Aug. 10, 1937. R. GUENTHER 2,089,204

ELECTRIC ORGAN

Filed Jan. 27, 1936 3 Sheets-Sheet 1

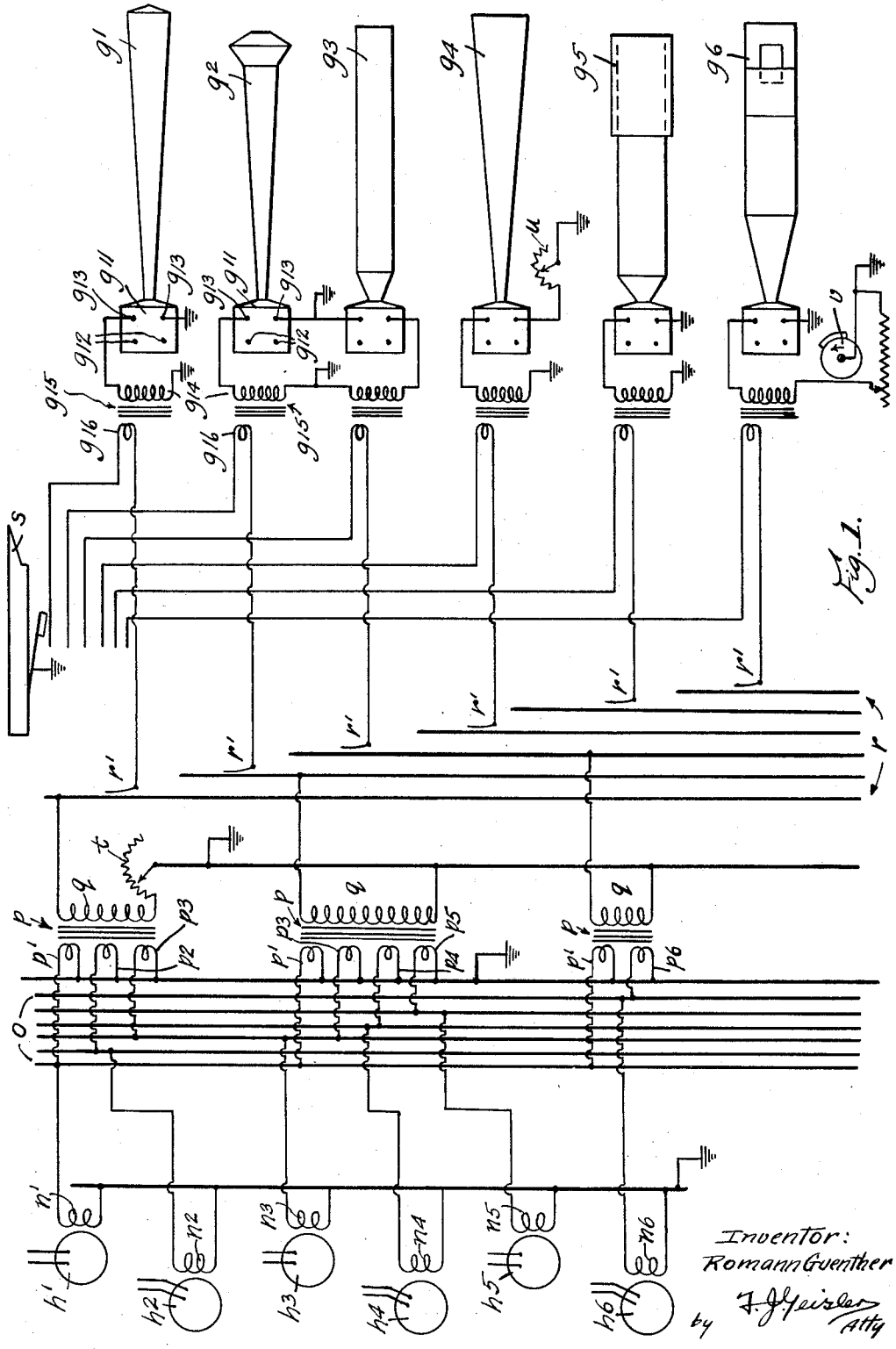


Fig. 1.

