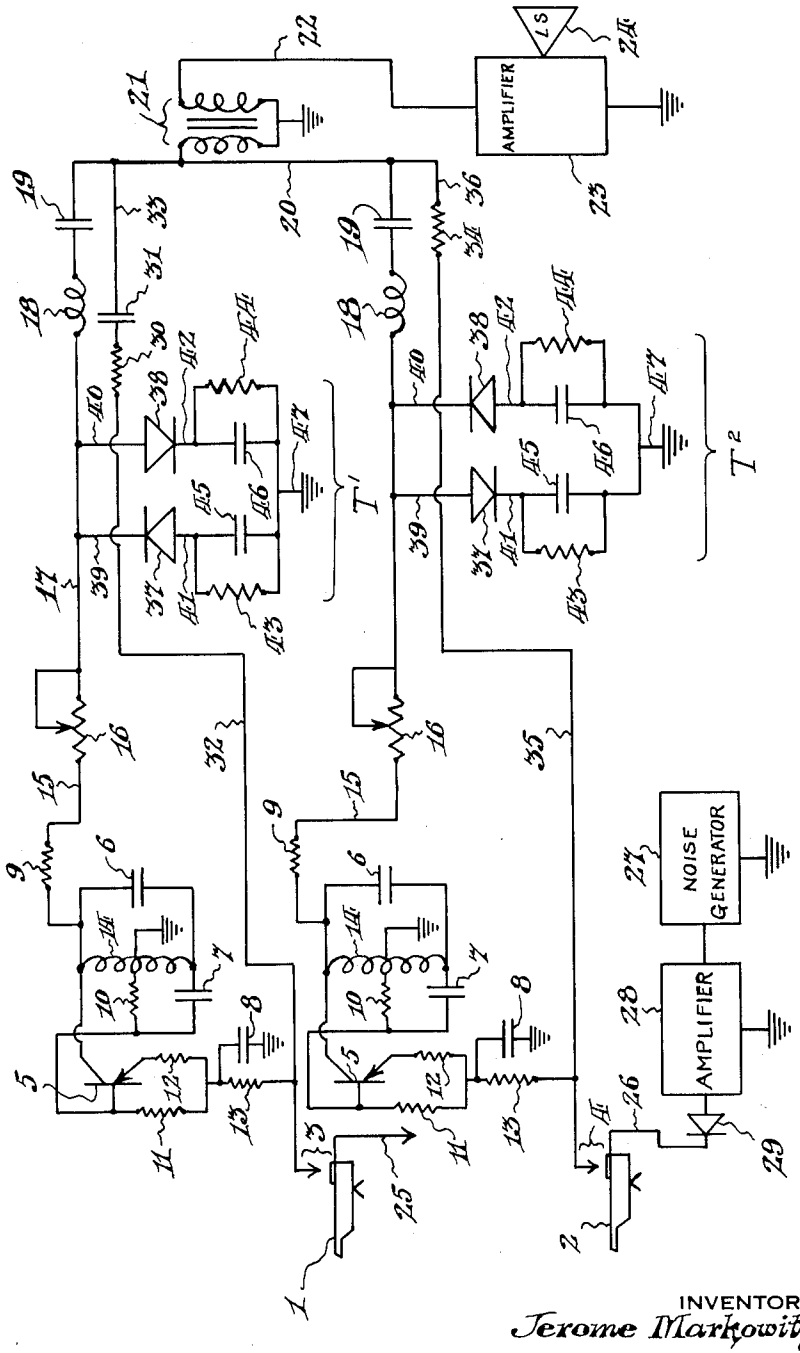
June 27, 1961 J. MARKOWITZ 2,989,886

ELECTRONIC ORGAN AND THE LIKE HAVING CHIFF AND OTHER TONAL CHARACTERISTIC PRODUCING MEANS

Filed May 15, 1959 5 Sheets-Sheet 1

Fig. 1.



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Filed May 15, 1959 5 Sheets-Sheet 2

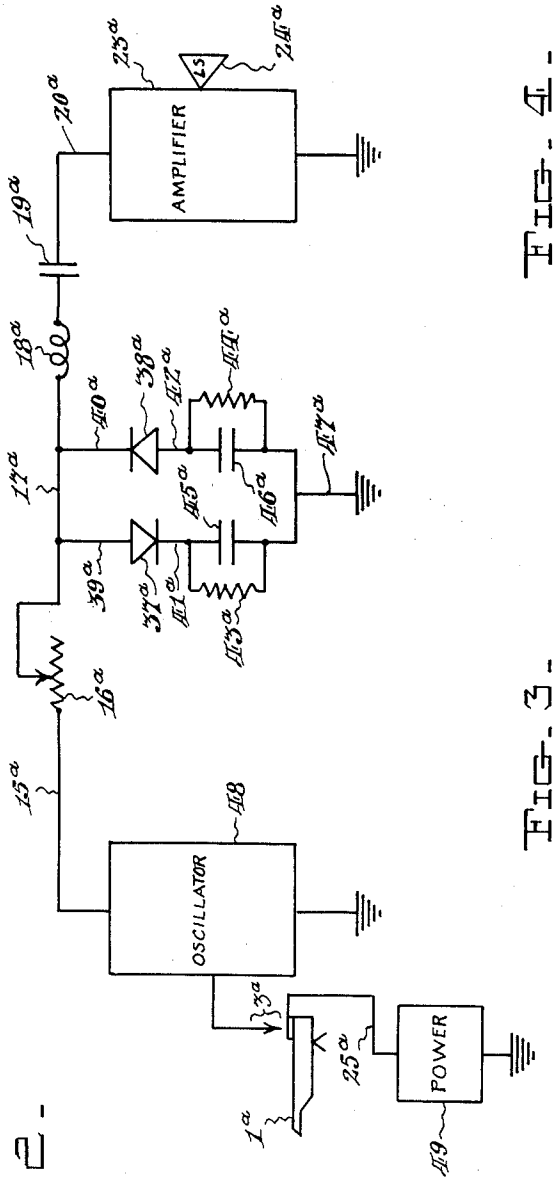


FIG. 2.

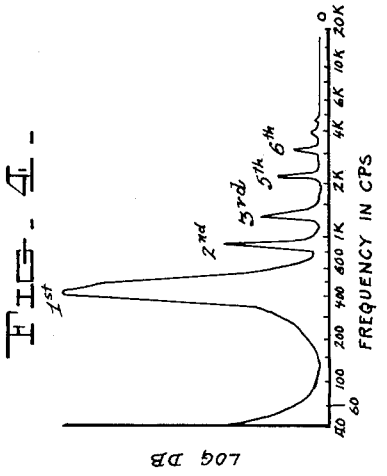


FIG. 4.

