of manually operated switch by which the tempo of the background instrument may be regulated. That is, when the tempo of the background instrument is to be changed, the operator locates the proper manual control and makes the necessary adjustment with one hand while continuing to play with the other. This conventional system of tempo control obviously does not lend itself to those rhythms in which the tempo changes several times during each playing since the operator cannot conveniently give his attention both to manually regulating the background instrument tempo and to playing the organ, the principal instrument. Furthermore, because the senses of sight, hearing and touch are involved in making tempo changes, conventional tempo control requires at least temporary overburden of these senses and attendant loss in music quality during each change of the background instrument tempo.

It is therefore a general object of the invention to provide an improved tempo control for a background electrical musical instrument by which the tempo of the background instrument may be kept or brought in step with a principal electrical musical instrument for which the background instrument is giving accompaniment.

Another general object is to provide a tempo control by which two electrical musical instruments, one manually and the other automatically played, may be kept in step by means of substantially continuous electrical comparison of the tempo of each instrument.

Another general object is to provide a tempo control by which two electrical musical instruments, one manually and one automatically played, may be kept in step by means which does not require use of the operator's vision or special manual motions.

Another object is to provide a tempo control for a background electrical musical instrument by which the tempo of the background instrument may be regulated by one of the conventional controls employed in the principal instrument.

A further object is to enable the operator of one

manually played electrical musical instrument to automatically adjust the tempo of a second electrical musical instrument being played under automatic operation and being used as background for the first.

Another more specific object is to provide means enabling the operator of a manually played electrical musical instrument having foot control to use such foot control as a means for adjusting the tempo of a second automatically played electrical musical instrument being used as a background for the first.

The above and further objects of the invention will appear as the description proceeds and in the drawings, in which:

FIGURE 1 is a general block diagram of the invention. FIGURE 2 is a more detailed block diagram illustrating an embodiment of the invention.

FIGURE 3 is a schematic representation of a foot pedal switch.

FIGURE 4 is a diagram illustrating possible variations in input pulse waves received from the background instrument.

FIGURE 5 is an electrical circuit diagram of the embodiment of the invention illustrated in block diagram in FIGURE 2.

FIGURE 6 is a diagram illustrating the relative pulse and wave shapes at different points in the circuit, the solid lines representing a slow tempo condition and the dashed lines a fast tempo condition.

FIGURE 7 is a diagram illustrating relation of the pedal pulses to the terminal points of the drum pulse waves in relation to tempo control of the background instrument.

The invention is explained in connection with a musical system in which an electrical organ is accompanied by a second electrical musical instrument of the repetitive percussion sound type. The organ will be referred to as the principal instrument and the second instrument will be referred to as the background instrument.

To begin explanation of the invention, it should be recognized that operation of any electric organ by a player is effected by manual and foot operation of control members such as keys and pedals each of which produces an electrical control pulse each time it is moved and the frequency of operation of these members sets the tempo at which the organ is played. The conventional background instrument also depends on pulse control in that the individual sound producing sections of the conventional background instrument receive their control pulses from a common pulse generator, frequently in the form of a rotating wiper switch or commutator. The rate at which the pulses are generated in the background instrument depends on the speed of the driving device which is usually an electric motor and by varying the speed of this motor the tempo of the background instrument can be regulated accordingly.

In the invention, recognition is made of the fact that the relative tempos of the principal and background instruments can be compared by taking pulses from the principal instrument that are in step with the tempo at which the principal instrument is being played and comparing these with pulses that are in step with the tempo at which the background instrument is being played. Such comparison is effected electrically and the electrical result is used to control the rate of operation of the drive for the background instrument pulse source. The background instrument pulse rate thus can be increased and decreased as dictated by the comparison of pulses coming from the two instruments so as to maintain the background instrument in step with the principal instrument.

The invention is broadly illustrated in FIGURE 1 in which 10 represents a pulse source at the principal instrument which is in time with the tempo at which the prin-

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principal instrument is being played. As later described, this can be the conventional pedal operated switch or a separate auxiliary switch on the principal instrument which is operated each time any of the foot pedals or other actuators are depressed. The principal instrument pulse source 10 is fed to pulse comparison circuitry indicated at 11 which also receives pulses from the background instrument pulse source indicated at 12. The background instrument pulse source 12, like the principal pulse source 10, represents a pulse source that is in time with the tempo of the background instrument and as is later described may be the drum pulse source found in background instruments of the kind now on the market and which appears in most of the basic rhythms derived from the background instrument.

