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2,818,759

TUNING MEANS FOR ELECTRICAL MUSICAL INSTRUMENT

Filed June 16, 1952

3 Sheets-Sheet 1

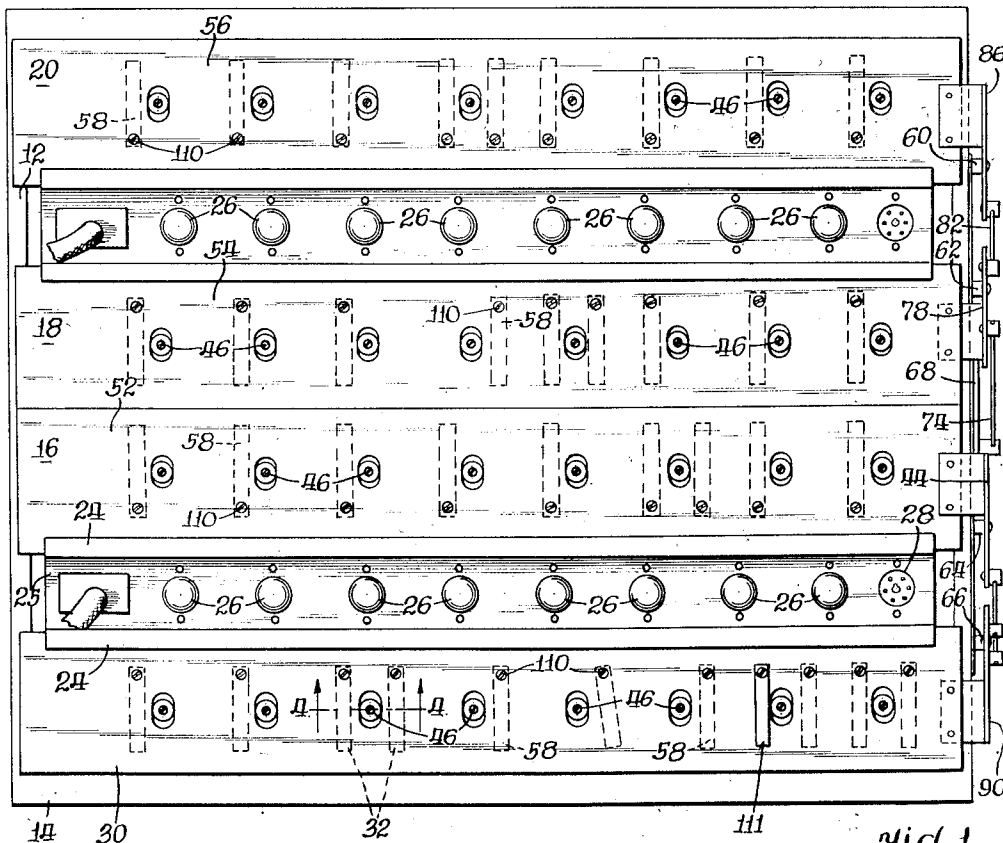


Fig. 1.

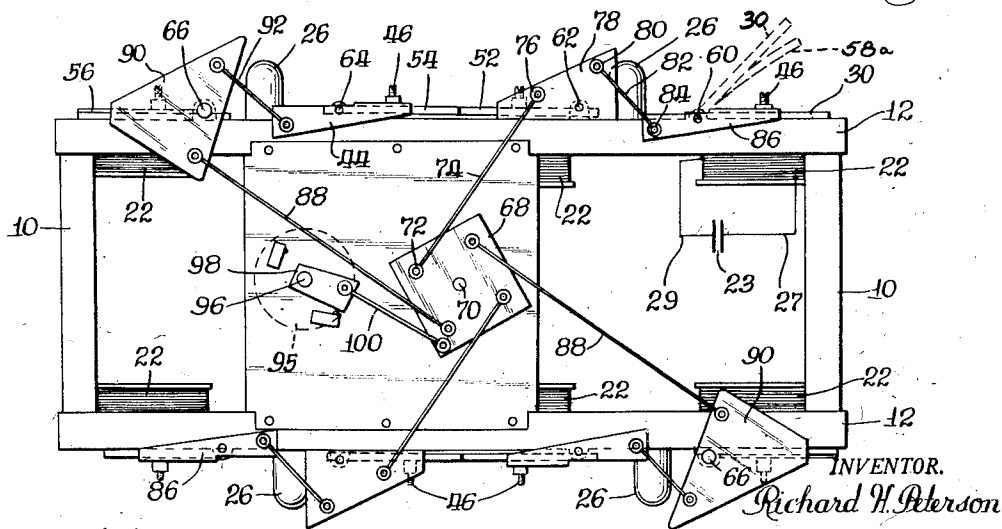


Fig. 2.