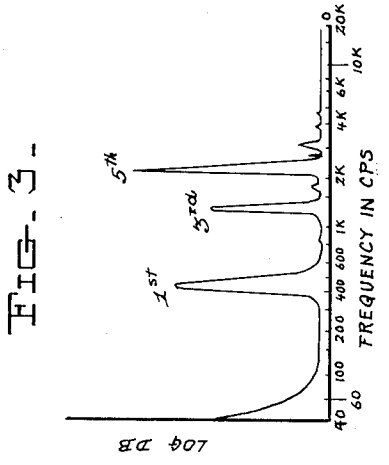


FIG. 3.

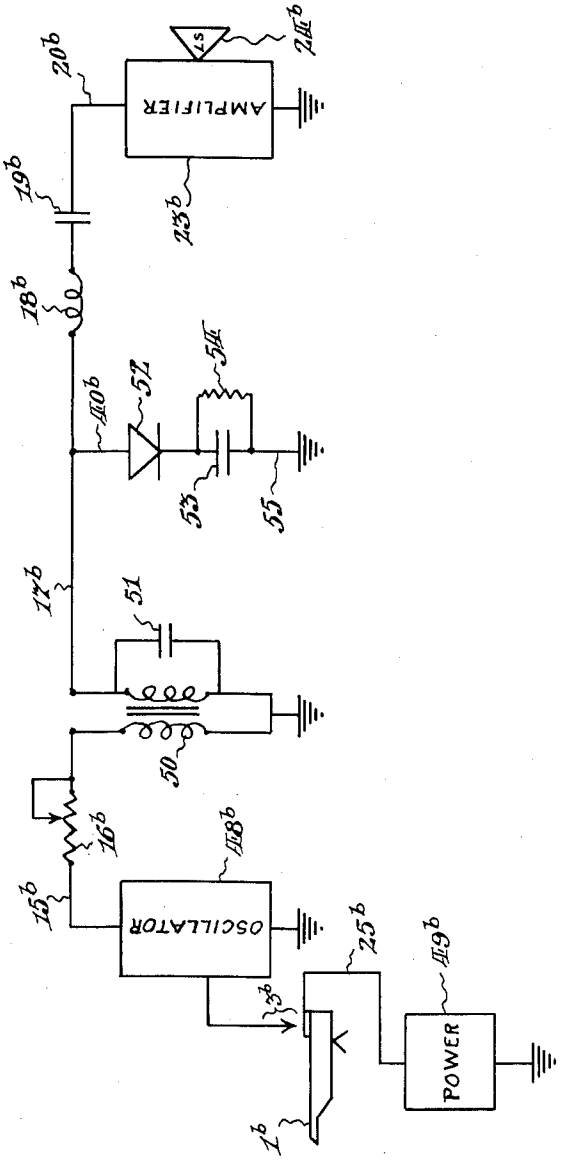
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ELECTRONIC ORGAN AND THE LIKE HAVING CHIFF AND OTHER TONAL CHARACTERISTIC PRODUCING MEANS

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FIG. 5.



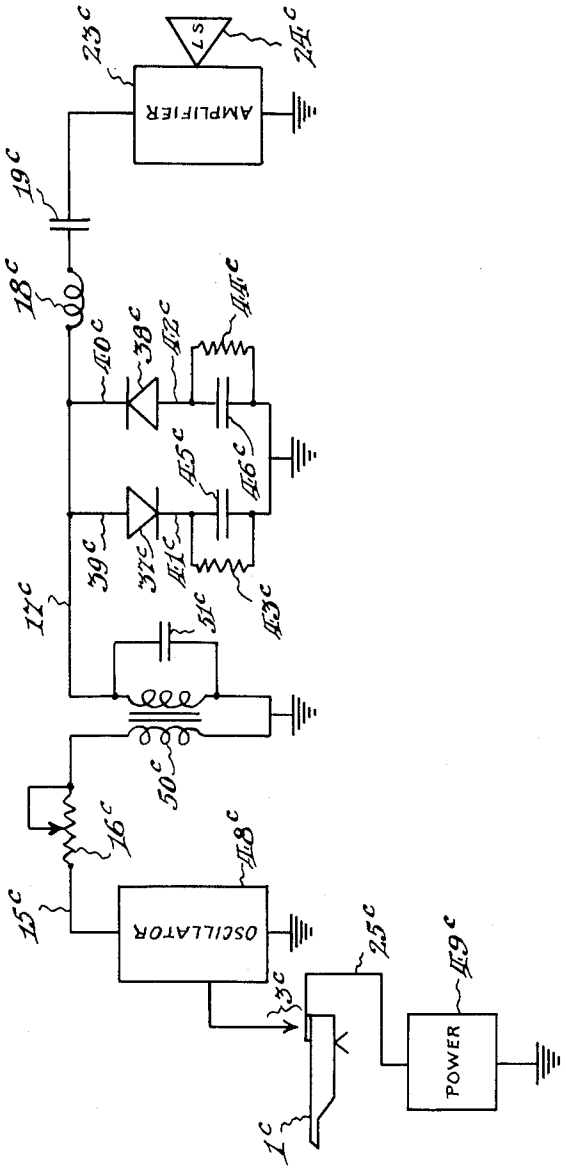
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ELECTRONIC ORGAN AND THE LIKE HAVING CHIFF AND OTHER TONAL CHARACTERISTIC PRODUCING MEANS

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FIG. 6.



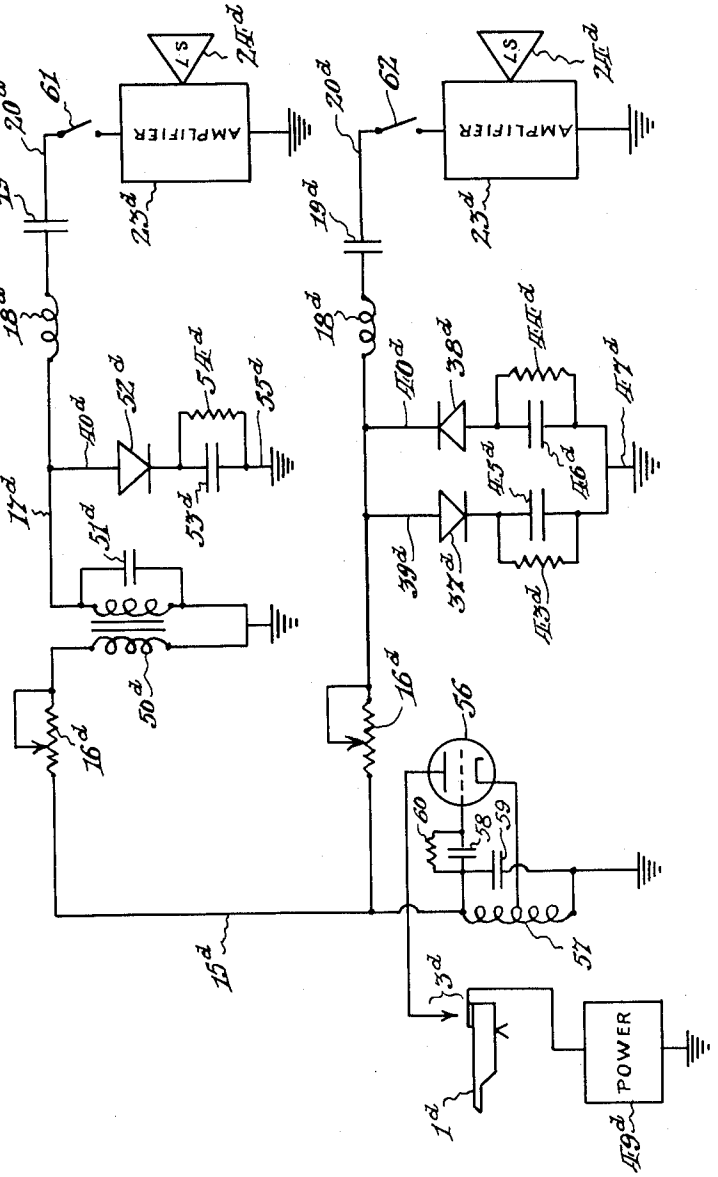
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ELECTRONIC ORGAN AND THE LIKE HAVING CHIFF AND OTHER TONAL CHARACTERISTIC PRODUCING MEANS

