

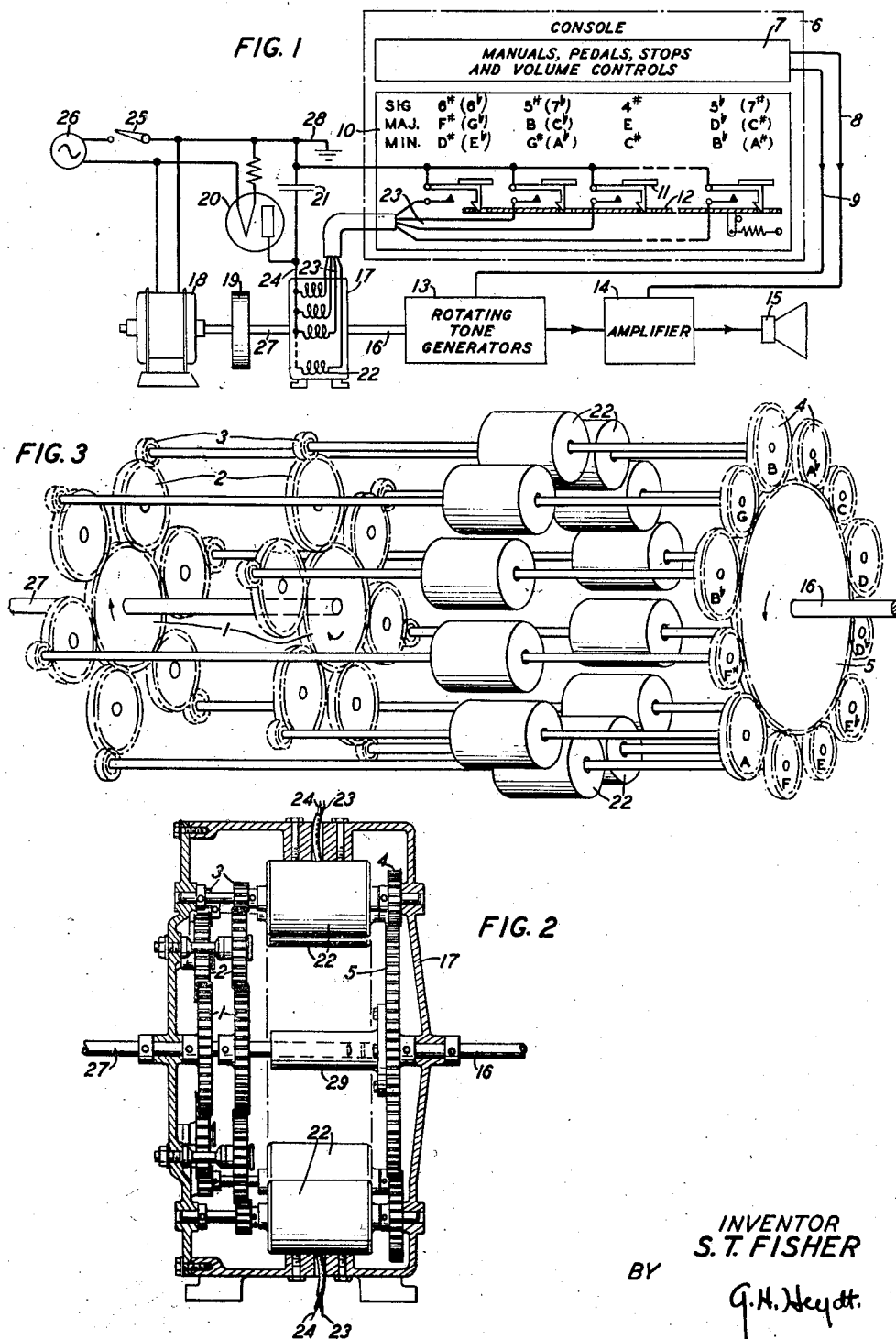
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MUSICAL INSTRUMENT

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MUSICAL INSTRUMENT

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8 Claims. (Cl. 84—1.11)

This invention relates to electrical musical instruments and more particularly to a control means for a transposing type musical instrument.

It is the object of this invention to provide an electrical musical instrument capable of playing musical compositions written in the natural key so that they may sound in any other key desired, although the keying and fingering technique will remain the same as for the natural key signature.

The foregoing object is attained by providing a musical instrument having a series of motor-driven rotating tone generators with a plurality of gear trains of different ratios interconnecting the motor and the tone generators, an individual clutch inserted in the gear train to each generator and a means for selectively energizing any one of these clutches.

