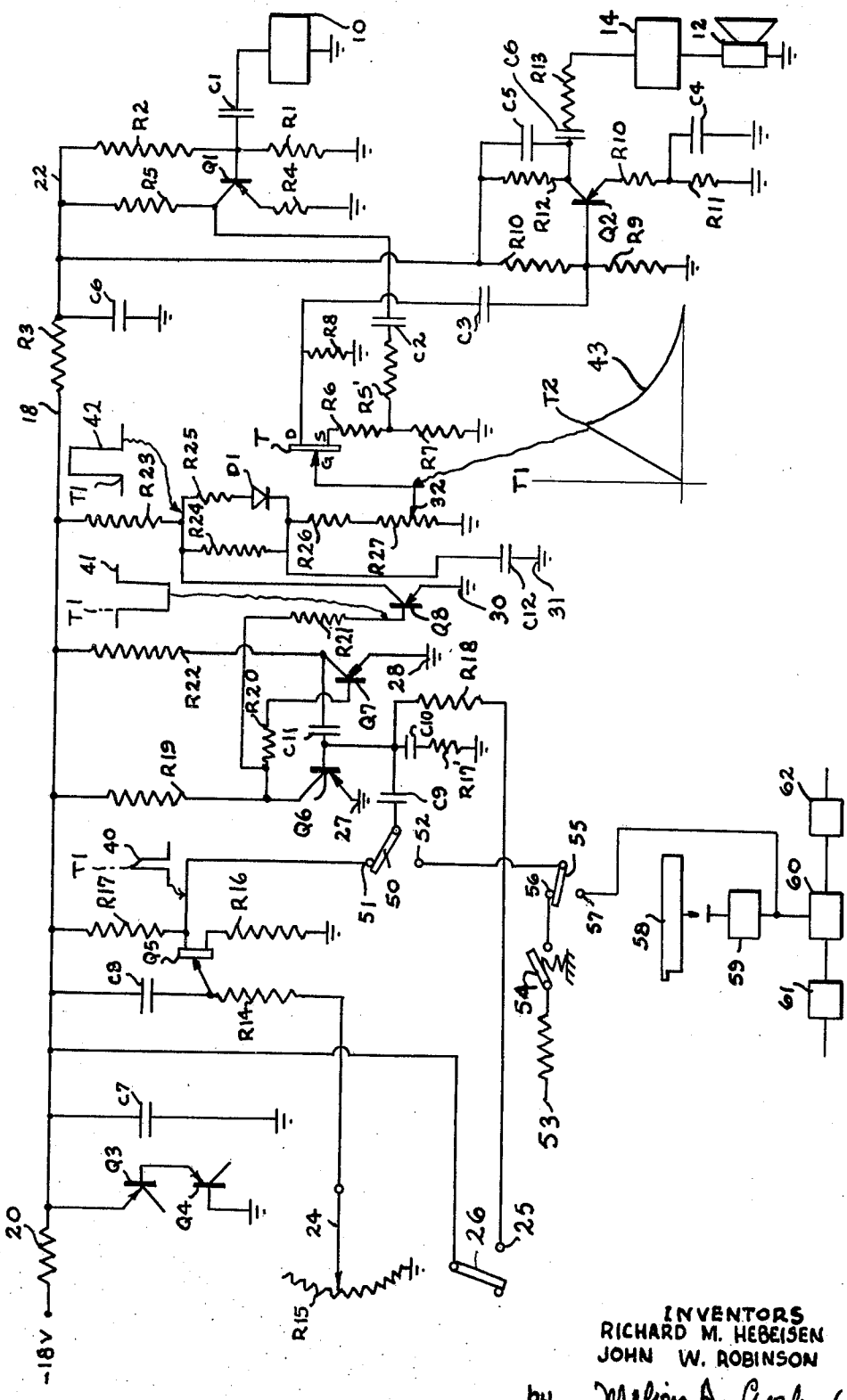
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CIRCUIT FOR OBTAINING REPEATER AND PERCUSSION EFFECTS IN AN ELECTRICAL MUSICAL INSTRUMENT UTILIZING A FIELD EFFECT TRANSISTOR

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CIRCUIT FOR OBTAINING REPEATER AND PERCUSSION EFFECTS IN AN ELECTRICAL MUSICAL INSTRUMENT UTILIZING A FIELD EFFECT TRANSISTOR

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ABSTRACT OF THE DISCLOSURE

Circuit for controlling the signals delivered to the speaker means of a sound reproducing system in which a field effect transistor is interposed in the path of the signals and the bias on the gate terminal of the field effect transistor is controlled so as to control the impedance of the field effect transistor and thereby control the passage of signals through the field effect transistor.