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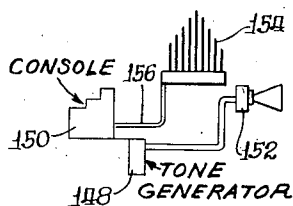
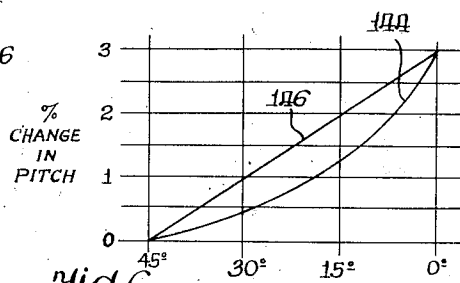
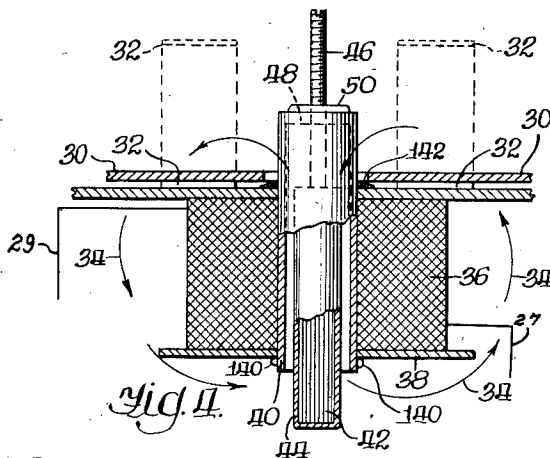
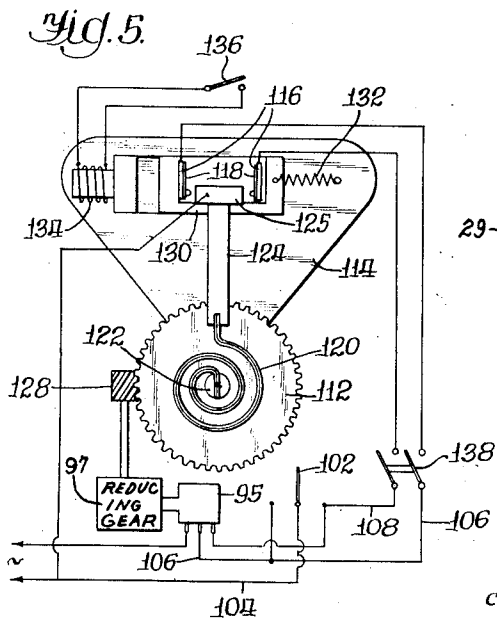
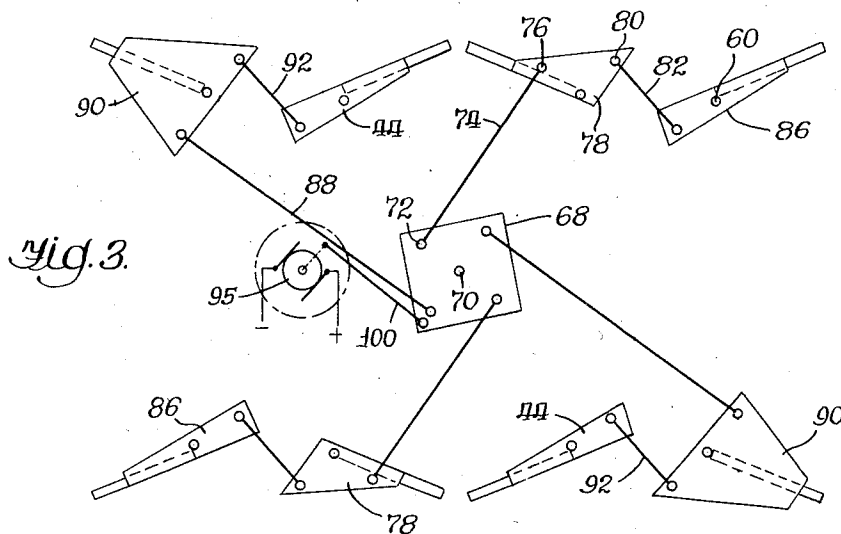
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TUNING MEANS FOR ELECTRICAL MUSICAL INSTRUMENT