Filed May 15, 1959 5 Sheets-Sheet 5

FIG. 7.



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United States Patent Office 2,989,886 Patented June 27, 1961

2,989,886

ELECTRONIC ORGAN AND THE LIKE HAVING CHIFF AND OTHER TONAL CHARACTERISTIC PRODUCING MEANS

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Filed May 15, 1959, Ser. No. 813,376
10 Claims. (Cl. 84—1.19)

This invention relates to electronic musical instruments, such as electronic organs, and more particularly concerns unique means adapted to be included in the electrical systems of such instruments to enable the same to produce, in combination with the usual or normal fundamental tones thereof, certain special transient sound variations or modifications that effect substantial correspondence, equality, or identity, between the musical or tonal capabilities and capacities of the electronic instrument and those of the particular category of imitated counterpart musical instruments which inherently produce such special transient sound variations or modifications.

The perfectionists among classical organists, in making critical comparisons between the musical or tonal capabilities and capacities of available modern electronic organs and those of the imitated counterpart pipe organs, are prone to hold that there still exist certain readily discernible and significant transient sound variations or modifications which, to those appreciative of the best in organ music, lend a certain measure of superiority to the pipe organ music. In support of this holding, the said perfectionists contend that such transient sound variations or modifications are more particularly apparent, or pronounced, when it comes to a comparison between the modern electronic organ and, for example, the older type pipe organs of the so-called baroque or classical period. In this connection, the said perfectionists contend that, to the more discriminating pipe organ music enthusiasts, the indicated transient sound variations and modifications have a distinct and characteristic musical appeal. These special transient musical sound variations or modifications referred to by the said perfectionists seem to stem from the unnicked pipes and low pressure wind system of such older type pipe organs and are in the order of pipe speech or articulation characteristics that provide such pipe organs with sound capabilities and capacities difficult to analyze and define with any degree of accuracy, due mainly to the transient nature thereof. However, the audible order of the special transient musical or tonal variations or modifications of the mentioned older type pipe organs, seem to initially comprise a combination air noise and certain extra loud harmonic tonal components, which combination, after a short period, develops into a somewhat stabilized or steady state tone of a more readily analyzable series of harmonics. For identification and condensed designation purposes, the said audible order of special transient musical or tonal variations or modifications characteristic of the referred to older type pipe organs, will hereinafter be expressed by the word "chiff."

Although the production of certain types of transient musical or tonal variations or modifications has heretofore been made possible by electronic musical instruments which incorporate, for example, air means, in accordance with the invention of my U.S. Patent No. 2,888,850, which was issued on June 2, 1959, or incorporate electronic means in accordance with U.S. Patent No. 2,846,208, which was issued October 25, 1949, to my knowledge, the problem of making it possible for an electronic musical instrument, or organ, to produce the indicated chiff type transient tonal variations, or modifications, has not heretofore been solved.

One object of my invention is to provide novel means which can be readily cooperatively associated with the tone producing system of an electronic musical instrument, such as an electronic organ, so as to enable the latter to produce chiff type transient musical or tonal sound variations or modifications, thereby to effect substantial correspondence or identity, between the musical and tonal capabilities and capacities of the said electronic musical instrument and that of the particular category of simulated musical instruments which constitutes the counterpart of said electronic instrument and inherently produces chiff type transient musical or tonal sound variations or modifications.

Another object is to provide such means in the form of a chiff generating unit or arrangement having certain structural, functional and other features of advantage over the prior art transient sound producing units that are associated with electronic musical instruments.

An additional object is to provide such a chiff unit or arrangement which comprises a single pole, single throw key contact per note pitch compatible with any standard electronic organ system, which contact controls the chiff sound transient that is automatically combined with the steady state tone of the particular key.

Another object is to provide such a chiff unit or arrangement which comprises a simple tuned chiff circuit that is adapted to be cooperatively combined with a regular or standard tone generator of an electronic musical instrument in such manner as to make it possible to selectively include with the particular tone of the generator, a chiff type transient musical or tonal effect.

Another feature of the invention resides in the provision of such a chiff unit or arrangement which comprises an electronic oscillator, a single contact key controlled chiff circuit of substantially maximum structural and functional simplicity in that it may include only a single diode and does not require any external biasing voltages and which chiff circuit is also free of leakage into the audio system in that the oscillator is operative only when the control key thereof is depressed.

A further object is to provide a relatively simple, completely electronic organ, which has cooperatively combined or associated with its musical tone or sound producing system, novel means for producing chiff type musical or tonal variations or modifications.

Another object is to provide an electronic oscillator type organ, the tonal output of which includes random variations such as are found in pipe organs because the operating potential of these oscillators is derived from a supply source with inherent random output voltage characteristics.

With these and other objects in view, which will become more readily apparent from the following detailed description of the various embodiments of my novel and practical improvements that are illustrated and exemplified by the accompanying drawings, my invention comprises the unique electronic musical instrument, chiff circuits, elements, features of construction and arrangement of parts in cooperative relationship, as more particularly indicated and defined by the hereto appended claims.

In the drawings:

FIGURE 1 is a diagrammatic, or a schematic, illustration which discloses certain electronic tone producing and other parts of a standard or conventional electronic organ system, having my invention cooperatively associated therewith.

FIG. 2 is an illustration similar to FIG. 1, but shows only a single chiff type electronic tone producing circuit, or arrangement, in accordance with my invention, which is adapted to be incorporated in an electronic

musical instrument system and controlled by one of the operating keys thereof.