The present invention relates to a circuit for producing special sound effects and, more particularly, the present invention relates to an electrical circuit arrangement especially adapted for use in connection with electric or electronic organis for the purpose of creating percussion effects and also to cause sounds to be intermittently produced.

Among the special effects available in connection with an electric or electronic organ are banjo xylophone and marimbaphone effects, and the like, all of which are characterized in the intermittent production of the sounds.

Heretofore, such effects have been created by interrupting the signal supply periodically, or, on the other hand, periodically permitting the signal supply to pass through to the speaker means of the organ. While the simple interrupting of the signal or the simple passing through of the signal produces a repeated sound, the arrangements heretofore provided for that purpose have been lacking in certain respects and the effects that have been obtained have departed in rather substantial degrees from the sounds of the various instruments which the special circuitry was provided to simulate.

As is known, each musical instrument or percussion device has, among its other characteristics, a certain rate of attack and rate of decay which contributes certain outstanding characteristics to the sounds produced thereby. The simple initiation and interruption of a signal is not sufficient to approximate the rates of attack and rates of decay in the sound needed to arrive at a relatively close simulation of the sound of the natural instrument of the nature referred to.

Still further, repeater circuits, as they are referred to in the art, have sometimes introduced transients into the organ circuits, or have otherwise so effected the circuits that the use of the respeater circuit produced some adverse effects.

With the foregoing in mind, it is a particular object of the present invention to provide a greatly improved repeater circuit for an electric organ, or the like, by means of which the effects of perscussion instruments characterized by an intermittent sound can be relatively closely simulated.

Another object of the present invention is the provision of a repeater circuit of the nature referred to which requires extremely small amounts of power to operate.

A still further object of this invention is the provision of a repeater circuit of the nature referred to in which particular rates of attack and rates of decay can be simulated in the sound given off by the instrument when the repeater circuit is active.

A still further object of the present invention is the provision of a special circuit for use in connection with an electric organ, or the like, which is subject to selective control so that the repeater circuit can be made idle, or can be turned on to produce a predetermined speed of repetition of sounds, or so that it can be triggered from an organ keying circuit or by other player controlled switches or keys.

The exact nature of the present invention and still other objects and advantages thereof will become more apparent up reference to the following detailed specification taken in connection with the accompanying drawing which illustrates in schematic form, a repeater circuit according to the present invention.

In the drawings, **10** represents a source of signals which are to be supplied to a loud speaker **12** by way of an amplifier **14**. The signals are to be periodically interrupted and established so that from a continuous source of signals supplied by signal source **10**, an intermittent sound will be produced at loud speaker means **12**.

The output side of signal source **10** is connected through a capacitor C1 to the base of a transistor Q1. The base of the transistor is connected through a resistor R1 to ground and through a second resistor R2 and a filtering resistor R3 to a wire **18** which leads through a relatively low ohmic resistor **20** to a negative source of voltage of, say, 18 volts.

The emitter of transistor Q1 is connected through a resistor R4 to ground, while the collector of the transistor is connected through a resistor R5 to wire **22**, which forms the connection between resistors R2 and R3. The collector of transistor Q1 is also connected to one side of a capacitor C2, the other side of which is connected through resistors R5′ and R6 to the source terminal of a field effect transistor T. A still further resistor R7, is connected between ground and the junction of resistors R5 and R6.

The drain terminal of field effect transistor T is connected through a resistor R8 to ground and is also connected through a capacitor C3 to the base of a transistor Q2. The base of transistor Q2 is also connected to ground through a resistor R9 and to wire **22** by way of a resistor R10. The emitter of transistor Q2 is connected to ground through the serially arranged resistors R10 and R11 while a capacitor C4 is connected between ground and the junction of resistors R10 and R11.

The collector of transistor Q2 is connected through a resistor R12 to wire **22** which is bypassed by capacitor C5. The collector of transistor Q2 is also connected through a capacitor C6 and a resistor R13 with the input side of amplifier **14**. Wire **22** is also connected to ground via a filtering capacitor C6.

In the circuit described above, transistor Q1 and the components associated therewith form an input pre-amplifier, whereas transistor Q2 and the components associated therewith form an output pre-amplifier.

The repeater circuit, yet to be described, is isolated from the regular organ circuitry by way of the pre-amplifiers above referred to, while, at the same time, the use of the two pre-amplifiers insures that the signal from the output pre-amplifier will be so phased that it will not interfere with any normal signals from the organ which are to be converted into audible sounds and which are not repeated.