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3 Sheets-Sheet 2



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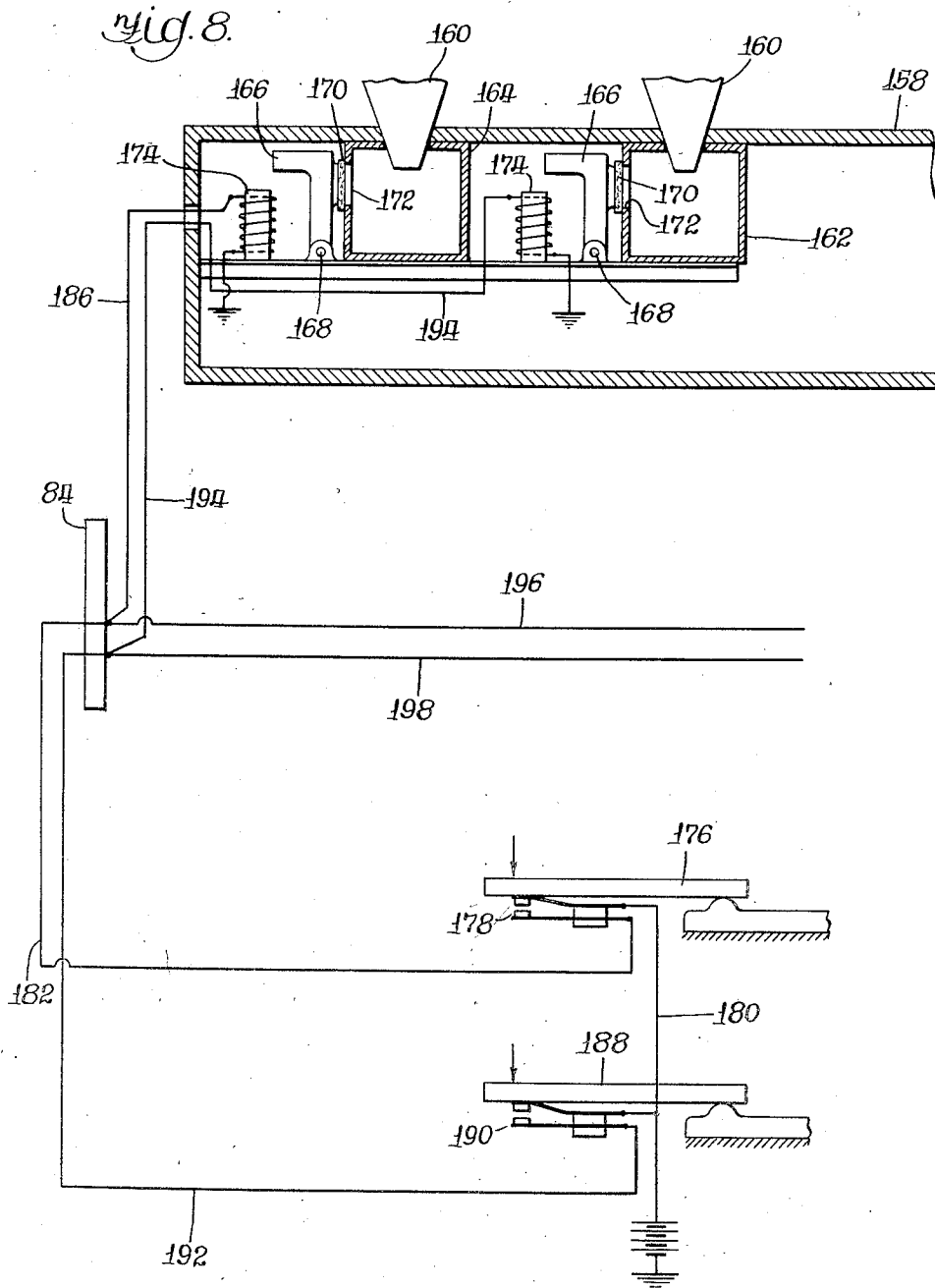
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TUNING MEANS FOR ELECTRICAL MUSICAL INSTRUMENT