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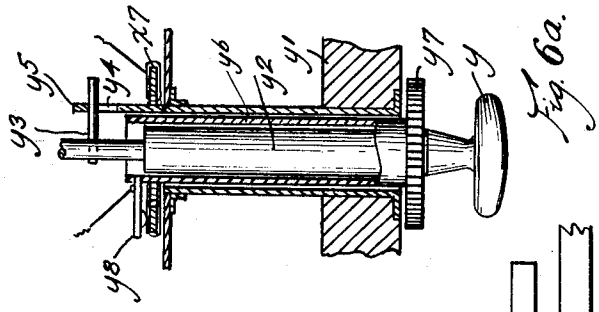


Fig. 6a.

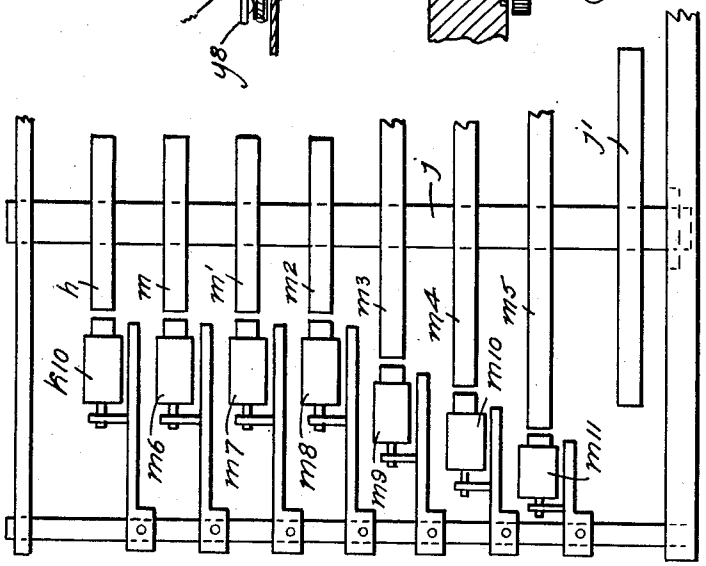


Fig. 3.

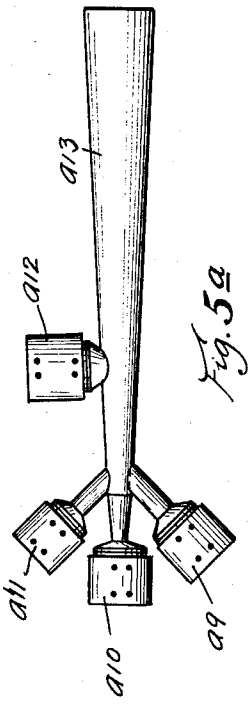


Fig. 5a

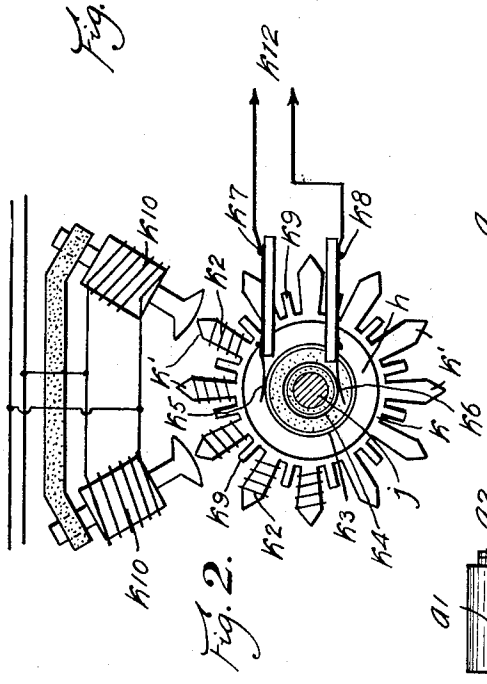


Fig. 2.

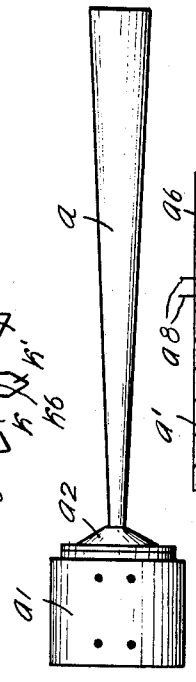


Fig. 4.