Turning now to the repeater circuit, the object of the repeater circuit is to supply such signals to gate terminal G of the field effect transistor T as to vary the conductivity thereof and thereby control the supply of signals from the input pre-amplifier transistor Q1 to the transistor Q2 of the output pre-amplifier.

As is known, the field effect transistor T is characterized in having a high impedance between the source and drain terminals, S and D, respectively, when the voltage at gate G is high in one direction, while the impedance between the said terminals reduces as the voltage at gate G tends toward zero. Furthermore, the field effect transistor T has substantially linear characteristics. Accordingly, by controlling the nature of the signal supplied to gate terminal G of transistor T, a corresponding control of the supply of signals from the input pre-amplifier to the output pre-amplifier can be effected. As shown in the drawing, a high negative bias at gate G produces high impedance in transistor T, and when the voltage at gate G is zero or a low negative value, the impedance of transistor T is low.

In the form in which the repeater circuit is illustrated in the drawing, the field effect transistor T is normally conductive and does not interfere with the passage of signals from the input pre-amplifier to the output pre-amplifier or modify the signals in any manner.

Turning now to the portion of the circuit which modifies the impedance of the field effect transistor T, on the opposite side of resistor **20** from the negative voltage source is a pair of transistors Q3 and Q4 forming a Zener regulator to provide for substantially constant voltage on wire **18**. A capacitor C7, in parallel with the serially connected transistors Q3 and Q4, filters out undesirable voltage variations.

A unijunction transistor Q5 is provided which, together with the circuit components connected thereto, functions as a variable speed pulse generator and provides short spike-shaped pulses at an adjustable rate of speed. The emitter terminal of transistor Q5 is connected via capacitor C8 with wire **18** and via a resistor R14 with moveable contact **24** adjustable along the pulse generator speed controlling resistor R15, one end of which is connected to ground.

One base terminal of transistor Q5 is connected to ground by way of resistor R16 and the other base terminal is connected via resistor R17 to wire **18**. The said other base terminal of transistor Q5 is also connected through a capacitor C9 with the base of a transistor Q6 which is one of two transistors making up, together with the components connected thereto, a monostable multivibrator.

The base of transistor Q6 is connected to ground through a filter network, consisting of a capacitor C10 and resistor R17', and is also connected through a resistor R18 with one terminal **25** of an on-off switch which comprises a moveable contact arm **26** connected to wire **18** and adapted for being closed on contact **25** or disconnected therefrom.

The emitter of transistor Q6 is connected to ground at **27** and the collector thereof is connected through a resistor R19 to wire **18** and is also connected through a resistor R20 to the base of transistor Q7 which forms the other transistor of the monostable multi-vibrator. The collector of transistor Q6 is also connected through a resistor R21 with the base of a transistor Q8 forming a pulse inverter which changes the polarity of the output pulse from the monostable multi-vibrator from negative going to positive going so that the pulse will be effective for controlling the field effect transistor T.

The emitter of transistor Q7 is connected to ground at **28** and the collector thereof is connected to wire **18** through resistor R22. The collector of transistor Q7 is also connected through a capacitor C11 with the base of transistor Q6.

The emitter of transistor Q8 is connected to ground at **30** while the collector thereof is connected through resistor R23 to wire **18**. The collector of transistor Q8 is also connected through a resistor R24 to one side of a capacitor C12, the other side of which is connected to ground at **31**. Connected in parallel with resistor R24 is a branch consisting of a resistor R25 and a diode D1.

Connected in parallel with capacitor C12 is a branch comprising a resistor R26 and a resistor R27 having an adjustable tap point **32** connected to the gate G of field effect transistor T.

In operation, if switch arm **26** is disconnected from contact **25**, transistor Q6 will be in a non-conductive state so that the bases of both of transistors Q7 and Q8 will have negative bias thereon and these transistors will, thus, be in a conductive state. Conduction by transistor Q7 at this time has no effect on the circuit but conduction of transistor Q8 will cause the gate G of transistor T to be so biased that the transistor T will offer little of no impedance to the passage of signals from the input pre-amplifier to the output pre-amplifier. Gate G of transistor T is, at this time, under a bias no more negative than only slightly negative so that the impedance of transistor T is quite low. The exact level of the bias on gate G of transistor T is, of course, variable according to the setting of adjustable tap point **32** along resistor R27.

While transistor Q6 is non-conductive, the pulse generator, represented by unijunction transistor Q8 is, of course, supplying spike pulses, but these pulses are positive going and have no effect on transistor Q5 when the latter is in a non-conductive condition.