Filed June 16, 1952

3 Sheets-Sheet 3



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2,818,759

TUNING MEANS FOR ELECTRICAL MUSICAL INSTRUMENT

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Application June 16, 1952, Serial No. 293,739

8 Claims. (Cl. 84—1.01)

My invention relates to the electronic production of music and includes among its objects and advantages a practical combination of electronic sources and sound sources in which the sound is generated in a vibrating body of air.

An electronic source of musical sound in which a tuned circuit generates the primary vibration, is not temperature-sensitive. An organ pipe or other sound source operating by the vibration of a body of air is temperature-sensitive, and if such an instrument is in perfect tune with an electronic instrument at a given temperature such as seventy degrees, a rise in temperature to eighty degrees will change the pitch of the non-electronic source enough to effect serious alterations in the result when both instruments are played together.

An interesting, incidental advantage of the invention is that the operator can, when that is desired, alter the pitch of the electronic source just enough so that when the two sources are sounded at the same time, a desirable, combined effect commonly called "celeste" is available.

In the accompanying drawings:

Figure 1 is an elevation of a double-deck of eight panels, comprising sixty-four separate, individual, musical tone sources, provided with regulating means according to the invention;

Figure 2 is an end view of the unit of Figure 1;

Figure 3 is a diagrammatic end view, indicating the tuning flaps in an intermediate position;

Figure 4 is an enlarged detail section on line 4—4 of Figure 1;

Figure 5 is a diagrammatic end view of means for making the temperature adjustment automatic;

Figure 6 is a diagram of the relationship between pitch and flap position;

Figure 7 is a view of a complete assembly including an air-blown unit and an electronic unit; and

Figure 8 is a partly diagrammatic view of a combined unit embodying a common junction board.

In the embodiment of the invention selected for illustration, the chassis frame may be conventional, and includes four corner posts 10 cross-connected by end pieces 12 rigid with longitudinal panels 14, 16, 18, and 20 for the front side. Four more panels on the rear side constitute another set of identical construction. Each panel carries eight tone producing units, each including a conventional tuned circuit of high constancy, of which the inductances are indicated at 22 in Figure 2.

Each inductance 22 is associated with a capacitor 23 connected to it by conductors 27 and 29. This is a conventional and well-known arrangement of the type illustrated in Heytow and Peterson Patent 2,649,006, where the condenser carries reference character 94, and the inductance is 92 in Figures 2 and 4 of the patent drawings. It will be obvious that other types of oscillators include inductances which may be varied according to this invention, although the current connections

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between the inductances and capacitors and tubes are arranged in any one of a large variety of arrangements.

Between the panels 16 and 14 I provide a structural cross-piece having flanges 24 and a shallow trough 25 between the flanges. Abreast of the tone producing units of the panels 14 and 16 are sockets for receiving eight space discharge tubes 26. Each space discharge tube has its interior elements in duplicate, and performs the electronic function involved for both of the tone producing units abreast of it. A slight economy in space is achieved by having the tubes 26 spaced longitudinally a little less than the tone producing units, so that there is room at one end for a spare socket 28 for establishing connections to other electrical units forming part of the complete instrument.

A duplicate center trough and set of tubes is positioned between the panels 18 and 20.

Means are provided for high precision, simultaneous adjustment of the pitch of all the tone producing units. Beside each panel I provide a pivoted flap of non-metallic material, and pieces of magnetic material are mounted on the flap to move into and out of the magnetic field of the inductances 22. Thus, the flap 30 for the panel 14, when in the closed position of Figures 1 and 2, positions two small iron plates 32, where, as best indicated in Figure 4, they lie within the space included in the field of flux indicated by the arrows 34 and increase the permeability of the magnetic field excited by the winding 36.