FIGS. 3 and 4 are heterodyne type wave analyzer diagrams which indicate the chiff type tonal characteristics generated by the circuit arrangement of FIG. 2.

FIGS. 5, 6 and 7 are diagrammatic, or schematic, illustrations which respectively disclose certain modified chiff type electronic tone producing generators or arrangements in accordance with my invention, that are adapted to be incorporated in an electronic musical instrument system and, in each instance, are controlled by a single operating key of such an instrument.

For purposes of illustration and exemplification, my invention is herein disclosed as embodied in, or applied to, a standard, or conventional type electronic organ. However, only those parts of such an electronic organ have been shown or indicated in the drawings as are deemed necessary to facilitate a clear understanding of the construction and operation of my invention, the performance of its intended purpose in cooperative relation with the tone producing system of such an organ and the manner in which it achieves certain unique, desirable and advantageous results. In this connection it is, of course, to be understood that the elecronic organ system with which my invention is cooperatively associated, includes all those usual standard and conventional mechanical, electrical and electronic parts that make such a system complete in every respect and operative in the manner of the prior art electronic organ practice. For further information concerning a complete electronic organ system reference may be had to the pertinent prior art U.S. patents and literature made available by electronic organ manufacturers.

From the disclosure of my invention in association with an electronic organ, it will be readily apparent to those skilled in this art how the same can be similarly applied to and utilized with electronic musical instruments in general.

It will be helpful to an understanding of my invention to first briefly point out some of the more important aspects and phases thereof so that these may be kept in mind when subsequently reading the detailed description of the various embodiments thereof that are disclosed in the drawings. Accordingly, it is noted that the instant invention is more particularly adapted to effect the modification, or variation, of the fundamental tones of an electronic organ in such manner that such tones include the previously indicated chiff type tonal characteristics, thereby to effect substantial correspondence, or identity between the musical and tonal capability and capacity of the electronic organ to which my invention is applied and, for example, a baroque or classical period type pipe organ that has a tone producing system normally or inherently endowed with such chiff type tonal characteristics.

At the present time, there seems to be no definite explanation for what actually occurs when a pipe of the mentioned baroque or classical period type pipe organ is caused to "speak," but it is clearly evident that the pipe tones of such an organ include, along with their fundamental harmonic tonal structure, a certain sound, noise, or special tonal characteristic, that differentiates the tones of such an organ from those of the pipe organs provided in more recent times. Since the baroque or classical period type pipe organs differ structurally and functionally from pipe organs provided in more recent times, mainly in that the baroque type pipe organs embody unnicked pipes that are activated by a low pressure wind system, it seems logical to assume that the special tonal and musical characteristics of the baroque type pipe organs stem from, or are due to, such, and perhaps other, structural and functional variations.

To my knowledge, these special tonal and musical characteristics which I prefer to designate, or identify, by the word "chiff," have not heretofore been producible with an electronic instrument, such as the electronic organ or the like.

Referring now to the accompanying drawings, in which similar reference characters designate corresponding parts, these illustrate various means in accordance with my invention that can be readily cooperatively associated with the tone producing system of a standard or conventional type electronic organ, for the purpose of modifying, or varying, the fundamental tones thereof, so as to include the chiff type tonal characteristics.

In FIG. 1, certain of the well known parts of the tone producing system of an electronic organ are schematically indicated. These parts generally comprise two of the organ console keys **1** and **2**, which form part of a complete tone range operating set of such keys and which respectively actuate single contact switches **3** and **4**, of two electronic fundamental tone producing circuits T^1 and T^2. The upper one of said circuits, for exemplification, is arranged to produce a high organ tone or note, such as a high C of 1024 cycles, whereas the lower circuit produces a low organ note, or tone, such as low C of 64 cycles. The upper and lower circuits are similar to a certain extent in that each circuit includes such usual fundamental organ tone producing elements as a standard or conventional transistor type oscillator **5**, capacitors **6**, **7**, **8**, resistors **9**, **10**, **11**, **12**, **13** and an inductance element **14**, all of which elements are connected with each other and grounded, as indicated, in the usual manner of the prior art electronic organ system construction practice. Both of said circuits also include a conductor **15** which connects the resistor **9** with a usual type variable resistance unit **16** for controlling the loudness or softness of the particular organ tone produced, as well as a conductor **17** which connects unit **16** with an inductance element **18** that is combined in series connected relation with a capacitor **19** to effect tuning of the organ tone so that it will include the desired harmonics. A conductor **20** is arranged to connect the capacitors **19**, **19**, with the primary winding of a transformer **21** and the secondary winding of the latter is connected by a conductor **22** with a usual type amplifier unit **23**, and has combined therewith a loudspeaker **24**.

The keys **1** and **2** of the organ keyboard are respectively connected by wires **25** and **26** to a source of power, including the depicted series connected parts comprising an electronic noise generator **27**, an amplifier **28** and a rectifier **29**. The noise generator **27** may be of a well known type made and sold by the Grason-Stadler Co., of West Concord, Massachusetts and the amplifier **28** and rectifier **29** may be of a standard type available on the open market. Such a power source constitutes a random varying source of direct current power which provides the fundamental organ tones produced respectively by the upper and lower circuits shown in FIG. 1, with a continuous random varying tonal characteristic.

If desired, the upper circuit may be provided with means which will impart to the fundamental high C organ tone produced thereby a special tonal characteristic, such as a high white noise characteristic, which white noise characteristic is similar to the air noise of a conventional organ pipe. Similarly, if desired, the lower circuit may be provided with means which will impart to the fundamental low C organ tone produced thereby, a low white noise characteristic. The means for imparting to the fundamental organ tone produced by the upper circuit, a high white noise characteristic, is shown in FIG. 1 as comprising the inclusion in the upper circuit of a series connected combination resistor **30** and capacitor **31**, which combination is connected between the key **1** and the conductor **20**, by wires **32** and **33**. The means for producing a low white noise or simulated low air sound characteristic is shown as comprising the inclusion in the lower circuit of a resistor **34** which is connected between the key **2** and the conductor **20** by wires **35** and **36**. The use of a resistor only in the lower note

or sound producing circuit provides a characteristically lower white noise, or air sound effect, because of the natural impedance of a resistor to higher frequencies, whereas the resistor-capacitor combination in the upper or higher tone producing circuit limits the amount of lower frequencies and provides a higher pitched type air sound than that which is applied to the lower note.