The pulse comparison circuitry 11 acts to compare the two pulse sources and produce an output whose ultimate effect is to control the drive source circuitry indicated at 13 from which the background instrument drive indicated at 14 is fed. In the embodiment being used as an example, drive 14 is selected to be some frequency sensitive device such as a synchronous motor and the drive source circuitry 13 is a frequency type control. The speed of drive 14 is controlled by the drive source circuitry 13 which like drive 14 is located between the comparison circuitry 11 and background instrument pulse source 12. In turn, drive 14 controls the rate at which pulses are emitted by the background instrument pulse source 12. When pulses from the principal instrument pulse source 10 are synchronized with the pulses from the background instrument pulse source 12, the drive 14 will remain at the speed at which it is running. However, if the pulses are not synchronized, the drive 14 will automatically be made to speed up or slow down as required to bring the pulses in synchronization with the pulse rate of the principal instrument pulse source as required.

The principal and background instrument pulse sources may vary in form and in the degree to which they are mechanical, electrical or electronic in nature. It is important that the principal instrument pulse source be representative of the principal instrument tempo and that the background instrument be representative of the background instrument tempo. It also is important that the comparison circuitry be adapted to control some electrical characteristic which will affect the rate at which the background instrument's pulses are being produced. Various possibilities are immediately evident to those skilled in the art. In the embodiment now to be explained, the principal instrument pulses are precisely shaped as pulses and are made to control an "and" gate through which the background instrument pulses pass in the form of waves. The electrical "comparison" takes the form of coincidence of arrival at the gate of the pulses and the waves. Such wave portions as are passed by the gate are directed to a memory circuit the output level of which is used to control the speed of the drive which produces the background instrument pulses. A difference in tempo between the two instruments results in a change in memory output level that tends to change the background instrument drive as required to make the tempos equal.

To explain the invention further in block diagram but in somewhat more detail, reference is next made to FIGURE 2 in which there is illustrated a circuit employing the invention. In FIGURE 2, the principal instrument pulse source 10 includes the foot pedal operated switch 15 and a pulse voltage supply 16 on the principal instrument. Such foot switches are a common and well known part of electric organs and furnish a convenient point from which to derive a pulse representative of the principal instrument tempo. A preferred form is the type of switch which operates each time one of the pedals is depressed. FIGURE 3 illustrates schematically a typical electric organ or other principal instrument foot pedal arrangement in which 17 represents a foot pedal, 18 a rocker arm, 19 a rocker arm and conductor and 20, 21 points of contact

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between which the rocker conductor 19 moves as pedal 17 is operated. For the moment it is sufficient to note that the rate at which pulses derived from the pulse voltage supply 16 are passed by the circuitry of FIGURE 3 will depend on the rate at which foot pedal 17 is operated.

Referring further to FIGURE 2, the pulse emanating from pulse voltage supply 16 is fed to and stored in the capacitor of a shaper 25. Then, upon operation of foot pedal 17, the stored pulse is fed to a relay gate 26 of the "and" type whose opening is controlled by such pulses. The shaper 25 provides means to clamp and differentiate the pedal wave so as to produce a pulse of precise time interval, width and amplitude. As the frequency of the pedal pulse changes, the frequency of the shaper output changes. The relay gate 26 provides a switch contact which stays closed a precise time interval of relatively short duration by reason of the control asserted by the shaper 25. The closing action of relay gate 26 is initiated by the pulse coming from shaper 25 but is independent of the foot pedal wave shape due to the action of the shaper. The relay gate 26 in a preferred and well known form, not shown in detail, consists of two reed contacts enclosed by a coil which when energized close the contacts through magnetic action. The shaper pulse operates the coil and the reed contacts carry the separate pulse arriving from the background instrument as later mentioned.

Reference is made next to that portion of the circuit involved in converting the background instrument pulses to wave form and bringing the waves to the relay gate 26. Oscillator 27 represents a variable frequency oscillator which is driven from the cathode follower 28 and which in turn drives a driver unit 29 that serves to reproduce the wave shape with greater power but with the same frequency. From the driver unit 29, the signal is fed to the drive 30 which represents the actual drive device in the background instrument that mechanically drives the background instrument pulse generator and whose speed determines the pulse rate of the background instrument.