The entire inductance includes the winding 36, the supporting disk 38, the central axial tube 40, and the laminated iron core 42 carried in the small tube 44. Basic adjustment of the inductance is provided by moving the core 42 axially. In the tube 40 we have illustrated a threaded extension 46 of non-magnetic material, such as brass, which may have threaded engagement with the top partition 48 of the tube 40 and be locked in axial position by tightening a lock nut 50. The other three pivoted flaps, 52 for the panel 16, 54 for the panel 18, and 56 for the panel 20 may be duplicates of the panel 30. It will be noted that most of the tuned units are provided with only a single tuning strip 58 rather than a double tuning strip 32. The double tuning strips are needed in connection with the tones of lower frequency, where the total inductance of the tuned circuit is relatively large and needs to be changed by a greater amount than can be achieved with a single tuning strip. As best indicated in Figure 2, the flap 30 is pivoted at 60. The flap 52 is pivoted at 62, the flap 54 is pivoted at 64, and the flap 56 is pivoted at 66. In each instance, the horizontal distance from the axis of the inductance 22 over to the pivot for the flap is the same.

Means are provided for swinging all four flaps from the active position of Figures 1 and 2, where the tuning strips are as close as possible to the coils 36, up about forty-five degrees into inactive position. A midway position is indicated in Figure 3. In such adjustments it is obviously necessary that all the units have their pitch changed simultaneously to the same extent in all adjusted positions of the flaps. I have indicated a master plate 68 pivoted at 70. The stud 72 in the upper left-hand corner of the master plate is connected by a pitman 74 to a stud 76 in a triangular intermediate plate 78 rotating with the panel 52 about the pivot 62. On the remote corner of the plate 68 is stud 80 connected by the pitman 82 to a stud 84 on the narrow end plate 86 on the end of the flap 30. It will be apparent that clockwise rotation of the plate 68 will produce a clockwise rotation of the plate 78, and the counter-clockwise rotation of the plate 86. The lower left-hand corner of the plate 68 is similarly connected through pitman 88 with a triangular plate 90 turning with a flap 56, and the plate 90 is con-

nected by pitman 92 to the heel of plate 94 turning with flap 54. By employing correct geometric proportions and angular relationships between the parts of linkage, it is possible to have all four flaps move in perfect unison of movement, so far as the amount of displacement from the position of Figure 2 is concerned, but with the flaps 30 and 54 turning counter-clockwise, and the flaps 52 and 56 turning clockwise. In the embodiment shown, all the linkages including the master plate 68 are parallelograms.

The rear side of the generator illustrated is a complete replica of the front side. The manual control means may include a conventional electric motor 95 geared to rotate the shaft 96 and arm 98 around the axis of the shaft 96. Arm 98 is connected to one outer corner of the plate 68 by the pitman 100. For manual control, it is convenient to employ a simple two-way switch diagrammatically indicated at 102 in Figure 5 and adapted to connect the conductor 104 to the conductor 106 to actuate the motor in one direction, or to the conductor 108 to actuate the motor in the other direction. When manual control is used, it is a simple matter for an experienced musician to adjust the pitch of the electronic unit by ear, so that it harmonizes perfectly with the non-electronic units, which may all be connected to the same keyboard. Also, if the "celeste" effect is desired, the operator need only change the adjustment of the plate 68 so that the electronic units are either sharp or flat by a small percentage of a semi-tone with respect to the non-electronic units, and the "celeste" effect results.

In producing and adjusting such an assembly, all the flaps are turned out forty-five degrees, and each individual tone source is accurately tuned to the exact frequency desired by adjusting the core 42 and fastening it in adjusted position with the lock nut 50. It remains to adjust the tuning strips 58 and 32 so that movement to the position of Figures 1 and 2 lowers the pitch of every individual tone source by exactly the same amount. For this purpose, all the tuning strips 58 and 32 are pivotally connected to the inner face of their flaps by means of fastening screws 110. By rotating the tuning strip for each individual unit about its pivot to move it farther into or out of the magnetic field, the amount by which the frequency of the entire tuned circuit is lowered by lowering the flap can be adjusted with high precision. Thus, an individual adjustment of each tuning strip 58 and each pair of double tuning strips 32 is made, so that precisely the same lowering of pitch results in all of the units.