The electronic organ circuitry of FIG. 1, which has so far been described, is illustrative of a system for introducing random tonal variations of a determined intensity and frequency and also for introducing "wind noise" at the same time. Noise generator **27** is coupled to amplifier **28** so as to provide sufficient voltage output and current to act as a supply voltage source to transistor oscillators **5**. The voltage output of amplifier **28** is fed through the rectifier **29**, through the key and contact arrangements **1** and **3**, and **2** and **4**, to the transistor oscillator arrangements comprising the parts **5**, **6**, **7**, **9**, **10**, **11** and **12** inclusive. In connection with this arrangement, resistor **13** and capacitor **8** function as a delay or keying circuit so that the "speech" of the transistor oscillator arrangement is similar to that of an organ pipe. This resistor-capacitor network also functions as a filter for the rectified A.C. voltage which originates at the noise generator **27**. The filtering effect of resistor **13** and capaictor **8** is not complete. In other words, pure direct current such as normally used as a supply voltage for transistors and similar electron oscillators, is avoided. The filtering effect of resistor **13** and capacitor **8** is incomplete to the extent that the output of the transistor oscillator arrangements will be modulated by the random voltage which is produced by noise generator **27** through amplifier **28** and rectifier **29**. In actual practice the size of resistors **13** and associated capacitors **8** is "scaled" through the various notes of the organ system so that the proper amount of random variations is present in each note. Generally speaking, much larger capacitors and resistors are required for the lower notes than for the higher notes. Rectifier **29**, as shown, is an ordinary half-wave rectifier, however, it is to be understood that more complex rectifiers, such as a full-wave bridge rectifier could be employed. Such arrangements are old and the application of rectifiers to alternating currents is well known in this art.

Concerning the advantage of including the white noise tonal characteristics with the fundamental tones produced by the upper and lower circuits of FIG. 1, it is pointed out that such white noise tonal characteristics are the electrical equivalents of the air noises present in connection with the fundamental tones produced by the pipes of a conventional pipe organ. The presence of air noise in an organ pipe invariably raises the issue of whether this is desirable per se or whether this desirability is due to an association with familiar musical sounds. The advantage of including the white noise tonal characteristics in an electronic organ system of the type exemplified by FIG. 1 will become apparent if it is assumed, for example, that the wave shape of an electronic organ tone, or signal, is equivalent to that of a particular pipe tone of a pipe organ and involves an equal amount of fundamental and upper harmonics. If a low level white noise is impressed upon this signal, beats or interferences will be set up between the frequencies of the white noise that are close in frequency and intensity to the frequency components of the electronic organ tone, or signal. In effect, therefore, there is produced a random pitch fringe noise, sound, or something akin to many random tremulants effecting the upper partials of the tone. This effect, which can be recognized in organ pipe tones, is duplicated by the injection of the white noise into the basic tone of the upper and lower circuits of FIG. 1, by the means previously described.

The electronic organ circuitry of FIG. 1, which has so far been described, shows how to combine with the fundamental tones produced, certain transients, such as white noise and other tonal characteristics. The chiff generating means of my invention is adapted to be cooperatively utilized and combined with such a circuitry in the manner next described.

One form of chiff generating means in accordance with my invention is shown cooperatively associated with the upper organ tone producing circuit of FIG. 1, and corresponding chiff generating means is shown cooperatively associated with the lower organ tone producing circuit of FIG. 1. Since the chiff generating means of both these circuits are structurally and functionally alike, descriptive redundancy will be avoided by describing only one such means and applying the same reference characters mentioned to the corresponding parts of both such chiff generating means.

The form of chiff generating means of my invention shown in FIG. 1, comprises a pair of matched opposite polarity silicon type diodes **37** and **38**, each having one terminal thereof connected with the conductor **17** by separate wires **39** and **40** and the other terminal thereof connected by separate wires **41** and **42** with two similar time-constant capacitor-resistor combination units that, in each instance, consist of corresponding resistor elements **43** and **44** and corresponding capacitors **45** and **46** arranged in parallel connected relationship, as shown, both of which units are grounded by a conductor **47**.

The form of chiff generating means disclosed in FIG. 1 functions substantially as follows:

When one of the keys **1** or **2** is depressed, the transistor oscillator (comprising parts **5** to **14**, inclusive) of the respective upper or lower circuit, will be caused to oscillate and as a consequence an audio voltage flows through variable resistor **16** through a tuned unit which is represented by inductance **18** and capacitor **19**, to a relatively low impedance load represented by the primary of transformer **21**. The said audio voltage will flow through both of the diodes or rectifiers **37** and **38** and charge both capacitors **45** and **46**. While these capacitors are charging, current will flow through the diodes **37** and **38**. The presence of these diodes in the active circuit will cause the generation of an odd series of harmonics. The purpose of the inductance **18** and capacitor **19** is to provide a tuned circuit to select the desired harmonic or harmonics which are desired to speak during the initial period of the oscillation. When capacitors **45** and **46** are fully charged (the amount of time desired for this purpose being established by the size of the capacitors) no more current will flow through the diodes **37** and **38**. The wave shape which appears across impedance load, represented by the amplifier **23**, will then revert to the normal wave shape of the output of the oscillator comprising parts **5** to **14** inclusive, plus any further modification of this wave shape which may be caused by inductance **18** and capacitor **19**.

As an exemplification of the tonal effect produced by the chiff generating means, let it be assumed that the oscillator comprising elements **5** to **14** inclusive, provides a tone or signal which consists of a fundamental and certain upper harmonics of lower intensity. Let it also be assumed that the series tuned circuit elements **18** and **19** are tuned to the 5th harmonic of the fundamental. When a key **1** or **2** is depressed a strong 5th harmonic will immediately appear across the load represented by the amplifier **23** along with a lesser amount of fundamental and 3rd harmonic. When capacitors **45** and **46** become charged, no more current will flow through the harmonic generating diodes **37** and **38** and the wave form developed across load **23** will revert to the original wave shape of the tone generator comprising parts **5** to **19** inclusive, namely, that of the fundamental and certain harmonics of lower intensity. When the keys **1** and **2** are raised, the charge in the capacitors **45** and **46** will leak off through resistors **43** and **44**, preparing the circuit for proper operation the next time that

the key is depressed. Typical values of the chiff circuit components for C–256 cycles are as follows:

Capacitor **45**	mfd..	.05
Capacitor **46**	mfd..	.05
Capacitor **19**	mfd..	.01
Resistor **43**	megohms..	3
Resistor **44**	do....	3
Inductance **18**	millihenries..	400

Such functioning of the chiff generating means will be further clarified when considering the heterodyne type wave analyzer diagrams of FIGS. 3 and 4, in conjunction with a description of FIG. 2, which follows.

FIG. 2 is a simplified illustration of a single contact key controlled electronic organ system circuit similar to either the upper or the lower electronic organ circuit schematically or diagrammatically shown in FIG. 1, with certain electrical elements of FIG. 1 omitted. The oscillator indicated by the numeral **48** in FIG. 2 represents an arrangement of elements such as the elements **5** to **14** inclusive shown in FIG. 1 and the power unit indicated by the numeral **49** in FIG. 2 represents a steady source of direct current power, such as derived from an electrical battery. Since certain of the other elements of FIG. 2 are similar to those of FIG. 1, such similar elements have been indicated by corresponding reference characters as applied to the upper circuit of FIG. 1, with the exponent "*a*" added thereto for purposes of differentiation. It is noted that in FIG. 2 the conductor **20**^{a} connects the capacitor **19**^{a} directly with the amplifier **23**^{a}.