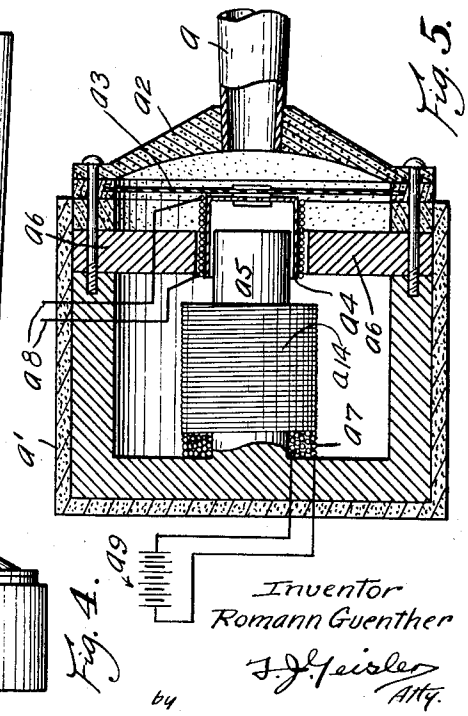


Fig. 5.

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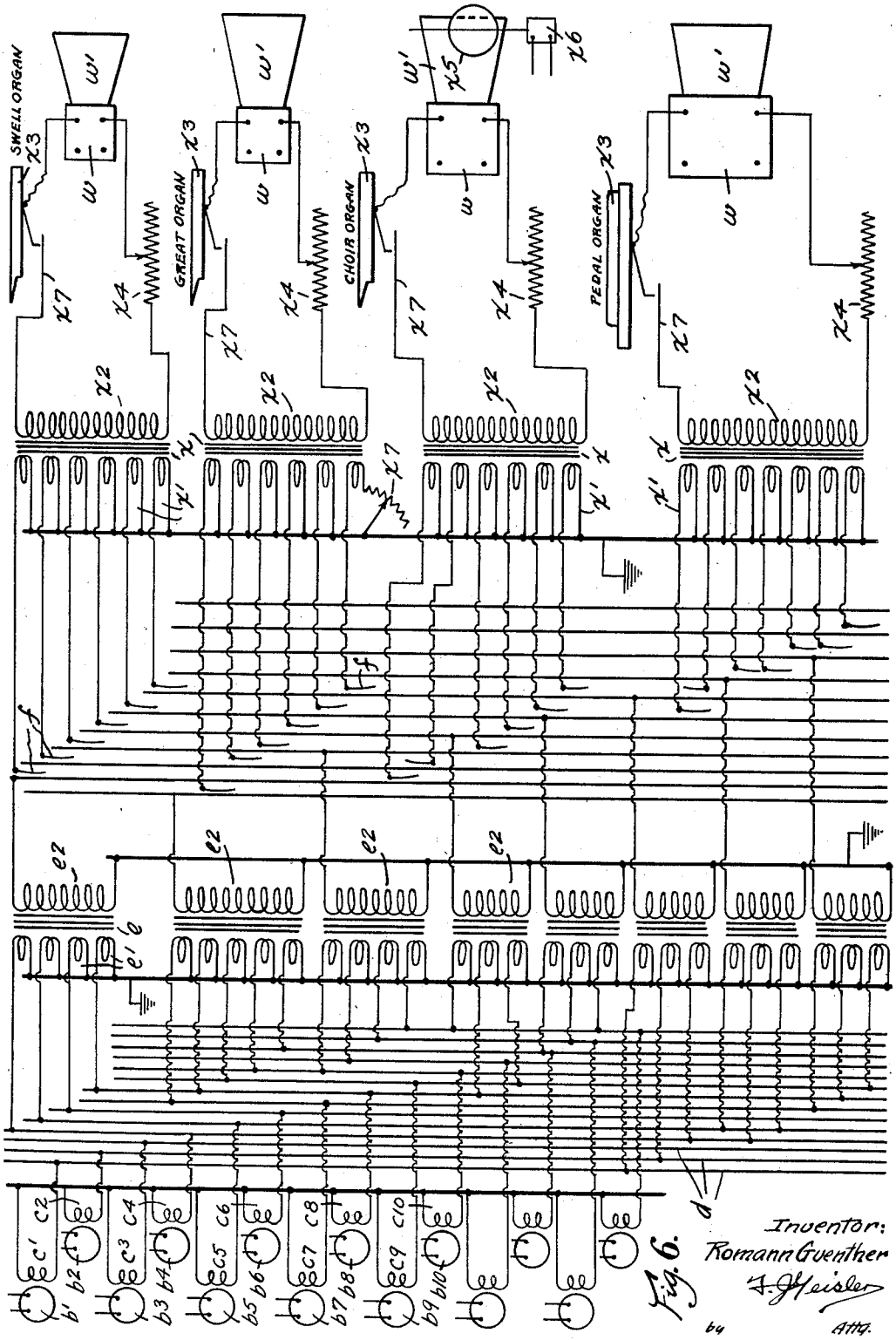


Fig. 6.