It is the speed or rate of operation of the drive 30 in whatever form it might be with which we are most concerned and what is desired to be controlled. That is, a principal part of the inventive concept is that of using the electrical result of the pulse comparison as a means of controlling the rate at which background instrument pulse generation takes place. Since drive 30 in this embodiment controls such rate of pulse generation, we are concerned here primarily with controlling the speed of drive 30. A drive device suitable to the purposes of this particular embodiment of the invention is a synchronous motor, not shown, which is employed to drive the wiper switch or commutator 31 of the background instrument. The pulses emanating from a background instrument pulse voltage supply 32 are fed through the commutator 31 through the conventional selector switch circuitry 33 of the background instrument from which the pulses are distributed to the tone generators such as the blocks and cymbals tone generators indicated in dash lines at 34, 35 and the drum unit indicated at 36 and then to the amplifier 37 and speaker 38. It will be appreciated that the background instrument drive and pulse circuitry will vary in form from that indicated in FIGURE 2. Reference is again made to my previously identified copending application in which a more detailed explanation of one form of background instrument circuitry may be found.

While the pulses which represent the background instrument tempo might come from any of several points in the background instrument circuit, I have found that use of the drum pulses is a convenient indicator of the background instrument tempo since drum pulses appear in almost all forms of rhythms heard from the background instrument with the exception of the metronome tone. Accordingly, drum pulses from the background instrument are fed to a pulse amplifier 40 which feeds to a differentiator circuit 41, from which they are fed to an integrator circuit 42, then to an inverter circuit 43 and to

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a capacitive and differentiating coupling 44. Amplifier 40, differentiator 41, integrator 42, inverter 43 and the differentiator-coupling 44 are primarily concerned with taking the drum pulses in their typical spike form as illustrated at the top of FIGURE 6 and converting them to a continuous wave form in which the ends of each respective wave coincides with the beginning of the next drum pulse. This same circuitry is also concerned with producing a wave shape from the drum pulse that varies in length on the time axis proportionate to the change in frequency of the drum pulse.

Cooperating with the mentioned pulse-to-wave converting circuitry is a transistor time constant circuitry indicated at 45 and a D.C. level set source indicated at 46 both of which affect the pulse-to-wave converting circuitry as well as operation of the memory circuit indicated at 47. To better understand these individual circuits and their manner of cooperation it is noted that the background instrument drum pulses are amplified, spread and inverted by action of amplifier 40 and are passed to the differentiator 41 which alters the D.C. level to ground for coupling into the integrator 42. Integrator 42 in turn spreads the pulses out to a wave shape which is inverted and made into a positive going pulse by inverter 43 from which a substantially continuous wave is derived by the capacitor differentiating coupling 44. As the inverter goes positive the positive half is developed and as it returns to the original level the negative going pulse is developed.

It should be understood at this point that the ultimate purpose of forming the background instrument pulses into waves and gating them through the relay gate 26 as regulated and controlled by the shaped principal instrument pulses is to obtain an output D.C. level in the memory 47 which can ultimately be employed to regulate the speed of commutator 31 so as to keep the drum pulse rate in time with the principal instrument pulse rate. The wave shape which is gated into the memory is an important aspect of the invention since it must change in shape and amplitude as a function of the drum pulse. By producing a wave shape from the background instrument pulse that is alternately positive and negative, the gate, depending on when it is closed, will pass to the memory 47 either a positive or negative or average or zero pulse depending on the precise shape of the wave which enters the gate from the differentiator-coupling 44. This is further referred to in FIGURE 7.