The invention may be better understood by referring to the drawing, in which:

Fig. 1 is a schematic representation of a complete system embodying the invention;

Fig. 2 discloses a gear box and clutch arrangement according to the invention; and

Fig. 3 is an expanded view of the gear system in Fig. 2.

Referring now to Fig. 1, in which the organ console 6 is schematically represented as having mounted thereon the usual manuals, pedals, stops and volume controls 7. The manuals, pedals and stops are adapted to control the action of the rotating tone generators 13 via cable 9 while the volume controls and other switches associated with the amplifier 14 act through cable 8, interconnecting the console 6 with amplifier 14. The electrical output of amplifier 14 is converted into acoustic energy by a suitable speaker system 15. The system so far described may be any one of several well-known electric organs such as for example that disclosed in the United States patent to Laurens Hammond, No. 1,956,350, issued April 24, 1934.

The rotating tone generators 13 are driven from a shaft 16 and in the prior art this shaft is usually connected directly to a driving motor 18. In United States Patent 1,778,374, issued to Spielmann, October 14, 1930, a variable speed belt drive is interposed between the motor and the tone generators for varying the speed of the entire system. According to the present invention, this is accomplished for transposing purposes by a gear box 17 containing a plurality of gear trains capable of driving shaft 16 at various speeds. Each gear train has included therein a

suitable electromagnetic clutch 22, the coils whereof are shown schematically in Fig. 1. Electric power for operating these clutches is obtained from alternating current supply source 26 through rectifier 20. One conductor 24 is connected in common to all of the coils and to source 26 through rectifier 20. The other terminal of each of the coils 22 is connected to its associated switch 11 in key-control section 10 of the console 6 via conductors 23. A grounded conductor 28 connects all of the key-control switches 11 to source 26 through main switch 25. A suitable filter condenser 21 is connected to rectifier 20 to smooth out the rectified pulsations. It is obvious that other well-known power supply means, either alternating or direct, may be substituted for rectifier 20 to operate the clutches, the specific one herein disclosed being for illustrative purposes only.

In order to prevent injury to the gear system, it is necessary that switches 11 be so arranged mechanically as to preclude the simultaneous operation of two switches. Switches capable of this function are well known, an example of which is disclosed in United States Patent 679,310 to J. L. Hall, issued July 30, 1901. Upon the operation of any one of the switches 11 it is held closed by means of a locking plate 12 in a manner well known in the art. If thereafter any other switch 11 is operated, locking plate 12 acts first to release the switch previously operated and then locks the second switch. Further description of this switching system is unnecessary as it is well known in the art. It is sufficient to say that the plurality of switches are of the locking type and are mechanically interconnected to prevent the operation of but one switch at a time.

In order to increase the rate at which speed changes may be made a flywheel 19 may be mounted on shaft 27 to increase the effective inertia of the armature of motor 18. Motor 18 is preferably of the synchronous type so as to maintain a constant speed.

The above described system operates as follows: Main switch 25 is closed to start synchronous motor 18 and also to supply suitable direct current through rectifier 20 for energizing clutches 22. A connection may also be made from the load side of switch 25 to supply power to amplifier 14. This connection has been deleted for the sake of clarity. Since the key-control switches 11 are mechanically interlocked and of the locking type, one of them will always be operated. Hence, as motor 18 runs it drives the ro-

tating generators 13 at a speed corresponding with the speed of motor 18 and the gear ratio in gear box 17 associated with the clutch 22 which is then energized. The organ may then be played in the previously selected key according to the usual technique. The written music as read by the organist, however, is always written as if it were in the key of C major (or A minor), that is in the natural key. It may be made to sound, however, in any key without changing the fingering technique by simply pressing the desired key-control switch 11 to transpose the music to sound in the desired key. Upon pressing any one of these key-control switches, it will be understood that the electromagnetic clutch 22 which was previously energized will immediately become de-energized and the newly selected electromagnetic clutch will become energized, thereby adjusting the speed of the rotating tone generators to correspond with the new key in which the music is to sound.