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UNITED STATES PATENT OFFICE

2,089,204

ELECTRIC ORGAN

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Application January 27, 1936, Serial No. 60,926

5 Claims. (Cl. 84—1)

My invention relates to pipe organs in which actual pipes, tubes, and reeds are used to produce the musical sounds, and in this respect is to be distinguished from certain modifications of electric organs in which radio tubes and loud speakers are used for the production of musical notes in place of the conventional organ pipes. On the other hand the invention, while concerned with electric organs having actual pipes, etc., is not concerned with, but is to be distinguished from, the conventional electric pneumatic pipe organ in which air under pressure is forced into the organ pipes to produce the desired vibrations and tones. In short, in this invention, the vibrations of the air in the pipes are caused by electric impulses acting upon diaphragms in sound boxes connected with the pipes, and one of the purposes of the present invention is to eliminate the necessity for pneumatic apparatus, wind chests, etc., in an organ in which organ pipes are used for the production of tones.

While, in an ordinary electric pneumatic pipe organ, the structure, shape and size of each pipe largely determine the quality of tone produced by the pipe,—and thus the different kinds of tone qualities, or sound effects, are dependent upon the number of different kinds of pipes employed, and, in smaller organs, are considerably restricted because of the necessity of limiting the number of pipes,—I have discovered that musical sounds may be produced thru the medium of organ pipes in which are provided electrically vibrated diaphragms, and the variations in the vibrations of these diaphragms will produce not only notes of different pitch in the pipe, but also notes of the same pitch but of different qualities. By my invention, I am thus able to use a single pipe in an organ for producing several notes, either of different pitches within a limited range of pitch, or of different qualities, and thus make possible greater varieties of tone qualities with a smaller number of pipes.

Due to the fact that tone qualities are affected by sympathetic vibrations and overtones, I discovered that it is possiple, by "mixing" or combining electric impulses produced from independent sources, to obtain multiple vibrations of an electrically vibrated diaphragm, connected with an organ pipe, and in that way to produce the fundamental and overtones required for particular tone colorings or effects. Furthermore, by such "mixing" or combining of selected electric impulses much truer reproductions of tone qualities can be obtained thru an organ pipe than would otherwise be possible. For example, if it is desired to reproduce an oboe quality of tone in an organ pipe, it is customary to use a pipe of a particular shape, which produces a note having somewhat the same quality as the oboe. However, by selection of proper fundamental and overtone vibrations, obtained by means of electric impulses transmitted from separate sources, I am able to reproduce the oboe quality much more accurately. Furthermore, changes in the combinations or blending of fundamental overtones thru said "mixing" of electric impulses make possible innumerable shades and grades of tonal effects not capable of reproduction by the usual means employed in pipe organs.

Therefore, one particular object of my invention is to provide a pipe organ in which more accurate reproductions of tone qualities and a greater variety of shadings of quality are rendered possible than heretofore by producing predetermined variations of the vibrations of electrically actuated diaphragms in the pipes.

A further object of my invention is to provide suitable and practical means for producing the initial electric impulses or oscillations to be utilized to bring about the various desired vibrations in diaphragms connected with organ pipes.

A further, and most important object of my invention is to provide practical means of "mixing" or combining the initial electrical oscillations from independent selected sources and transmitting these to the diaphragm in order that the effect of the combined, selected oscillations will be caused to impart to the diaphragm the particular gradations of vibrations desired. This most important object I attain by providing a series of transformers, which I designate as "harmonic transformers", each "harmonic transformer" consisting of one or more primary coils which are connected to individual sources of initial electrical oscillations,—such primary coils being arranged in various combinations—, and secondaries of which "harmonic transformers" can be connected thru suitable switch mechanism to the means by which the diaphragms connected with the organ pipes are caused to be vibrated.

The above described objects and incidental features of my invention I attain by devices hereinafter fully described by me with reference to the accompanying drawings, in which:

Fig. 1 is a diagrammatic drawing of the set-up of my invention and illustrates its method of operation;

Figs. 2 and 3 are diagrammatic drawings of the means for producing the initial electrical impulses or oscillations which are used in caus-

ing the vibrations resulting in the desired musical tones;

Fig. 4 is a side elevation of a resonator with attached organ pipe thru which the tone vibrations are emitted;

Fig. 5 is a view similar to Fig. 4, but with the resonator shown in section and illustrating, more or less diagrammatically, the construction and operation of the diaphragm and movable coil within the resonator;

Fig. 5*a* illustrates a modification in the manner of connecting the organ pipes and resonators of Fig. 1;

Fig. 6 is a diagrammatic drawing of a modification of my invention; and

Fig. 6*a* is a sectional view taken longitudinally showing a portion of a draw-knob switch control and variable resistance control for use in my invention.