Unless otherwise provided for, the integrator 42 will have a constant R-C time constant and therefore a constant produced wave shape for every input drum pulse. Several possibilities exist as shown in FIGURE 4. The drum beat and developed wave can be synchronized; the drum beat and developed wave can be out of synchronization with blank time spaces between waves; the drum beat and produced wave can be out of synchronization with the waves overlapped. In the last case, one actually sees a distorted single wave on the oscilloscope due to the illustrated overlapping. Without control of the R-C time constant of integrator 42, it has also been found that the pulses at low speed will tend to produce overcontrol. Therefore, in order that the pulse width produced by integrator 42 will be synchronized with the drum beats and to overcome the mentioned low speed problem, there is provided the previously referred to transistor time constant circuit 45. Associated with the transistor time constant circuit 45 is the D.C. level set indicated at 46 which is injected into the transistor time constant circuit 45 so as to establish a D.C. level which varies with the memory level. The D.C. level set also establishes a D.C. level at point 64 around which the entering wave operates (FIG. 5). Through such arrangement, the wave which finally enters the gate 26 will have the desired D.C. axis and will begin and terminate at the same time as the drum pulses. This effect is illustrated by comparing the pulse shapes in solid lines at the top of FIGURE 6

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with the wave shapes in solid lines at the bottom of FIGURE 6, these representing respectively the spike pulse shape directed to the pulse amplifier from the background instrument drum pulse source and the wave shape produced by the differentiator coupling 44. It should also be observed in this connection that the wave shape which enters gate 26 at any particular time is controlled in part by the state of the transistor time constant at the instant the wave is passed.

Reference has already been made to the operation of gate 26 through which it is noted, the drum pulse waves pass to the memory unit 47 and then to the cathode follower 28 which is characterized by a low impedance output suitable to driving oscillator 27. Memory unit 47 is an integrator and inverter and maintains a stable level output for long periods of time and is controlled by the integrated pulse input received through the relay gate 26. A capacitor, later referred to in FIGURE 5, is employed with the tube of the memory to store the incoming pulses and produce the D.C. level output previously referred to which will vary as the pulse input varies. The output of memory unit 47 thus gradually changes oppositely to the input and when fed to the cathode follower 28 will act to control the frequency of oscillator 27 and in turn the driver 29 and the speed of drive 30 and consequently the rate at which pulses emanate from the commutator 31, this rate being representative of the background instrument tempo.

The drum pulses are continuously fed back and used to generate successive continuous waves that are functions of each respective drum pulse. So long as the foot pedal beat is multiple or a sub-multiple of the drum beat and the beats are simultaneous, the memory level will remain constant. On the other hand if the pedal beat is not a multiple or sub-multiple of the drum pulse beat, or if the pedal beat and drum beat are not simultaneous, the memory level will change in the direction to bring the beats to the point that the pedal beat is a multiple or sub-multiple of the drum pulse beat and is simultaneous with it. Thus, the operator of the principal instrument, the organ, is given control over the tempo of the background instrument through the organ foot control which, of course, may be either one of the conventional foot pedal controls or a special foot pedal control provided solely for the purpose of controlling the background instrument tempo.

To complete the general description in reference to FIGURE 2, it is noted that the circuit of the invention provides for a manual control 48 whose purpose is to override the drum pulse control and thereby place the commutator speed under manual rather than automatic control. The details of this manual control which involves switching in a potentiometer voltage divider will be considered later in reference to FIGURE 5 to which the description now turns.

In FIGURE 5, the drum pulses are put into the circuit at 50 across resistor 52 and at this point have the sharp spike effect as indicated at the top of FIGURE 6, the solid lines in FIGURE 6 being indicative of a relatively slow tempo condition and the dashed lines being indicative of a relative fast tempo condition. The previously mentioned pulse amplifier 40 shown in FIGURE 5 and into which the drum pulses are initially fed includes the pi network of resistors 52, 53 and capacitor 54 which cause the pulse to be introduced to the grid 55 in the spreaded shape indicated in FIGURE 6. In order that the operator may have some visual indication of drum pulses being received, the circuit includes the neon tube indicator light 56 and associated voltage supply 57 which is designed to cause the tube 56 to fire each time a pulse is received by amplifier 40.

The integrating capacitor 58 helps spread the now inverted pulse further as it is fed to the differentiator 41 comprising resistor 59 and capacitor 60 and then to the integrator 42 comprising capacitor 61 and diode 62. In-

version of the wave takes place in the inverter 43 which also contributes further spreading by means of the capacitor 63. The desired wave which terminates and ends in time coincidence with the drum pulses is finally obtained at the output of the coupling capacitor and differentiator 44 indicated at point 64 in FIGURE 5 and assumes the shape indicated at the bottom of FIGURE 6. It is again desirable to recognize that the obtaining of this wave shape is dependent not only on the amplifier, differentiator, integrator, inverter and coupling circuits discussed above and indicated in FIGURE 5 but is also equally dependent on the D.C. level set circuit 46 and the transistor time constant circuit 45. However, before discussing further the contribution of the D.C. level and time constant circuits to the drum pulse shaping, it is desired to look at the circuitry associated with the gate and the gating action.