Since it is desired that any note of the twelve-note scale may be employed as a tonic frequency, it is necessary that gear box 17 have included therein twelve gear trains. One preferred form of such gearing is shown in Fig. 2 in which shaft 27 is the driving shaft and shaft 16 is driven. These reference numerals correspond to those shown in Fig. 1. Two driving gears 1, 1 are attached to drive shaft 27 as shown and the inner end of shaft 27 is supported in a long bearing 29 mounted on the inner face of driven gear 5. Driven gear 5 is attached to driven shaft 16. Drive gears 1, 1 are connected to driven gear 5 through a system of idler gears 2 and pinions 3 and 4. All of the gears and pinions are in mesh at all times. Each drive pinion 3, of which there are twelve in number, is associated with a driven pinion 4 and drives the same through an electromagnetic clutch 22. Terminal conductors 23, 24, issuing from each clutch coil is brought out through the housing of its clutch and the gear housing 17 as shown in Fig. 2. All of the conductors 24 are electrically connected together and to the rectifier circuit as shown in Fig. 1, while the conductors 23 are carried to the key-control switch assembly 10, also as shown in Fig. 1.

Since, as previously stated, there are twelve gear trains and an electromagnetic clutch for each, there must be twelve locking switches 11 in switch unit 10, one for each clutch. It is preferable that these switches be adapted for pedal control. It will be apparent when referring to the table below that these twelve gear trains will permit playing key signatures from seven sharps to seven flats in both the major and relative minor modes. Suitable inscriptions over each switch may be provided as shown in Fig. 1 for identification purposes.

Fig. 3 shows an expanded view of the gear train and clutches of Fig. 2 showing more clearly their inter-relationship. While each gear train has been identified at its pinion 4 as to which key signature it belongs, it is apparent to those skilled in the art that a different arrangement of gearing employing similar principles may be employed. The particular arrangement herein disclosed, however, is preferred as it affords a rather compact yet easily accessible arrangement of parts. The two gears 1, 1 each have eight-six teeth while the driven gear 5 has one hundred and seventy-two teeth. The number of teeth for

gears 2, 3 and 4 for each gear train are shown in the table below:

Table of tonic frequencies and gear ratios for various keys

Key			Major tonic frequency	Ratio N_5/N_1	Number of teeth*		
Major	Minor	Signature			Gear 2	Gear 3	Gear 4
F#(G ^b)	D#(E ^b)	6#(6 ^b)	363.000	11/8	57	16	44
B(C ^b)	G#(A ^b)	5#(7 ^b)	495.000	15/8	65	16	60
E	C#	4#	330.000	5/4	55	16	40
A	F#	3#	440.000	5/3	64	18	60
D	B	2#	297.000	9/8	58	24	54
G	E	1#	396.000	3/2	59	16	48
C	A	Natural	264.000	1	53	20	40
F	D	1 ^b	352.000	4/3	58	18	48
B ^b	G	2 ^b	462.000	7/4	63	16	56
E ^b	C	3 ^b	316.800	6/5	57	20	48
A ^b	F	4 ^b	412.500	25/16	60	16	50
D ^b (C#)	B ^b (A#)	5 ^b (7#)	280.500	17/16	52	16	34

*Gears 1 and 5 have 86 and 172 teeth respectively for all keys.

Referring to the table above, it will be seen that the tonic frequency for the key of C major is 264 cycles per second. The tonic frequencies for the relative minor keys are not shown but in every case their frequencies will be $\frac{2}{3}$ of the tonic frequency of their relative major keys. For example, the tonic frequency for the key of A minor is $\frac{2}{3}$ of 264 cycles or 220 cycles. The particular scale disclosed is described more in detail in applicant's copending application Serial No. 361,221 filed on even date herewith.

To take another specific example from the table above, the key of B major carries a key signature of five sharps which is also the key signature for the key of G sharp minor. The tonic frequencies for the major key of B is 495 cycles per second. As previously stated the tonic frequency for the relative minor key of G sharp minor is $\frac{2}{3}$ of 495 cycles per second or 412.5 cycles per second.

Instead of tuning the organ in the above-described scale it may be tuned in the scale of equal temperament with the major tonic frequencies as given above. In this case, however, the minor tonic frequencies will not be exactly $\frac{2}{3}$ of the major but rather they will be equal to their relative major tonic frequencies divided by the fourth root of 2.

The column headed "Ratio N_5/N_1 " refers to the speed ratio of driven gear 5 to drive gear 1. It will be seen that for the natural key of C major, this ratio is unity. Referring again to the key of B major, it will be observed that this ratio is 15/8. Before playing, the organist will press the appropriate key signature switch 11 labeled B(C^b) major as shown in Fig. 1 to cause all of the rotating tone generators 13 to increase in speed by a ratio of 15/8 so that when the white digital commonly referred to as middle C is played a tone will be sounded having a frequency of 495 cycles per second rather than 264 cycles per second. Hence, the music may be written and played as if it were in the key of C major but the key signature indicates that it is to sound in the key of B major. This is similarly true for all other keys. The music is always written as if for the key of C major (or A minor), but will sound in the key corresponding to the key control switch 11 which is operated.