It remains to make sure that when all the units are in perfect tune with the flaps moved out to forty-five degrees, and also in perfect tune at a slightly lower pitch with the flaps in the closed position of Figures 1 and 2, each individual tone unit will also be in perfect tune with all the other tone units throughout all intermediate positions. For this purpose, the flaps may be set in a position about halfway between their two extreme positions, as in Figure 3, and the third tuning comparison is made. Theoretically, this might involve great complications. The lowering of the pitch of the unit by successive increments of angular movement from the position of Figure 3 to the position of Figure 2, does not necessarily result in equal increments of change of pitch. The relationship is not a linear function, but is represented by a curve of gentle curvature. The curvature of this curve is increased by positioning the tuning strip 32 closer to the axis of the core 42, but such an adjustment also increases the total effect. Accordingly, when it is found by test in intermediate position that a particular unit is working on a curve that is a little flatter or a little less flat than the other units, it is necessary to readjust the curvature to fit the standard curvature. This may be done in various ways, including: (1) change the tuning strip 58 to one of different size, return the unit at extreme positions, and then test at intermediate

position to make sure the amount of change is right; (2) bend the free end of the strip a little away from the flap, as indicated at 58a in Figure 2, but not far enough so that flattening the strip will stress the metal beyond its elastic limit; (3) locate part of the tuning strip material on top of the flap, as shown at 111 in Figure 1. Changes 2 and 3 flatten the curve, but change 1 can either decrease or increase the curvature.

In practice, at least with the linkage disclosed for actuating the flaps, it is found that if all the units are in perfect tune at the three widely spaced points represented by the positions of Figures 2 and 3 and another position turned out forty-five degrees, all the other intermediate positions will be in substantially as perfect tune as in the three positions tested.

A combined electronic and non-electronic unit in which the temperature adjustment means is as above described appears to function perfectly. At the beginning of use of the combined unit, the organist needs to adjust the electronic unit, which he can do very quickly by ear. Thereafter, the temperature in the room will very rarely change the effect before he finishes playing, to require any further adjustment, but if the session is prolonged and the room grows warmer or cooler, he can make a new adjustment in a moment at any time.

It will be apparent that the primary tuning of each oscillator is done at the place of manufacture by means of the adjustment screw 46. It is always possible for a service man to alter this adjustment, but in practice that is almost never necessary. Subsequently, still at the factory, the much more sensitive tuning strips 32 are adjusted and re-adjusted for each oscillator until the movement of the flaps throughout their entire range results in changes in pitch that keep all the oscillators in substantially perfect tune throughout the range of the trimming or vernier adjustment. This trimming adjustment is the only adjustment available to the player and will normally be used by the player once at the beginning of each performance or session and occasionally whenever the temperature of the premises rises or falls materially before the session is over.

Under certain circumstances, it may be desirable to have the unit stay in tune without adjustment by the operator. In Figure 5 I have indicated a worm wheel 112 and a sector arm 114, both rigid with the shaft 96. The sector 114 carries spaced lugs 116, each carrying an electrical contact element 118. A spiral piece of bimetal 120 rigidly mounted on a stationary stud 122 co-axial with the shaft 96 carries a simple arm 124, the outer insulated head of which lies between the electrical contacts 118. It will be apparent that if the arm 124 moves in either direction due to any change in temperature, the head 125 will contact one of the contacts 118, and establish an appropriate circuit for energizing the motor 95 to turn the worm wheel 112 and sector 114 together with the shaft 96 in a clockwise or counter-clockwise direction as the case may be. Such a unit will keep the equipment of Figures 1 and 2 in perfect temperature adjustment at all times. If it is desired to enable the operator to produce the "celeste" effect at will, it is a simple matter to mount the lugs 116 on a slide 130 held in the full line position of Figure 5 by a tension spring 132. The electromagnet 134 may be controlled by a suitable open-and-shut switch 136 on the console, and when it is energized, the slide 130 will be pulled to the left and the "celeste" effect will result until the switch 136 is again opened.