Referring first to Figs. 4 and 5, *a* indicates an organ pipe of any conventional shape and construction as used in familiar types of pneumatic pipe organs. The organ pipe *a* is attached to the cover *a2* of a resonator *a'*, which resonator comprises a hollow box of wood, fiber, aluminum, or other suitable material,—preferably a material which is a non-conductor of electricity,—within which box is mounted a diaphragm *a3* connected at the center to a movable coil *a4*. A stationary field coil is indicated by *a5* and comprises an iron core mounted on a base *a14* of the same metal, which is preferably extended up along the inside walls of the resonator, and also preferably has lateral arms *a6* attached at the top, the said arms terminating near the movable coil *a4*. The movable coil *a4* shown in Fig. 5 has been made in the form of a cap adapted to be moved over the central core of the stationary field coil *a5*, and between the ends of the lateral arms *a6*. The wiring *a7* of the field coil is connected to some outside source of direct current *a9*. The wire *a8* of the movable coil *a4* is connected to a transformer by means of which induced electrical impulses operate to cause vibration of the movable coil and diaphragm in a manner to be described later. The exact shape and construction of the movable and stationary coils may, of course, be considerably varied, and the construction which I have indicated is to be considered as merely illustrative. It would also be possible to substitute a permanent magnet for the stationary field coil.

The idea of producing sounds by electrically vibrated diaphragms is old. But I believe my invention is the first practical application of electrically vibrated diaphragms in connection with conventional organ pipes. The quality of tone produced thru the combination of my resonator, with the electrically vibrated diaphragm and a conventional organ pipe, is determined by the size, shape and construction of the organ pipe itself (as is true in the case of pneumatic types of pipe organs), and by the quality or character of the vibrations imparted to and by the diaphragm. Further, it will be apparent that the size of diaphragm and resonator and the strength of the coils also influence the type of tone produced. The possibilities for variations in tone qualities thru the use of variously shaped and variously constructed pipes in pipe organs of ordinary types are well known to anyone familiar with the art and need not be described here. Fair imitations of brass, wood-wind, and stringed instruments, as well as many modifications of the more commonly recognized organ tones are obtained in modern pneumatic pipe organs with numbers of differently shaped and differently constructed pipes, including round pipes, square pipes, metal pipes, wooden pipes, closed pipes, open pipes, etc. Any pipes suitable for use in a pneumatic pipe organ may be used in my invention and attached to resonators such as I have indicated. In Fig. 1 are diagrammatically indicated a few of the well known types of organ pipes.

Referring now to Fig. 1, *g'*, *g2* to *g6* indicate various organ pipes designed for producing certain qualities of tone, each pipe being attached to a resonator *g11*. Each resonator *g11* contains a stationary field coil, the terminals of which are indicated by *g12*, and a diaphragm and movable coil, the terminals of the movable coil being indicated at *g13*. The movable coil is connected to the secondary *g14* of a transformer *g15*.

The initial electrical oscillations which are transformed into certain predetermined electric impulses, causing the actuation of the diaphragms to produce the desired vibrations in the organ pipes, are obtained from rotating elements which are indicated diagrammatically by *h'*, *h2* to *h6*. The construction and manner of operation of these elements are shown more clearly in Figs. 2 and 3, and consequently I refer at this point to Figs. 2 and 3.

In Fig. 2 *h* indicates a rotating element having a disk of fiber or other suitable material rigidly attached to a shaft *j* and having an iron ring *k* mounted on the disk, the outer periphery of which iron ring is made with a number of equal size and equally spaced radial iron poles or cores *k'* wound serially and in the same manner with the wire *k2*, and thus constituting a plurality of electromagnets. The ends of the wire *k2* are attached to rings *k3* and *k4* of suitable conducting material mounted on the disk *h* but insulated from each other. Brushes *k5* and *k6* bear on the rings *k3* and *k4*, respectively, and the said brushes are connected to a source of direct current, indicated at *k12*, thru the conductors *k7* and *k8*. The iron ring *k* on the periphery of disk *h* is also made with stub radial projections *k9* between the wound poles *k'*, these stub projections *k9* constituting opposite poles to the extremities of the wound poles *k'*.