The principal instrument pulse voltage supply is schematically indicated at 16 and includes the transformer secondary 70, resistor 71 and diode 72. With the previously mentioned conductor arm 19 in normal position, the voltage is transferred through contact 20 of the foot pedal switch 15 to the resistor 73 and capacitor 74 of pulse shaper 25 and under this condition capacitor 74 is charged. Upon operation of the foot switch as previously described in connection with FIGURE 3, conductor arm 19 is switched to contact 21 and the capacitor 74 discharges through the coil 75 of the relay 26, the "and" gate, causing contacts 76 to close and pass whatever portion of the drum pulse wave shape is then at point 64 and ready to go through the gate. With a rhythmic operation of the foot pedal switch 15, the pedal pulse supply 16 and pulse shaper 25 will develop a pulse sequence in coil 75 generally corresponding to the pulse shapes shown in FIGURE 7. Depending on the time coincidence of the pulse shapes developed in coil 75 and the wave shapes arriving at point 64 it can be seen that there will be either an addition, subtraction or no change in memory 47. At this point in the description, it seems advisable to turn to the D.C. level, memory and time constant circuitry.

The D.C. level set indicated generally by 46 includes the neon tubes 80, 81 as precise voltage dropping devices, the resistors 82, 83, 84 and 85, and a voltage supply 86 which provides a voltage slightly in excess of the firing potential of the neon tubes. The D.C. level set is connected to the plate of the memory 47 through line 87 which gives a changing D.C. level corresponding to the memory change. This changing D.C. level is fed through line 88 to point 64 which gives the drum pulse wave shape arriving at point 64 from the coupling capacitor differentiator 44, the injected D.C. level or axis about which the wave operates. The effect of this injected level is further illustrated at the bottom of FIGURE 6 and may be said to be necessary in order to keep the drum pulse wave shape in a desirable range of operating potential. The D.C. level set is further connected through line 89 to a conventional voltage divider circuit 90 which establishes the correct bias for the base of the transistor 91 employed in the transistor time constant circuit 45.

Mention has already been made in describing FIGURE 2 of the action of transistor time constant 45 in altering the R-C time constant of the integrator 42 to which it is connected at point 92. The transistor time constant is in turn altered by the D.C. level set through the connections mentioned so that it can be seen that the integrator 42 R-C time constant is made to change both by action of the transistor time constant circuit 45 as well as by the action of the D.C. level which in turn depends on the change in memory 47. Since the condition of the memory dictates the amount of R-C time constant change needed in the integrator 42 to keep the terminal points of the drum pulse waves arriving at point 64 coinciding in time with the pulse spikes put in at point 50, this R-C time constant change is thus constantly monitored and corrected by the circuitry just described.

In this particular embodiment of the invention, it is deemed to be necessary to the success of the invention though it is recognized that the same problem of R-C time constant control may not be as critical or may not even arise in other types of circuits employed in practicing the invention.

The sensitivity of the memory 47 is controlled by the variable resistor 95 and manual control over the memory is made through the potentiometer 96 and switch 97. The memory 47 includes the tube 98 and the capacitor 99 which stores the pulses coming in through the "and" gate as represented by contacts 76. The cathode follower 28 duplicates the memory output with more power and produces a slow changing D.C. at point 100 which slowly changes the operating frequency of the relaxation type oscillator 27. As to the cathode follower 28, both construction and operation is in general conventional. The circuit includes the plate load resistors 110, 111 and the voltage divider resistors 112, 113. The neon tubes 114, 115, 116, 117 and 118 are used as precise voltage dropping devices, the resistor 119 being provided for the purpose of starting the tubes 115, 116, 117 to fire which are followed by firing of tube 114. The oscillator circuit 27 includes the resistors 120, 121, the capacitors 122, 123, the neon tube 124 and the conventional inductor 125. Connection from the oscillator 27 to the remainder of the circuit is made through the coupling capacitor 126.