FIGS. 3 and 4 are heterodyne type wave analyzer charts, or diagrams, which substantially diclose the effect of the chiff generating means of the electronic organ tone producing circuit of FIG. 2 in connection with the fundamental organ tone produced by this circuit. In these charts the vertical vectors represent logarithmic decibles and the horizontal vectors represent the frequency of the tone harmonics in cycles per second.

During the first fleeting instant that the key **1**^{a} of FIG. 2 is depressed, the relationship of the frequency of the harmonics of the organ tone produced by the circuit of FIG. 2 is as shown by FIG. 3. During this first fleeting instant, the capacitors **45**^{a} and **46**^{a} are charged, as previously explained in connection with the description of FIG. 1. Continued depressing of the key **1**^{a}, after the said capacitors have been charged, will result in the harmonics of the organ tone to develop into a steady state tone in which the relationship of the harmonics is substantially as shown in FIG. 4.

It is to be noted that in the electronic organ tone producing circuit of FIG. 2, the white noise and the random variation sound producing means of FIG. 1 have been omitted. In this arrangement, the chiff generating means functions to emphasize the odd numbered harmonics, as indicated by FIG. 3, during the first fleeting instant that the key **1**^{a} is depressed.

FIG. 5 illustrates a modified form of electronic organ tone producing circuit which is similar to FIG. 2, but which includes a coupling medium, or device, in the form of a transformer **50** having a capacitor **51** shunted across its secondary winding. Such a device may be included by connecting the primary and secondary windings thereof across a gap in the conductor **17**^{b}, as shown, to effect a change in the fundamental tone produced by the circuit, somewhat in the manner or order of the change that is effected in the fundamental tone produced by the pipe of a pipe organ when such pipe, or a part thereof, is constructed of different materials, such as wood, metal, etc., or a combination of such materials. In FIG. 5 I have also shown a practical simplified form of chiff producing means, comprising a single silicon diode **52**, arranged in series connected relation with a unit consisting of a combined capacitor **53** and resistor **54**, which unit is grounded through a wire **55**. Such a simplified form of chiff producing means functions to emphasize the sounding of an even series of harmonics, during the first fleeting instant that the key of FIG. 5 is depressed. Since the circuit arrangement of FIG. 5 is otherwise substantially the same as that disclosed by FIG. 2, the elements of FIG. 5 which are like those of FIG. 2 have been indicated by corresponding reference characters, to which the exponent "*b*" has been added for purposes of differentiation.

FIG. 6 illustrates another modification of my invention which differs from the circuit arrangement of FIG. 5 only in that the circuit of FIG. 6 includes chiff generating means as disclosed and described in connection with FIG. 2. Since the circuit and circuit elements of FIG. 6 are similar to those shown in FIG. 5, except for the chiff generating means which is like that of FIG. 2, the same reference characters have been applied in FIG. 6, to designate the corresponding parts shown in FIGS. 2 and 5, but with the exponent "*c*" added thereto for purposes of differentiation.

FIG. 7 discloses another modified electronic organ tone producing circuitry in accordance with my invention. In this instance an electron tube type oscillator is combined with two fundamental tone producing circuits, i.e., an upper circuit which is like that of FIG. 5 and a lower circuit which is like that of FIG. 2, both of which are simultaneously operated when a control key **1**^{d} is depressed. In this arrangement, the tube type oscillator **56** has cooperatively combined with the filament, grid and plate thereof the usual elements that cause the said oscillator to perform its normal and intended functions, such as an inductance **57**, capacitors **58** and **59** and resistor **60**, all cooperatively connected as clearly shown and in compliance with the prior art electronic organ system practice. To avoid repetition of descriptive material, the elements of FIG. 7 that are similar to those of FIGS. 2 and 5 are identified by corresponding reference characters but with the exponent "*d*" added thereto for purposes of differentiation.

It is to be noted that, in the upper and lower circuits of FIG. 7, the two conductors **20**^{d}, which in each instance establish a connection between a capacitor **19**^{d} and an amplifier **23**^{d}, are each provided with an interposed switch **61** and **62** that may be controlled by a stop key on the organ console, so that either the upper or the lower circuit may be selectively opened, or disconnected from operation, before the key **1**^{d} is utilized or depressed.

Diagrams 2, 5, 6 and 7 do not show low impedance to input matching transformers but for practical purposes best operation will occur if the amplifiers have low impedance inputs.

It is also to be noted that the circuits of FIGS. 2, 5, 6 and 7 include plain or ordinary power supply means, whereas the circuit of FIG. 1 includes noise generator power supply means. Nevertheless, transient phenomena are established by the circuits of all these figures in the manner indicated and described.

Of course, it will be apparent to those skilled in this art that the improvements specifically shown and described can be changed and modified in various ways without departing from the invention herein disclosed, the scope of which is more particularly indicated by the hereto appended claims.

I claim:

1. In an electronic musical instrument having an oscillation generator, keying means, an amplifier and loudspeaker unit, and a resonant chiff generating circuit interposed between said generator and unit.

2. In an electronic musical instrument according to claim 1, wherein the resonant chiff generating circuit comprises a tuned circuit, at least one diode, and an associated decay circuit.

3. In an electronic musical instrument according to claim 1, wherein the resonant chiff generating circuit comprises a tuned circuit, two diodes connected in reversed order relative to each other, and an associated decay cir-

or sound producing circuit provides a characteristically lower white noise, or air sound effect, because of the natural impedance of a resistor to higher frequencies, whereas the resistor-capacitor combination in the upper or higher tone producing circuit limits the amount of lower frequencies and provides a higher pitched type air sound than that which is applied to the lower note.

The electronic organ circuitry of FIG. 1, which has so far been described, is illustrative of a system for introducing random tonal variations of a determined intensity and frequency and also for introducing "wind noise" at the same time. Noise generator **27** is coupled to amplifier **28** so as to provide sufficient voltage output and current to act as a supply voltage source to transistor oscillators **5**. The voltage output of amplifier **28** is fed through the rectifier **29**, through the key and contact arrangements **1** and **3**, and **2** and **4**, to the transistor oscillator arrangements comprising the parts **5**, **6**, **7**, **9**, **10**, **11** and **12** inclusive. In connection with this arrangement, resistor **13** and capacitor **8** function as a delay or keying circuit so that the "speech" of the transistor oscillator arrangement is similar to that of an organ pipe. This resistor-capacitor network also functions as a filter for the rectified A.C. voltage which originates at the noise generator **27**. The filtering effect of resistor **13** and capaictor **8** is not complete. In other words, pure direct current such as normally used as a supply voltage for transistors and similar electron oscillators, is avoided. The filtering effect of resistor **13** and capacitor **8** is incomplete to the extent that the output of the transistor oscillator arrangements will be modulated by the random voltage which is produced by noise generator **27** through amplifier **28** and rectifier **29**. In actual practice the size of resistors **13** and associated capacitors **8** is "scaled" through the various notes of the organ system so that the proper amount of random variations is present in each note. Generally speaking, much larger capacitors and resistors are required for the lower notes than for the higher notes. Rectifier **29**, as shown, is an ordinary half-wave rectifier, however, it is to be understood that more complex rectifiers, such as a full-wave bridge rectifier could be employed. Such arrangements are old and the application of rectifiers to alternating currents is well known in this art.