The column in the above table headed "Number teeth" indicates in three separate subcolumns the numbers of teeth on gears Nos. 2, 3 and 4 in each gear train corresponding with the key signature selected. For example, refer again

to the key of B major wherein it will be seen that gear No. 2 has sixty-five teeth, gear No. 3 has sixteen teeth and gear No. 4 has sixty teeth. Since, as above stated, gear No. 1 has eighty-six teeth and gear No. 5 has one hundred seventy-two teeth, it will be apparent that the over-all ratio N_5/N_1 is 15/8 as shown in the table.

It will be noted that the speed control means described above provides an easy and rapid means of changing the speeds of the rotating tone generators and moreover these changes are accomplished through steps of predetermined fixed ratios whereby a high degree of precision in tuning is attained.

What is claimed is:

1. In a transposing electrical musical instrument for transposing music to sound in keys other than that in which it is written, a system of rotating tone generators, means for driving said system, speed control means including clutches interposed between said system and said driving means for quickly and accurately changing the speed of said system throughout a plurality of predetermined fixed ratios and a separate control for each key to be selected adapted to operate the clutches to substantially instantaneously change said speed control means from one speed ratio to another.

2. In a transposing electrical musical instrument for transposing music to sound in keys other than that in which it is written, a system of rotating tone generators, means for driving said system, speed control means interposed between said system and said driving means comprising a plurality of permanently enmeshed parallel connected gear trains of predetermined fixed ratios, an electromagnetic clutch interposed in each train and a separate control switch for each clutch adapted to substantially instantaneously switch said speed control means from one speed ratio to another.

3. In a transposing electrical musical instrument for transposing music to sound in keys other than that in which it is written, a system of rotating tone generators, means for driving said system, speed control means interposed between said system and said driving means comprising a plurality of permanently enmeshed parallel connected gear trains of predetermined fixed ratios, an electromagnetic clutch interposed in each train and a separate control switch for each clutch adapted to substantially instantaneously switch said speed control means from one speed ratio to another, said switches being mechanically interconnected to permit the operation of but one at a time.

4. In a transposing electrical musical instrument, a plurality of rotating tone generators, a mechanical coupling means interconnecting said generators adapted to maintain their speeds at predetermined fixed ratios with respect to any one generator, and means for adjusting the speed of said coupling means to any predetermined rate, said means comprising a constant speed motor, a plurality of permanently enmeshed gear

trains of different ratios interconnecting said motor and said mechanical coupling means, an individual electromagnetic clutch inserted in each train, and means for selectively energizing any one of said clutches.

5. In a transposing electrical musical instrument, a plurality of rotating tone generators, a mechanical coupling means interconnecting said generators adapted to maintain their speeds at predetermined fixed ratios with respect to any one generator, and means for adjusting the speed of said coupling means to any predetermined rate, said means comprising a constant speed motor, a main drive gear directly coupled thereto, a plurality of drive pinions driven by said main gear and effectively permanently enmeshed therewith, a driven gear on said mechanical coupling means, a driven pinion for each of said drive pinions permanently enmeshed with said driven gear, an individual electromagnetic clutch interconnecting each pair of drive and driven pinions, each of said pairs adapted to drive said driven gear at a different predetermined speed, and means for selectively energizing any one of said clutches.

6. A musical instrument comprising a conventional keyboard with seven white digitals and five black digitals per octave, means responsive to each of said digitals for producing a fundamental frequency different from that responding to every other digital but bearing an exact harmonic relationship with the tonic frequency, and means for transposing the key in which the music sounds without changing the keyboard manipulation, said means comprising a means for simultaneously changing the frequencies of all digitals by the same common factor.

7. A musical instrument comprising a conventional keyboard with seven white digitals and five black digitals per octave, means responsive to each of said digitals for producing a fundamental frequency different from that responding to every other digital but bearing an exact harmonic relationship with a tonic frequency and means for transposing the key in which the music sounds without changing the keyboard manipulation, said means comprising a pedal control means for simultaneously changing the frequencies of all digitals by the same common factor.

8. A musical instrument comprising a conventional keyboard with seven white digitals and five black digitals per octave, means responsive to each of said digitals for producing a fundamental frequency different from that responding to every other digital but bearing an exact harmonic relationship with the tonic frequency, and means for transposing the key in which the music sounds without changing the keyboard manipulation, said means comprising a plurality of pedal-operated push buttons one for each desired key change, each adapted to simultaneously change the frequencies of all digitals by a common factor.

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