Closing of switch arm **26** on contact **25** will supply negative bias from wire **18** through resistor R18 to the base of transistor Q6 so that the latter will be in a conductive state. When transistor Q6 conducts, transistors Q7 and Q8 are non-conductive and when transistor Q8 is non-conductive the gate G of field effect transistor T goes negative and the field effect transistor T is also non-conductive.

Turning now to the pulse generator, the rate at which capacitor C8 will build up a charge is determined by the combined resistances of R14 and R15 and, since the latter is adjustable, the rate at which the charge builds up on capacitor C8 is also adjustable. In any case, when the potential of the side of C8 toward resistor R14 reaches a certain value, the unijunction transistor Q5 will conduct and a spike pulse as represented at **40** will be conveyed through capacitor C9 to the base of transistor Q6. This pulse will make transistor Q6 go to non-conduction and, as explained before, this will bring about conduction of transistors Q7 and Q8. The pulse is supplied to the base of transistor Q8 and which represents the effective output pulse of the monostable multi-vibrator is a negative going pulse of approximately 10 milliseconds duration as indicated at **41**. The voltage at the collector of Q8, and which represents the effective pulse from the pulse inverter is a positive going pulse of the same duration as pulse **41**, and is represented at **42**.

The network consisting of the resistors R24, R25, R26, R27, diode D1 and capacitor C12 is a pulse shaping network that determines the shape of the pulse supplied to gate G of the field effect transistor T. During the time that transistor Q8 was non-conductive, capacitor C12 built up a charge from wire **18** via resistors R23 and R24. Normally, capacitor C12 becomes fully charged in this manner. When transistor Q8 commences to conduct and a positive going pulse is supplied to the juncture of resistors R23, R24, and R25, capacitor C12 will discharge. At this time diode D1 becomes conductive and a pulse will be supplied to gate G of field effect transistor T having a configuration somewhat along the lines illustrated at **43**. The portion of the pulse shown at **43** to the left of the peak represents the rate of attack for signals passing through transistor T, while that portion of the plate **43** to the right of the peak thereof represents the rate of decay of the said signals.

It will be evident that by selecting and modifying the components in the pulse shaping network, substantially any desired configuration of pulse to the gate G of the field effect transistor T can be formed.

With further reference to the spike pulse **40**, the pulse **41** representing the output from the monostable multi-

vibrator, the pulse 42 representing the output from the pulse inverter, and the pulse 43 which represents the pulse from the pulse shaping network that is supplied to the gate of transistor T, each of the said pulses is initiated at the time T1 and each of pulses 41 and 42 is of ten milliseconds duration. As to pulse 43, the peak point thereof will be seen to occur at a time T2 which is approximately ten milliseconds after time T1. The portion of pulse 43 to the left of the peak thereof is thus of the same duration as the pulses from the monostable multi-vibrator and from the pulse inverter. The angle of inclination of pulse 43 to the left side of the peak thereof is, of course, a function of the pulse shaping network. Similarly, the portion of pulse 43 to the right of the peak thereof, and which may be approximately 80 milliseconds, more or less, is also a function of the particular pulse shaping network employed.

It will be apparent that the pulse shaping network is determinative of the configuration of pulse 43 supplied to the gate of transistor T and which pulse 43 is, in turn, determinative of the manner in which the impedance of the field effect transistor T varies. Further, the width of the pulse supplied by the monostable multi-vibrator and the pulse inverter can be varied in which and this will also effect the shape of the pulse supplied to the gate of the field effect transistor.

As mentioned before, the circuit, as thus far described, could be considered as free running in that the closing of switch arm 26 on contact 25 sets the circuit into operation and the conduction of field effect transistor T varies according to a pre-adjusted time cycle. However, it is possible to operate the circuit in other manners and examples of this have been schematically illustrated in the drawing.

If, for example, the switch arm 50 is moved downwardly from contact 51 to contact 52, the monostable multi-vibrator could be triggered from a negative voltage source 53 by the closing of a switch 54. Still further, if switch arm 50 is adjusted to its lower position in engagement with contact 52, and switch arm 55 is adjusted from engagement with contact 56 into engagement with contact 57, the monostable multi-vibrator could be operated by a signal developed by the closing of a playing key 58 which causes a circuit component 59 to supply a signal to an electronically operable keying switch 60 interposed between voice circuit means 61 and amplifier means 62.

From the foregoing, it will be seen that the repeater circuit referred to can be operated in many different manners and can be employed for the production of a repeating tone or can be employed in connection with percussion effects requiring either a slow or fast attack or a long or short decay or any combination thereof desired.

The circuit is relatively simple and inexpensive and produces no distortion whatsoever in the resulting tones and imposes no load on the circuitry and is extremely flexible and can be adjusted and modified to meet substantially any of the conditions generally referred to above.