Concerning the advantage of including the white noise tonal characteristics with the fundamental tones produced by the upper and lower circuits of FIG. 1, it is pointed out that such white noise tonal characteristics are the electrical equivalents of the air noises present in connection with the fundamental tones produced by the pipes of a conventional pipe organ. The presence of air noise in an organ pipe invariably raises the issue of whether this is desirable per se or whether this desirability is due to an association with familiar musical sounds. The advantage of including the white noise tonal characteristics in an electronic organ system of the type exemplified by FIG. 1 will become apparent if it is assumed, for example, that the wave shape of an electronic organ tone, or signal, is equivalent to that of a particular pipe tone of a pipe organ and involves an equal amount of fundamental and upper harmonics. If a low level white noise is impressed upon this signal, beats or interferences will be set up between the frequencies of the white noise that are close in frequency and intensity to the frequency components of the electronic organ tone, or signal. In effect, therefore, there is produced a random pitch fringe noise, sound, or something akin to many random tremulants effecting the upper partials of the tone. This effect, which can be recognized in organ pipe tones, is duplicated by the injection of the white noise into the basic tone of the upper and lower circuits of FIG. 1, by the means previously described.

The electronic organ circuitry of FIG. 1, which has so far been described, shows how to combine with the fundamental tones produced, certain transients, such as white noise and other tonal characteristics. The chiff generating means of my invention is adapted to be cooperatively utilized and combined with such a circuitry in the manner next described.

One form of chiff generating means in accordance with my invention is shown cooperatively associated with the upper organ tone producing circuit of FIG. 1, and corresponding chiff generating means is shown cooperatively associated with the lower organ tone producing circuit of FIG. 1. Since the chiff generating means of both these circuits are structurally and functionally alike, descriptive redundancy will be avoided by describing only one such means and applying the same reference characters mentioned to the corresponding parts of both such chiff generating means.

The form of chiff generating means of my invention shown in FIG. 1, comprises a pair of matched opposite polarity silicon type diodes **37** and **38**, each having one terminal thereof connected with the conductor **17** by separate wires **39** and **40** and the other terminal thereof connected by separate wires **41** and **42** with two similar time-constant capacitor-resistor combination units that, in each instance, consist of corresponding resistor elements **43** and **44** and corresponding capacitors **45** and **46** arranged in parallel connected relationship, as shown, both of which units are grounded by a conductor **47**.

The form of chiff generating means disclosed in FIG. 1 functions substantially as follows:

When one of the keys **1** or **2** is depressed, the transistor oscillator (comprising parts **5** to **14**, inclusive) of the respective upper or lower circuit, will be caused to oscillate and as a consequence an audio voltage flows through variable resistor **16** through a tuned unit which is represented by inductance **18** and capacitor **19**, to a relatively low impedance load represented by the primary of transformer **21**. The said audio voltage will flow through both of the diodes or rectifiers **37** and **38** and charge both capacitors **45** and **46**. While these capacitors are charging, current will flow through the diodes **37** and **38**. The presence of these diodes in the active circuit will cause the generation of an odd series of harmonics. The purpose of the inductance **18** and capacitor **19** is to provide a tuned circuit to select the desired harmonic or harmonics which are desired to speak during the initial period of the oscillation. When capacitors **45** and **46** are fully charged (the amount of time desired for this purpose being established by the size of the capacitors) no more current will flow through the diodes **37** and **38**. The wave shape which appears across impedance load, represented by the amplifier **23**, will then revert to the normal wave shape of the output of the oscillator comprising parts **5** to **14** inclusive, plus any further modification of this wave shape which may be caused by inductance **18** and capacitor **19**.

As an exemplification of the tonal effect produced by the chiff generating means, let it be assumed that the oscillator comprising elements **5** to **14** inclusive, provides a tone or signal which consists of a fundamental and certain upper harmonics of lower intensity. Let it also be assumed that the series tuned circuit elements **18** and **19** are tuned to the 5th harmonic of the fundamental. When a key **1** or **2** is depressed a strong 5th harmonic will immediately appear across the load represented by the amplifier **23** along with a lesser amount of fundamental and 3rd harmonic. When capacitors **45** and **46** become charged, no more current will flow through the harmonic generating diodes **37** and **38** and the wave form developed across load **23** will revert to the original wave shape of the tone generator comprising parts **5** to **19** inclusive, namely, that of the fundamental and certain harmonics of lower intensity. When the keys **1** and **2** are raised, the charge in the capacitors **45** and **46** will leak off through resistors **43** and **44**, preparing the circuit for proper operation the next time that

the key is depressed. Typical values of the chiff circuit components for C–256 cycles are as follows:

Capacitor **45**	mfd..	.05
Capacitor **46**	mfd..	.05
Capacitor **19**	mfd..	.01
Resistor **43**	megohms..	3
Resistor **44**	do....	3
Inductance **18**	millihenries..	400

Such functioning of the chiff generating means will be further clarified when considering the heterodyne type wave analyzer diagrams of FIGS. 3 and 4, in conjunction with a description of FIG. 2, which follows.

FIG. 2 is a simplified illustration of a single contact key controlled electronic organ system circuit similar to either the upper or the lower electronic organ circuit schematically or diagrammatically shown in FIG. 1, with certain electrical elements of FIG. 1 omitted. The oscillator indicated by the numeral **48** in FIG. 2 represents an arrangement of elements such as the elements **5** to **14** inclusive shown in FIG. 1 and the power unit indicated by the numeral **49** in FIG. 2 represents a steady source of direct current power, such as derived from an electrical battery. Since certain of the other elements of FIG. 2 are similar to those of FIG. 1, such similar elements have been indicated by corresponding reference characters as applied to the upper circuit of FIG. 1, with the exponent "*a*" added thereto for purposes of differentiation. It is noted that in FIG. 2 the conductor **20^a** connects the capacitor **19^a** directly with the amplifier **23^a**.