Stationary secondary coils are indicated in Fig. 2 by *k10*. It is apparent that as the disk *h* rotates the revolving primary coils *k'*, excited by direct current, will cause oscillations thru the stationary coils *k10* in accordance with Lenz's law. The rapidity of these oscillations will depend upon the speed with which the disk *h* is rotated, and upon the number of primary coils mounted on its periphery. The rapidity of these oscillations determines the pitch of a tone ultimately produced in my electric organ. The number of stationary secondary coils *k10* does not affect the rapidity of the oscillations, but increasing the number of such stationary secondary coils *k10* will increase the strength of the oscillations induced in the secondary coils.

Fig. 3 shows diagrammatically a convenient mechanical set-up for the operation of a number of rotating elements such as that described with reference to Fig. 2. The rotating elements, indicated by *h*, *m*, *m'*, *m2*, *m3*, *m4*, *m5* and all similar to that shown in Fig. 2 are rigidly mounted on the same shaft *j*. The shaft *j* is driven at uniform speed by any convenient means, such as a belt connecting the pulley *j1* with an electric syn-

chronous motor (not shown). *k*10, *m*6, *m*7 to *m*11 represent the stationary secondary coils of the primary coils carried by disks *h*, *m*, *m'* to *m*5, respectively. Since these rotating elements are all mounted on the same shaft *j*, and all rotate with the same uniform speed, each would produce the same frequency of oscillations in its secondary stationary coils (that is to say would produce an ultimate note of the same pitch in my electric organ) provided each rotating element had the same number of primary coils mounted on its perimeter. By increasing the number of primary coils of these rotating elements in geometrical progression (for instance, making the element *h* with two coils, element *m* with four coils, element *m'* with eight coils, etc.) thus increasing the rapidity of oscillations by geometrical progression, element *m* will be caused to produce an ultimate note an octave higher than element *h*, element *m'* a note two octaves higher than element *h*, etc. As a preferential arrangement of such elements in my invention, I provide 12 sets of elements similar to the set shown in Fig. 3 mounted on shafts driven at different speeds, representing the 12 half tones between an octave. With 7 rotating elements in each set, as shown in Fig. 3, a range of 7 octaves or a total of 84 different pitches are obtained. By adding more rotating elements to each set a greater range would be obtained.

Returning now to Fig. 1, let it be assumed that *h'* designates a rotating element of the kind just described, producing oscillations suitable for a fundamental note of certain pitch, for example middle C; and *h*2 to *h*6 designate elements producing certain related oscillations suitable for notes harmonically associated with C, such notes as E, G, C an octave above, and so on, which notes would be present as overtones if certain qualities of tone of the note of middle C pitch were produced. Since variations in over-tones vary the nature and quality of the composite tone produced, an accurate reproduction of a note of certain quality necessitates reproduction of the over-tones which are combined in that particular quality.

The secondary stationary coils for the primary coils of rotating elements *h'* to *h*6 are indicated by *n'* to *n*6, which secondary coils are connected thru the medium of bus lines *o* to primary coils *p'* to *p*6 of a number of transformers *p*, which I designate as my "harmonic transformers" and which constitute a very important element of my invention. The secondary coils *q* of the harmonic transformers *p* are connected by means of switch board *r*—the switches *r'* of which are operated by stops, etc., located adjacent to the organ keyboard—, to the primaries *g*16 of the transformers *g*15 previously referred to. When a switch *r'* on the switchboard *r* is thrown in, the circuit to the particular primary coil *g*16 connected thereby is closed by the pressing down of the key *s* of the organ (which for this description is assumed to indicate the middle C key in a row of keys of the organ). When such circuit is closed, the impulses conveyed thru the medium of the particular transformer *g*15, and secondary coil *g*14 to the diaphragm in the resonator *g*11, cause vibrating of the diaphragm, resulting in vibrations in the organ pipe which produce the note with the particular quality desired.

The harmonic transformers *p*, as indicated in Fig. 1, have their primaries comprised of various combinations of the coils connected with the initial sources of oscillations for fundamental and overtones. Thus the impulses sent thru the secondary coils *q* of the harmonic transformers *p* are different in the case of each secondary coil *q*; that is to say, are different for each connected primary coil *g*16 of the transformers *g*15, when the corresponding switch is thrown in and the circuit closed by the organ key *s*. This "mixing" of initial oscillations thru the medium of the harmonic transformers *p* makes possible the obtaining of predetermined electric impulses for producing the vibrations of the diaphragm in each of the resonators *g*11 best suited for obtaining the most perfect reproduction of the desired tone quality from the organ pipe attached.

