THE HAMMOND ELECTRIC ORGAN

By JOHN L. LANGLEY, '38

With the successful introduction of the electric organ as an instrument of musical expression, an understanding of its operating principles should broaden the engineering student's conception of the brand new role assigned to electricity.

Until its appearance some eighteen months ago, no practical or commercially potential application had been thought of for using an electrical force as a means of producing acceptable music. But thanks to Laurens Hammond of Chicago (and the Hammond Clock Company) a new musical instrument, though familiar to the organist, is now being heard daily in homes, churches, and studios.

The technical comprehension of the organ requires an elementary knowledge of electrical physics and acoustics. Suppose that for the sake of humanizing the technical treatment, we follow the inventor, Mr. Hammond, and make a step by step inspection into his development of the electric organ.

From acoustics, the engineer knows that sound, as it comes to him, essentially is air in vibration, and vibrating bodies cause the molecules in the air to vibrate with the same frequency as that of the body. A pure monotone sound then is air vibrating at a definite single frequency, and ordinary sound or music is a combination of various frequencies within a definite range audible to the human ear.

From electrical physics, the engineer knows that alternating currents and sound waves have much the same characteristics in wave form and composition. Mr. Hammond, knowing this principle, sought a method by which an alternating current with the frequency of some audible tone could be made. Knowing that an alternating current could be induced in a coil (which circumvented a permanent magnet) by varying the magnetic flux linking the coil, (emphasis is here placed on the varying of or change of flux linking the coil as it is the very heart of the electric organ), he sought a simple method of varying the magnetic flux. If a flux change with a frequency of 256 times a second could be produced, an alternating current with the same frequency would be induced and by amplifying this current and feeding it to a loudspeaker, the note of pitch *C* would be sounded. Hammond solved this problem by rotating, within the magnetic field near the coil, a metallic disk, called a tone wheel. Upon the periphery of the disk (diameter of about two inches) a number of humps or high spots were equi-distantly placed,

THE HAMMOND ELECTRIC ORGAN

Courtesy Heaton's Music Store.

so that by rotating the disk at a certain speed, the number of flux changes caused by the high spots would be equal to their number on the periphery times their angular velocity. To secure other frequencies, he simply mounted more disks with a varying number of high spots on the shaft of a synchronous motor.

For his organ, he mounted ninety-one disks, all of which, when rotating, would be producing as many definite current frequencies. Each tone wheel had its own magnet and coil. So now having a source of synchronized electrical *tone currents,* the next problem concerned the instantaneous control and mixing of the currents necessary to produce definite composite tones.

By using the regular keys of the organ as electrical switches, the different tone currents could be turned on or off, and thus the chosen ones conducted into the harmonic producer at will. Here, currents at definite frequencies holding certain relations to the incoming currents were automatically added to the incoming currents.

Above the keyboards on the Hammond organ are located five sets of harmonic controllers, two for each keyboard and one for the foot clavier. Each set consists of nine drawbars or stops which themselves have nine positions regulating the presence and intensity of that harmonic produced or added by setting its drawbar in position.

Suppose that the key *middle C* were depressed on the keyboard. This closes an electrical circuit with that tone wheel circuit producing an alternating current of the same frequency, (256). Immediately this current flows to the harmonic controller. If one of the drawbars, say that for the second harmonic is drawn out, a current whose frequency (512) is twice that of the incoming current or fundamental, is added to that fundamental. When this is amplified—and permitted to operate a speaker, a tone will be sounded which consists of a fundamental, *C* and its second harmonic, the *C* one octave higher. Suppose that in addition to the second harmonic drawbar, the one controlling the sixth harmonic (or any other) be drawn out to some different position relative to the second harmonic drawbar. The tone current leaving the harmonic controller now consists of the currents whose fundamental is 256, a current which is the second harmonic of this fundamental, and a current with a frequency of 1536 (sixth harmonic). The strength of these component currents depends upon the relative positions of the drawbars, and the quality of the note sounded depends upon their relative intensity in presence.

Thus it is possible to produce tones of great richness as the harmonics tend to add timbre to the tones.

Further control is offered by means of *preset* keys on the left end of the keyboard. These correspond in general action or results to the pistons of the pipe organ.

It is with these preset keys and drawbars that the various tone combinations are set up in order to simulate other musical instruments. If an instrument of the reed family is to be imitated, the harmonics and tones predominant in or characteristic of that family are prearranged so that when the keyboard is played, the translation of the music seems to be from a reed instrument. Other families, diapason, flute, string, etc., may also be reproduced according to the player's choice.

As on the pipe organ, a foot clavier or foot pedals, tremulant control and swell control are represented to give the effects as suggested by their names.

Thus it is clear that outwardly, the console of the electric organ differs very little from that of the pipe organ in respect to controls. The real difference lies within the console, where, for the electric organ, is situated the sound producing mechanism. For the pipe organ, the console merely houses the controls in the electric circuits or the pneumatic controls found in some types.

If the reader understands for the most part the technical side of the organ, let this side of the discussion be terminated with the statement that the electric organ is capable of producing *253 million different tones.*

In analyzing the merits of the electric organ, one must be careful in using a standard for comparison, as a $1300 electric organ could not be expected to give the glorious, deep throated emotion-compelling sound pictures capable of a $35,000 pipe organ. This may be understood in comparing the types of music produced by the two organs. For certain forms, light in character and intensity of feeling, or perhaps the wandering meditative forms of music, the electric organ is well qualified to meet the demand. For the heavier tones suggestive of deep emotions, only the pipe organ has the strength, power, and majesty needed to convey and arouse these masterful feelings. There is some distortion in the lower registers of the electric organ.

As the electric organ is relatively new, its possibilities even now suggest what might be expected in the future with refinements and subsequent developments. It must be remembered that the large pipe organ is an individual instrument designed for the church or building in which it is located. Its sound source is not concentrated in one place, being spread out over the physical location of the pipes. In contrast to this, the electric organ has a specific sound source easily located by the listener. Where means are not taken to use walls as baffling surfaces, some dissatisfaction is felt with present installations of the electric organ. This seems to indicate an opening in the field for a sound engineer.

Finally, the economical aspects of the organ make it possible for those who have hithertofore been denied this type of music, to have an electric organ which has a low initial cost as well as low running costs. Retailing at around $1300, it is possible for homes to be filled with its appealing music, where before a much larger expenditure had to be made to secure an instrument capable of the expression of the electric organ. Furthermore, consuming only 200 watts of power, it falls within the cent-an-hour class to operate. Because of the novel principle of producing different tones, it can never get out of tune, a common trait of all instruments today.