Connection is made from capacitor 126 through line 130 to the grid 131 of the driver tube 132 forming part of the overall driver circuit 29. The driver 29 in its plate circuitry is combined with an auto-transformer comprised of the windings 135, 136 and the motor drive winding 137. In the actual device, winding 137 forms part of the synchronous motor circuit which drives the commutator 31 mentioned in connection with FIGURE 2. Therefore as the frequency of the output of driver 29 changes the frequency in winding 137 changes and consequently the speed of rotation of commutator 31 will change and result in a change in the rate at which the background instrument pulses are produced. To look at the operation, reference is now made to FIGURE 7.

In FIGURE 7 the drum pulse spikes as introduced into the circuit at point 50 of FIGURE 5 are indicated by the curve 150 and the wave developed from the spikes which is fed to point 64 is indicated by the curve 151. The gating wave which is developed from the principal instrument pulse sources and which is fed to coil 75 is represented at 152 for a first condition, at 153 for a second condition, and at 154 for a third condition. From the curves mentioned it will be seen that if the principal instrument gating wave such as that at 152 coincides in time with the terminal points of the drum pulse wave as at 155, zero wave is gated and therefore the status of memory 47 and all following elements including motor drive 30 will undergo no change. This further means that the rate at which the drum pulse spikes 150 are entering the circuit of FIGURE 5 will also remain fixed since this rate is, in the embodiment being described, dependent on the speed of the motor drive which has in this example undergone no change.

If the operator of the principal instrument now operates foot pedal 17 so that the gating pulse is slightly behind the terminal points as represented by gating wave 153, a positive portion of the wave 151 will be passed to the memory 47 which acts to slow down the oscillator 27 and consequently slow down the speed of motor drive 30 and in turn slow down the rate at which the drum pulses are being produced. On the other hand if the operator of the principal instrument operates the foot pedal 17 so that the gating pulse is slightly ahead of the terminal points of the drum pulse wave as represented by gating wave 154, a relatively negative portion of the drum pulse wave 151 will be passed to the memory 47 and that there will result an increase in the oscillator frequency and in turn a speeding up of motor drive 30

and an increase in the rate at which the drum pulses are fed to the circuit of FIGURE 5.

The variation of the pedal beat being a multiple or sub-multiple of the drum beat and the fact that either case produces no change has already been mentioned. As the operator gains experience with a particular circuit employing the invention, it will be found that the background instrument can in a very natural and easy manner be made to follow the principal instrument with essentially no more effort than is normally required to play the electric organ, or any similar independent pulse source played as a control.

It is apparent that various forms of pulse generators, pulse generation rate control and pulse comparison devices may be employed in musical circuitry to carry out the invention. Voltage and current controlled devices may be resorted to for pulse rate control rather than the frequency devices and circuitry referred to in the foregoing embodiment. Having pointed the way in what is believed to be a true innovation in the art, it is recognized that others will improve upon and devise other and perhaps better ways to perform the invention but without departing from the spirit and scope of the invention.

Having described the invention, I claim:

1. In an electrical background musical instrument of the automatic continuously audible repetitive rhythm type used to accompany an instrument under player control, electrical means for comparing the player's tempo with the repetitive rhythm instrument tempo, and automatic means responsive to the comparison of said tempos for altering the tempo of the repetitive rhythm instrument in the direction which will reduce the difference between said tempos.

2. In an electrical background musical instrument of the automatic continuously audible repetitive rhythm type intended for use with an instrument under player control, means for generating a series of electrical impulses corresponding to the player's tempo, means for comparing the time of occurrence of said impulses with the tempo of the repetitive rhythm instrument, and automatic means responsive to the comparison of said impulses with said tempo for altering the tempo of the repetitive rhythm instrument in such a direction as to make it more nearly coincide with the player's tempo.

3. Apparatus according to claim 2 wherein said electrical impulses corresponding to the player's tempo are obtained from the pedal keyboard of an electronic organ.

4. Apparatus according to claim 2 wherein said electrical impulses corresponding to the player's tempo are obtained from a switch associated with a separate actuator on which the player beats time.

5. In an electrical background musical instrument of the automatic continuously audible repetitive rhythm type intended for use with an instrument under player control, means for generating an electrical pulse corresponding to each major beat of the player's tempo, means for sensing the time of occurrence of said pulse relative to the major beat of the tempo of the repetitive rhythm instrument, and means responsive to said sensing means for increasing the tempo of said repetitive rhythm instrument when said pulse occurs before the major beat of said rhythm instrument and decreasing the tempo of said rhythm instrument when said pulse occurs after the major beat of said rhythm instrument.