As a matter of convenience, the motor wires 106 and 108 are led to the contacts 118 through a two-pole single-throw switch 138. This enables the operator to disconnect the automatic temperature control whenever he wishes and depend entirely on the switch 102. It is mechanically desirable to put the switch 102 under the switch 138, where it is not accessible to the operator with-

out opening the switch 138. This prevents an inadvertent short circuit.

In assembling the inductance unit of Figure 4, the tube 40 is provided with rivets 140 to form an abutment for the bottom fiber plate 38, and a duplicate fiber plate is put on the tube 40 and fastened in the position occupied in the Figure 4 by the panel. Then the winding 36 is wound in place, and in that condition the spool and winding are held below the hole that is to receive them. The upper plate is removed, and the tube 40 is thrust through the panel so that the panel itself is the mechanical abutment for the winding 36 in the final, assembled position. The tube 40 may be fastened in inserted position by a conventional pinching plate 142 commonly called a speed nut. This reduces the geometrical separation between the tuning strips 32 and the coil to a minimum, with corresponding maximum effectiveness of the magnetic metal in the strips 32 in changing the inductance of the parts shown in Figure 4 and the frequency of the tuned circuit.

In Figure 6, the curve 144 expresses graphically the lowering of the pitch of the tuned circuit by moving the tuning strip forty-five degrees into the position of Figures 1 and 2. It will be noted that this curve is neither a straight line nor a circle, and that its slope near the position of zero angle, where the strip is effective to lower the pitch by three percent, is many times as great as at the forty-five degree position. If it were possible to have the effectiveness of the strip a linear function of the rotation of the strip as expressed by the straight line curve 146, the sensitivity of the equipment to manipulation of the switch 142 by the operator would be constant throughout the range. To secure a substantial equivalent of the curve 146 for the combined assembly, so that the operator will not be embarrassed or annoyed by finding the response to manipulation many times as great when the flaps are at five degrees, compared with the response when the flaps are at forty degrees, the mechanical connection between the shaft 96 and the master plate 68 is adjusted so that the arm 98 comes almost but not quite into dead-center alignment with the pitman 109 in the position of Figures 1 and 2. This provides an increasingly rapid reduction in the ratio between increments of movement of the master plate 68 and the arm 98 as the closed position of Figure 2 is approached. This effect substantially corrects for the variation in sensitivity represented by the curve 144. The curve 144 is still an accurate presentation of the facts so far as the angular position of the flaps themselves is concerned, but the variable ratio of movement between the arm 98 and the plate 68 substantially cancels this irregularity and secures a curve which is a close approximation to the straight line curve 146, for the relation between pitch and the position of the shaft 96.

In Figure 7 I have indicated an electronic tone generating unit 148 according to Figure 2, connected by conventional cables to the console or keyboard 150 and the loud speaker 152. The air-blown unit 154 is connected to the same keyboard through the cable 156.

Referring now to Figure 8, I have indicated a conventional wind chest 158 and two organ pipes 160. The inlet to each pipe is enclosed in an individual box 162 and 164, provided with a conventional, electrically actuated valve. I have indicated armatures 166 pivoted at 168, and each carrying a leather facing 170 to enclose the inlet opening 172 of its box. Electromagnets 174 are effective to rotate the armatures 166 counter-clockwise to open the valves, whereupon the corresponding pipes will sound.

Thus, the key 176, when depressed by the finger of the player, closes contacts 178 to deliver current from the bus 180 through conductor 182 to the junction board 184. From the junction board, conductor 186 delivers current to the electromagnet 174 for the box 164. Similarly, the key 188 closes contacts 190 to deliver current through conductor 192 to another contact on the same junction board 184. From the other contact, conductor 194 delivers

energy to the solenoid 174 for the box 162. To incorporate an electronic unit in such a combination, I need only provide a conductor 196 to deliver current to the electronic unit that sounds the same note as the box 164, and a conductor 198 to deliver current to the tone producing unit for producing the same tone as the box 162, and so on.