The windings of the primary coils *p'* to *p*6 of the harmonic transformers *p* are not necessarily all the same. Actually these windings would be different in individual cases, depending on the prominence to be given a particular tone or overtone in a single composite group.

For simplicity of illustration, only one organ key *s*, in one of the rows of keys on the organ keyboard, is represented in the diagrammatic drawings in Fig. 1, and only 6 different qualities of tone represented by different organ pipes and organ stops are indicated in the drawings. It is apparent, however, that the number could be greatly increased, depending only upon the size and number of pipes to which it is desired to limit the organ, and also that the same general set-up may be used over several manuals or banks of keys, including the pedal keyboard, and that the various coupling devices may be employed for combining different manuals and different stops which are old in the art and common to ordinary pneumatic electric pipe organs, and which need not be described.

For controlling the intensity or loudness of the particular tone to be produced by the induced current through secondary coil *q*, an adjustable resistor element *t* could be placed in the circuit of the coil, such resistor being operable by the player from the keyboard of the instrument. In order to control the intensity of tone in the organ pipe a resistor element can be placed in the circuit of the movable coil of the resonator, as indicated at *u*, Fig. 1. Various attachments for producing the well-known tremolo or wavy tone effect could be arranged very easily; one of such means being indicated at *v* in Fig. 1, in which a motor causes an intermittent shunt in a resistance placed in one of the circuits of the resonator, thus causing the intensity of the tone to fluctuate.

It would be possible to have more than one resonator attached to a single organ pipe, as illustrated in Fig. 5*a*, where resonators *a*9, *a*10, *a*11, *a*12 are all connected to the same organ pipe *a*13. As indicated in Fig. 5*a* also the resonators need not always be connected to the base of the organ pipe, but, for different effects, may be connected at various locations at the side of the organ pipe as *a*12 in Fig. 5*a*, similar to the positioning of vibrating reeds in organ pipes.

In Fig. 6 a modified form of my invention is illustrated, the modification consisting in the elimination of the conventional organ pipes. In this modified form the different qualities of tone are dependent entirely upon the combinations of electric impulses which are conveyed to the electrically actuated diaphragm or reed located within a resonator *w*, to which resonator is attached a modified form of organ pipe *w'* acting in the nature of a megaphone or amplifier. In the preferred construction illustrated in Fig. 1, already described, the qualities of tone are determined

jointly by the character of the organ pipe attached to the resonator *g11* and by the character of the electric impulses transmitted to the diaphragm within said resonator. In the modified form illustrated in Fig. 6, only one resonator and pipe are required for each note of the organ keyboard, the same resonator and pipe therefore producing all the variations of tone qualities for that particular note, thus considerably reducing the size and cost of the instrument. While the results in this modified form of my invention, as far as tone qualities are concerned, are not as perfect as those obtainable with my preferred construction illustrated in Fig. 1, nevertheless, sufficiently satisfactory and pleasing variations of tone qualities are obtainable as to be adequate for most purposes. Except for the difference indicated, the construction in Fig. 6 is the same as that in Fig. 1. In Fig. 6, *b'* to *b10* indicate the rotating elements (similar to rotating elements *h'* to *h10* in Fig. 1) producing the initial electrical oscillations; *c'* to *c10* (corresponding to *n'* to *n10* in Fig. 1) are the stationary secondary coils which are connected thru the medium of bus lines *d* to the primary coils *e'* of the "harmonic transformers" *e* (corresponding to the "harmonic transformers" *p* in Fig. 1). The secondary coils *e2* of the "harmonic transformers" *e* are connected by switches *f* operated from the keyboard of the instrument, to the primary coils *x'* of the transformer *x*, of which the secondary coil *x2* is connected to the resonator *w* by the closing of the circuit *x1* thru the pressing down of organ key *x3*. The nature of the electric impulses obtained from the "harmonic transformers" *e* for each note will depend merely upon which switches on the switchboard *f* are connected. Control of the volume or loudness of each tone produced may be had thru resistor elements such as is indicated at *x4*, and specific control of the volume of each quality separately may be obtained by placing a similar resistor element in the circuit of each primary coil *x'* of the transformer *x*, as indicated at *x1*.