FIGS. 3 and 4 are heterodyne type wave analyzer charts, or diagrams, which substantially diclose the effect of the chiff generating means of the electronic organ tone producing circuit of FIG. 2 in connection with the fundamental organ tone produced by this circuit. In these charts the vertical vectors represent logarithmic decibles and the horizontal vectors represent the frequency of the tone harmonics in cycles per second.

During the first fleeting instant that the key **1^a** of FIG. 2 is depressed, the relationship of the frequency of the harmonics of the organ tone produced by the circuit of FIG. 2 is as shown by FIG. 3. During this first fleeting instant, the capacitors **45^a** and **46^a** are charged, as previously explained in connection with the description of FIG. 1. Continued depressing of the key **1^a**, after the said capacitors have been charged, will result in the harmonics of the organ tone to develop into a steady state tone in which the relationship of the harmonics is substantially as shown in FIG. 4.

It is to be noted that in the electronic organ tone producing circuit of FIG. 2, the white noise and the random variation sound producing means of FIG. 1 have been omitted. In this arrangement, the chiff generating means functions to emphasize the odd numbered harmonics, as indicated by FIG. 3, during the first fleeting instant that the key **1^a** is depressed.

FIG. 5 illustrates a modified form of electronic organ tone producing circuit which is similar to FIG. 2, but which includes a coupling medium, or device, in the form of a transformer **50** having a capacitor **51** shunted across its secondary winding. Such a device may be included by connecting the primary and secondary windings thereof across a gap in the conductor **17^b**, as shown, to effect a change in the fundamental tone produced by the circuit, somewhat in the manner or order of the change that is effected in the fundamental tone produced by the pipe of a pipe organ when such pipe, or a part thereof, is constructed of different materials, such as wood, metal, etc., or a combination of such materials. In FIG. 5 I have also shown a practical simplified form of chiff producing means, comprising a single silicon diode **52**, arranged in series connected relation with a unit consisting of a combined capacitor **53** and resistor **54**, which unit is grounded through a wire **55**. Such a simplified form of chiff producing means functions to emphasize the sounding of an even series of harmonics, during the first fleeting instant that the key of FIG. 5 is depressed. Since the circuit arrangement of FIG. 5 is otherwise substantially the same as that disclosed by FIG. 2, the elements of FIG. 5 which are like those of FIG. 2 have been indicated by corresponding reference characters, to which the exponent "*b*" has been added for purposes of differentiation.

FIG. 6 illustrates another modification of my invention which differs from the circuit arrangement of FIG. 5 only in that the circuit of FIG. 6 includes chiff generating means as disclosed and described in connection with FIG. 2. Since the circuit and circuit elements of FIG. 6 are similar to those shown in FIG. 5, except for the chiff generating means which is like that of FIG. 2, the same reference characters have been applied in FIG. 6, to designate the corresponding parts shown in FIGS. 2 and 5, but with the exponent "*c*" added thereto for purposes of differentiation.

FIG. 7 discloses another modified electronic organ tone producing circuitry in accordance with my invention. In this instance an electron tube type oscillator is combined with two fundamental tone producing circuits, i.e., an upper circuit which is like that of FIG. 5 and a lower circuit which is like that of FIG. 2, both of which are simultaneously operated when a control key **1^d** is depressed. In this arrangement, the tube type oscillator **56** has cooperatively combined with the filament, grid and plate thereof the usual elements that cause the said oscillator to perform its normal and intended functions, such as an inductance **57**, capacitors **58** and **59** and resistor **60**, all cooperatively connected as clearly shown and in compliance with the prior art electronic organ system practice. To avoid repetition of descriptive material, the elements of FIG. 7 that are similar to those of FIGS. 2 and 5 are identified by corresponding reference characters but with the exponent "*d*" added thereto for purposes of differentiation.

It is to be noted that, in the upper and lower circuits of FIG. 7, the two conductors **20^d**, which in each instance establish a connection between a capacitor **19^d** and an amplifier **23^d**, are each provided with an interposed switch **61** and **62** that may be controlled by a stop key on the organ console, so that either the upper or the lower circuit may be selectively opened, or disconnected from operation, before the key **1^d** is utilized or depressed.

Diagrams 2, 5, 6 and 7 do not show low impedance to input matching transformers but for practical purposes best operation will occur if the amplifiers have low impedance inputs.

It is also to be noted that the circuits of FIGS. 2, 5, 6 and 7 include plain or ordinary power supply means, whereas the circuit of FIG. 1 includes noise generator power supply means. Nevertheless, transient phenomena are established by the circuits of all these figures in the manner indicated and described.

Of course, it will be apparent to those skilled in this art that the improvements specifically shown and described can be changed and modified in various ways without departing from the invention herein disclosed, the scope of which is more particularly indicated by the hereto appended claims.

I claim:

1. In an electronic musical instrument having an oscillation generator, keying means, an amplifier and loudspeaker unit, and a resonant chiff generating circuit interposed between said generator and unit.

2. In an electronic musical instrument according to claim 1, wherein the resonant chiff generating circuit comprises a tuned circuit, at least one diode, and an associated decay circuit.

3. In an electronic musical instrument according to claim 1, wherein the resonant chiff generating circuit comprises a tuned circuit, two diodes connected in reversed order relative to each other, and an associated decay cir-

cuit interposed between the oscillation generator and unit.

4. In an electronic musical instrument according to claim 1, which includes random noise power supply means as the operating potential for the oscillation generator.

5. An electronic musical instrument comprising; an oscillation generator; playing key contact means; an audio output circuit connected to said oscillation generator; and a power source arrangement supplying operating potential for said generator, which arrangement is characterized in that it includes a random noise generator, a rectifier, and a filter connected between the random noise generator and the oscillation generator.

6. An electronic musical instrument according to claim 5, which includes a current limiting impedance, and means establishing a connection from the playing key contact means to the audio output circuit through said current limiting impedance.

7. An electronic musical instrument comprising, an electronic oscillator, random noise generator power supply means connected to said oscillator which means constitutes the source of energy for maintaining oscillation, and an audio output circuit connected to said oscillator.

8. An electronic musical instrument comprising, an oscillation generator, random noise generator power supply means connected to said generator which means constitutes the source of energy for maintaining oscillation, an audio output circuit connected to said generator, a chiff unit including a resonant circuit connected in intermediate relation with the generator and audio output circuit, and a key-controlled single-contact for effecting simultaneous operation of the generator and chiff unit so that the sound established by the generator will be modified by the action of the chiff unit.

9. In an electronic musical instrument comprising an oscillation generator, a random voltage power supply connected to the input terminal of said generator, and an audio output circuit connected to said generator.

10. In an electronic musical instrument having an oscillation generator, a random noise modulated operating potential cooperatively associated with said generator which operating potential constitutes the source of energy for maintaining oscillation, keying means, an amplifier and loudspeaker unit, and a resonant chiff generating circuit interposed between said oscillation generator and unit.

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