6. Apparatus according to claim 5 wherein said instrument under player control is a keyboard instrument having a pedal keyboard and wherein said electrical pulse corresponding to each major beat of the player's tempo is generated by depressing any key of said pedal keyboard.

7. Apparatus according to claim 5 including a separate pedal on which the player beats time, wherein said electrical pulse corresponding to each major beat of the player's tempo is generated by depressing said separate pedal.

8. In an electrical music generating system including a principal instrument having a pulse tone source responsive solely to player operation; a background instrument of the repetitive rhythm type having a pulse tone source under continuous automatic audible operation independent of player operation; electrical comparison means connected to both sources for comparing the rates of pulsing therein and developing an electrical output proportional to the difference in said rates; and electrical drive means connected between said comparison means and the pulse source of said background instrument, said drive means including control means for automatically adjusting the rate of pulsing in said background instrument pulse tone source in response to the output of said comparison means whereby to maintain the automatic pulse tone source substantially in step with the player operated pulse tone source.

9. The combination according to claim 8 wherein said principal instrument is an electric organ having a pedal keyboard and said principal instrument pulse tone source is a pedal operated tone source of said electric organ and is connected to said comparison means.

10. The combination according to claim 8 in which said comparison means comprises an "AND" type gate having input connections to said sources and an output connection to said drive means, the gate being closed by pulses from said principal instrument pulse tone source and being connected to develop said output from said background instrument pulses on said output connection when so closed.

11. The combination according to claim 8 in which said electrical drive means includes means connected to said comparison means for converting said output to a direct current level proportional to the difference in said rates and said control means is responsive to said level.

12. The combination according to claim 8 wherein each of said sources includes means connected for receiving and shaping the respective pulses coming therefrom into signal shapes substantially precisely representative of said rates and having output connections to said comparison means such that any difference between said rates will change said comparison means output.

13. The combination according to claim 8 wherein said principal instrument source includes means connected for receiving and shaping pulses coming therefrom into pulses of precise time interval, width and amplitude and said background instrument source includes means connected for receiving and shaping each pulse coming therefrom into a wave form whose end coincides with the beginning of the following background instrument pulse and whose period varies with the rate of said background instrument source, said principal and background instrument shaping means having output connections to said comparison means such that any difference in said rates will change the output of said comparison means.

14. The combination according to claim 13 wherein said background instrument shaping means comprises pulse amplifying, differentiating, integrating and inverting circuits connected in series and means connected to said integrating circuit to control the time constant therefor.

15. The combination according to claim 11 wherein said converting means includes memory, cathode follower, oscillator and driver circuits connected in series.

16. In an electrical music generating system including a principal instrument having a pulse tone source responsive solely to player operation; a background instrument of the repetitive rhythm type having a pulse tone source under continuous automatic audible operation independent of player operation; first shaping means connected to said principal instrument source for converting pulses coming therefrom to a signal form precisely representative of the rate thereof; second shaping means connected to said background instrument source for converting pulses coming therefrom to a signal form precisely representative of the rate thereof; electrical comparison means

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connected to receive said signal forms simultaneously from said first and second shaping means for developing an electrical output proportional to the difference in said rates; and control means responsive to said output connected between said comparison means and said back-  
ground instrument pulse tone source for automatically  
adjusting the rate of said background instrument pulse  
tone source in response to said output whereby to main-  
tain the automatic pulse tone source substantially in step  
with the player operated pulse tone source.

17. In a system for controlling the tempo of a back-  
ground instrument of the repetitive rhythm type having  
a pulse tone source under continuous automatic audible  
operation independent of player operation; an independ-  
ent pulse tone source responsive solely to player opera-  
tion; electrical means connected to both sources for  
comparing the rates of pulsing therein and developing

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an electrical output determined by the difference between  
said rates; and control means responsive to said output  
connected between said electrical means and said back-  
ground instrument pulse tone source for automatically  
adjusting the rate of said background instrument pulse  
tone source in response to said output whereby to main-  
tain the tempo of the background instrument synchro-  
nized with the rate of operation of said independent  
pulse tone source.

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