The switches *f*, similar to the switches *r'* of Fig. 1, may be connected to draw-knobs or "stops" located at the organ keyboard and operated by the player. In Fig. 6*a*, *y* indicates such a draw-knob extending thru the organ console case *y'* adjacent to the keyboard, as is customary. The shank *y2* has its inner end (not shown) mechanically connected to a switch *f* (Fig. 6), in a manner common to ordinary pipe organs, so that the pulling out of the knob *y* connects that particular switch *f*, and pushing the knob *y* back disconnects the switch. A pin *y3* attached to the shank *y2* is arranged to slide in a slot *y4* in a guide *y5* rigidly attached to the console case to prevent the draw-knob and shank being pulled or pushed too far in either direction. For manipulating a resistor element *x1* (Fig. 6) to control separately the volume or strength of the specific quality obtainable when the particular switch *f* is connected by the pulling out of the draw-knob *y*, a rotatable sleeve *y6* is provided for convenience about the shank *y2*, said sleeve *y6* at its outer end being connected to an annular dial plate *y7*, adapted to be turned in either direction by the player when the draw-knob *y* is pulled out, and said sleeve *y6* at its inner end having a contact finger *y8* attached to it and bearing on the stationary resistor element *x1*.

A tremolo effect may be produced either by such means as shown at *v* in Fig. 1, or by the placing of a partial shutter *x5* in the pipe *w'* and causing the partial shutter to rotate by means of a motor *x6*.

I claim:

1. In a musical instrument having an electrically vibrated diaphragm a source of electric impulses, a transformer connected to said source of electric impulses and to said diaphragm, a switch and a variable resistor element in a circuit of said transformer a draw-knob having a shank connected to said switch, said draw-knob located adjacent to the keyboard of said instrument, a rotatable sleeve about said shank, the inner end of said sleeve connected to said resistor element, a rotatable dial affixed to the outer end of said sleeve, said dial located between said draw-knob and the casing of said instrument, whereby the player, after closing said switch by means of said draw-knob, may, by manipulation of said dial, vary the resistance offered by said resistor element.

2. In a musical instrument containing an organ pipe and a diaphragm associated with said pipe, a plurality of separate rotating elements, each arranged to generate an electric current having a different frequency of oscillation, a transformer comprising a plurality of primary coils and a secondary coil, each of said electric currents passing thru one of said primary coils, a magnet and coil associated with said diaphragm adapted to cause said diaphragm to vibrate when an electric current is passed thru said latter mentioned coil, and means connected with said latter mentioned coil and with the secondary coil of said transformer, whereby composite induced current in said secondary coil will operate to cause a modulated predetermined vibration of said diaphragm.

3. In a musical instrument containing an organ pipe and a diaphragm associated with said pipe, a plurality of separate rotating elements, each arranged to generate an electric current having a different frequency of oscillation, a series of transformers, each transformer comprising a plurality of primary coils and a secondary coil, each of said primary coils having the electric current produced by one of said rotating elements passing thru said primary coil, each of said transformers arranged with selected groups of primary coils for each secondary coil, whereby a predetermined mixed induced current will be produced in each secondary coil, a second transformer having a series of primary coils and a secondary coil, switches connecting the secondary coil of each of said first mentioned transformers to a primary coil of said second transformer, a magnet and coil associated with said diaphragm adapted to cause said diaphragm to vibrate when an electric current is passed thru said coil, and the coil associated with said diaphragm connected to said secondary coil of said second transformer.

4. The combination described in claim 3 with the peripheries of each of said rotating elements provided with radially disposed, equally spaced, similarly wound poles, the winding of said poles connected to an outside source of electric current, and stationary coils located adjacent to the peripheries of said rotating elements, the winding of said stationary coils being connected to the primary coils of said first mentioned series of transformers.

5. In a musical instrument containing a diaphragm associated with an organ pipe and capable of being electrically vibrated for producing sound waves, a plurality of sources produc-

ing separate electric currents of different frequencies of oscillation, a plurality of transformers, each transformer having primary coils and a secondary coil, each of said primary coils energized by the current from one of said sources, the primary coils for each transformer chosen and arranged according to a predetermined selection whereby to produce a composite induced current in the secondary of such transformer corresponding to a particular grouping of fundamental and harmonic vibrations required for a particular tone quality, and manually operated means by which the induced current in the secondary of each transformer selectively can be made to cause the vibration of said diaphragm.

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