When effected by an experienced and skillful person, the tuning adjustments recited are adequate to secure conformity or "tracking" between the different units within limits so close that the ear does not detect any objectionable deviation during testing or during subsequent playing of any number of notes simultaneously. However, it will be obvious that absolute mathematical identity is not at all closely approximated. This is particularly true for two reasons: (1) the inductance coils vary greatly in size and in the shape of the field of flux; and (2) because the iron cores are made as small as may be, to obtain adequate tuning, and therefore operate over wide enough flux ranges so that the permeability curve is not a straight line. It is believed that these factors introduce scores, if not hundreds, of minuscule pitch deviations, each one individually too small to be noticeable. These variations are actually advantageous because, when a large number of notes are sounded, it is these variations that give the resultant total sound output that richness or "ensemble" effect most pleasing to the cultivated ear and present in any well-built, air-blown pipe organ. It is precisely the absence of these minuscule pitch deviations, of the order of magnitude of one-tenth of one percent in frequency, that makes many electronic organs sound unnatural and harsh.

Others may readily adapt the invention for various conditions of service by employing one or more of the novel features involved or equivalents thereof. It will, for instance, be obvious that if more precise automatic correlation between the two units is desired, the temperature sensitive control of Figure 5 may be replaced by a sensed electronic control involving a first microphone activated by the vibration in an air-filled pipe kept at the ambient temperature, and a second microphone activated by a corresponding tuned circuit in the electronic unit. With these two juxtaposed, any beat note between them can activate a relay to change the adjustment and eliminate the beat.

Similarly, plates with holes to pass over the tubes 44, might have advantages in manufacture, compared with the strips 32. It is obvious that the principles of the invention are fully applicable to any musical instrument susceptible to pitch variation for any reason.

The orientation of the parts shown in Figures 1 and 2 is immaterial. A single such assembly can be set with corner posts 10 horizontal, and rest directly on a floor or table, or several assemblies can be set one above the other in spaced relationship in a rack or frame, with the corner posts 10 vertical, as in Figure 2.

As at present advised with respect to the apparent scope of the invention, I desire to claim the following subject matter:

1. An electronic musical instrument comprising at least two audio-frequency tuned oscillators, a trimmer tuner adjustably associated with each oscillator, player-operated control means, and means interconnecting said control means and said trimmer tuners for causing simultaneous tuning adjustment of all of said oscillators in the same direction.

2. An instrument according to claim 1 having a keyboard; said control means being located adjacent said keyboard and accessible to a player; whereby manual tuning adjustments of all said oscillators can be made by the player, substantially without interruption of the playing of the instrument.

3. An instrument according to claim 1 in which each oscillator includes an inductance coil; and each trimmer tuner comprises a ferro-magnetic element movable between two positions; said positions being a first, outer

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position of minimum inductance and maximum frequency, substantially outside the geometrical confines of the field generated by said inductance coil; and a second, inner position of maximum inductance and minimum frequency, at least partially within the field of said inductance coil.

4. An instrument according to claim 3 in which each trimmer tuner is mounted for mechanically guided movement between said first and second positions, and said control and interconnecting means includes a single manual control element and connections for causing all said trimmer elements to move in and out simultaneously in unison.

5. An instrument according to claim 4 in which the tuning effect of each trimmer element is a continuous but non-linear function of its movement; and means for adjusting each individual trimmer element to secure, within predetermined limits, variation of the magnitude of the total trimmer tuning effect, and variation of the degree of departure of the effect from a linear relationship.

6. An instrument according to claim 5 in which a plurality of said trimmer elements are affixed to a common supporting panel; said panel being pivoted to fold down toward or up away from a plurality of inductance coils; each of said inductance coils being part of a separate oscillator; means for varying the position of each trimmer element in the plane of said panel to vary the amount of the tuning effect; and means for varying the position of each trimmer in the direction of its movement, to vary the degree of departure from a linear relationship.

7. An instrument according to claim 2 combined with

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temperature-sensitive means forming part of said interconnecting means, for automatically adjusting said interconnecting means to superimpose on the tuning adjustment made by the player, automatic variations in frequency equal in amount and in the same direction as the frequency changes of an organ pipe due to fluctuations in temperature.

8. An instrument according to claim 7 in combination with a conventional pipe organ; said instrument having a keyboard conventionally connected for playing the instrument itself, or the pipe organ, or both simultaneously; said temperature-sensitive means being positioned to be affected by the temperature obtaining in the organ pipes.

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