In the drawing, the FET shown at T is an N-channel device and positive going pulses are supplied to the gate thereof to reduce the impedance of the device in a controlled manner. However, the device could be a P-channel device in which case the gate would take a positive bias to produce high impedance of the device, and negative going pulses would be supplied to the gate to reduce the impedance of the device in a controlled manner. Both N-channel devices and P-channel devices are contemplated within the purview of the present invention.

It will be understood that this invention is susceptible to modification in order to adapt it to different usages and conditions and, accordingly, it is desired to comprehend such modifications within this invention as may fall within the scope of the appended claims.

What is claimed is:

1. In combination: a signal source, a signal receiver, a field effect transistor having one of its source and drain terminals connected to the output side of said signal source and the other thereof connected to the input side of said signal receiver, said field effect transistor having a gate terminal, the impedance of said field effect transistor being high when the bias on said gate terminal is high in one direction and reducing as the bias on said gate terminal changes toward the other direction, and control means for controlling the bias on said gate terminal to control the strength of the signals reaching said signal receiver from said signal source via said field effect transistor, said control means comprising pulse shaping network having one end connected to ground, a source of voltage connected to the other end of said network, said gate being connected to a first point of said network located between said ends, and means connected to said network at a second point between said first point and said other end and operable for selectively connecting said second point to another point which is at a different potential than that normally existing at said second point for thereby varying the potential at said first point for controlling the bias on said gate terminal of said field effect transistor.

2. The combination according to claim 1 in which said other point is ground.

3. The combination according to claim 1 in which said last mentioned means is a second transistor having its collector-emitter circuit connected between said second point and ground, and second means connected to the base of said second transistor for controlling the bias on said base and thereby controlling the conductivity of said second transistor.

4. The combination according to claim 3 in which said second means is a monostable multi-vibrator having an output terminal connected to the base of said second transistor, said monostable multi-vibrator having a control input terminal.

5. The combination according to claim 4 in which said monostable multi-vibrator comprises third and fourth transistors and said output terminal is connected to the collector-emitter circuit of said third transistor, said control terminal of said monostable multi-vibrator being connected to the base of said third transistor, and third means connected to said control terminal and operable for supplying trigger pulses thereto to control the conductivity of said third transistor.

6. The combination according to claim 5 in which said third means comprises a pulse generator.

7. The combination according to claim 6 in which said pulse generator comprises an adjustable speed controlling resistor.

8. The combination according to claim 5 in which said third means comprises a source of biasing voltage and switch means operable to connect said source of biasing voltage to said control terminal.

9. The combination according to claim 5 in which said third means comprises the keying circuit of an electrical musical instrument and includes player controlled key means.

10. The combination according to claim 1 in which said signal source includes an input pre-amplifier and said signal receiver includes an output pre-amplifier.

11. The combination according to claim 10 in which said source of signals includes signals adapted to be reproduced as sound and said signal receiver comprises speaker means to convert the signals received by said signal receiver into sound.

12. The combination according to claim 1 in which said pulse shaping network is a resistance-capacitor network.

13. The combination according to claim 12 in which said pulse shaping network comprises a main resistance branch extending from said one end of said network to said other end thereof, a capacitor connected between a third point of said network being located between the said first and second points thereof and ground, and a

resistor and diode connected in series between said second and third points in bypassing relation to the part of the main resistance branch therebetween and with said diode poled in a direction toward said third point.

14. The combination according to claim **13** in which at least said one point is adjustable along said main resistance branch.

15. The combination according to claim **7** which includes a selectively operable switch connected between a source of biasing voltage and the base of said third transistor operable when closed to place said third transistor in that condition of conduction or non-conduction which is opposite to that caused by a said trigger pulse supplied to the base of said third transistor.

16. The combination according to claim **1** in which said second means is a pulse inverting transistor having its collector-emitter circuit connected between said second point and ground, a monostable multi-vibrator having third and fourth transistors, the base of said second transistor being connected to the collector-emitter circuit of said third transistor, said third transistor being conductive when the base thereof is negatively biased, said second transistor being biased toward non-conduction when said third transistor conducts and toward conduction when said third transistor is non-conductive, means connected

to the base of said third transistor for supplying positive going trigger pulses to said base, and other means connected to the base of said third transistor for selectively connecting said base to a source of negative biasing voltage.

17. The combination according to claim **16** in which means including a capacitor is connected to the base of said third transistor for controlling the length of time said third transistor is non-conductive following the supply of a positive going trigger pulse to the base thereof.

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