Fig. 1. The largest Minshall organ, Model LC, which has a chorus generator.

The New Minshall Organ

RICHARD H. DORF*

In Two Parts — Part I

A new approach to design details has produced an electronic organ with the kind of construction economy and performance standards that make for good engineering in any field.

IT IS A SAFE BET at this moment that the next product of the electronic art scheduled for a boom in the manner of radio, television, and high-fidelity sound is the electronic organ. The bet is safe because that boom has already begun, even though it is still just in its infancy and may never perhaps attain the proportions of the high-fidelity market. All of the companies in the field, principally occupied for years only with selling to churches, now make spinet and medium-sized organs for the home—and are selling them by the carload. Complete kits are becoming available for home construction of organs. And new companies, sensing the growing demand, are entering the field with new designs. The consumer is finding that an instrument with the ability to produce sustained tones with many different timbres is a fascinating and rewarding one to buy or build, and, as in so many industries before this one, his discovery is working a metamorphosis.

One of the principal problems which manufacturers of organs have is economy of design consistent with good performance. When the market was confined almost exclusively to churches this problem did not loom so large because churches, while most of them are by no means wealthy, can at least, in effect, pool the funds of many individuals to pay for an instrument. The home organ buyer, however, is using only his own money and now that he is an important customer prices must be scaled down. This is a problem because organs are inherently somewhat expensive. They must, for example, provide at least one separate tone generator for each of at least 60 notes, and this alone leads to volume consumption of tubes and other components.

One of the most economical and interesting designs is that of the Minshall electronic organ (made by Minshall Organ, Inc., Brattleboro, Vt.—formerly Minshall-Estey but now having no connection whatever with Estey). The Minshall tone generators employ only half a tube, 4 resistors, and 3 capacitors per note. Similar economies occur throughout the instrument. Yet it produces a great variety of tones which are imitative of pipe-organ sounds, and the organ is at home with music of any type from Bach to Basin Street.

The original all-electronic model of the Minshall is described in the writer's book, *Electronic Musical Instruments*. The company is one of the youngest in the field and this was its first commercial realization. Since then, however, a good deal of change has been made to overcome faults which extensive field reports brought to notice and to increase very greatly the quality and variety of tonal resources. In this article we shall see the organ and its components and point out improvements.

There are today four standard Minshall models. Top of the line is the LC shown in *Fig.* 1. This is a full 2-manual unit with 25-note pedal clavier. It is distinguished from the Model L, shown in *Fig.* 2, by the fact that the LC has a second 4-octave set of tone generators which may be tuned slightly sharp or flat of the main generator set and can be switched in to give a "celeste" effect. The two models are otherwise identical. *Figure* 3 shows the spinet Model S, which has two offset 44-note manuals and 13 pedals; the S has about the same registration as the larger models despite its smaller size and lower price, which makes it one of the most versatile spinets offered. The new Minshall Chord Organ

* *Audio Consultant, 255 W. 84th St., New York 24, N. Y.*

Fig. 2. Model L, described in this article.

is shown in *Fig.* 4. This is a single-manual unit with 48 keys. It may be played in the standard way, but for chord use ten chord buttons are provided. These are used with the lower-octave keys of the manual to produce ten chords in each of the 12 keys, 120 in all. In this article we shall describe the Model L in detail. All the other models are essentially similar except for the chord organ which would require a separate article.

Over-all Scheme

A simple block diagram in *Fig.* 5 gives a general idea of the layout of the organ sections. Each of 12 tone-generator chasses produces five notes separated by octaves, so that 60 notes are generated in all. These are wired to a key-switch assembly for each manual. Each key-switch assembly has three output busses,[1] one each for 4-, 8-, and 16-foot tones. Each bus goes to an amplifier, after which the tones are fed through tone filters. The original tones are roughly sawtooth in shape and contain considerable harmonics; the tone filters, selected by tablet switches, shape the tones to imitate various organ voices. The outputs of the filters are combined and fed through a preamplifier which incorporates the swell-shoe attenuator, after which the tones are amplified by a power amplifier and fed to a speaker. The speaker is contained in the console of the Chord Organ and the Model S; the larger models employ separate tone cabinets. The Model H, a one-manual organ which is being discontinued, also uses a self-contained speaker.

Tone Generators

The basic distinction of Minshall electronic organs has always been the tone-generator system, invented by George Hadden who is also responsible for other advances in the electronic music art. The basic circuit of this generator has been described fully in the writer's book and in other articles and the description will not be repeated here. The principal virtue of the circuit is that it is inexpensive and yet reliable.

The complete circuit of a tone-generator chassis appears in *Fig.* 6. Each of the frequency dividers requires only one-half of a 12AX7, with no transformers or other expensive components. The resistors and capacitors used are all standard 10 per cent tolerance components, none having to be specially selected except for R_1 through R_5. The frequency ranges over which a generator with one set of values will operate and divide properly is over half an octave. There are four dividers on a chassis, however, and the useful ranges overlap somewhat so that the total range for the chassis may possibly be less than five semitones. For this reason, the required total 12-semitone range for all the generators has been divided into four sub-ranges of three semitones each and four sets of values are used to cover the total. The values for these are all shown in *Fig.* 6.

The master oscillator which may be tuned to set the organ in tune is a well designed Hartley. To allow for vibrato creation by variation of d.c. element voltages, the time constant of the grid-leak network R_7-C_4 has been made slightly smaller than would be required for optimum stability and an a.c. path has been added between plate supply and grid consisting of C_3 and R_6. When the plate supply voltage is varied at a rate between 5 and 8 cps, the frequency varies at the same rate. The use of the L-C oscillator is a part of the new models and is an improvement over the old design in which R-C phase-shift oscillators were used. The R-C oscillators tended to be somewhat unstable over a period of time because of change in tube plate resistance.

The frequency-divider stages are effectively voltage amplifiers in which the plate output is used to charge a capacitor between plate and cathode. The value of the capacitor is so chosen that it can charge only at a rate in the neighborhood of half the input frequency. The fundamental component of the plate voltage is then fed back to the grid in such phase as to cause the tube to cut off during every other input cycle; this causes the alternate positive peaks of the input wave to make the tube conduct and produce plate-current pulses at half the input frequency. The action, like that of most feedback systems, is hard to describe in a few words; complete details can be obtained elsewhere.

The plate output is the result of a capacitor which is charged and discharged,

Fig. 3. The spinet, Model S, has abbreviated manuals and pedals.

Fig. 4. The Minshall Chord Organ, an active competitor of the Hammond for the tired - businessman market, may also be played without using the chord buttons.

[1] For explanations of the terms used in connection with organs, see the writer's book "Electronic Musical Instruments," Radio Magazines, Inc., P. O. Box 629, Mineola, N. Y., $7.50.

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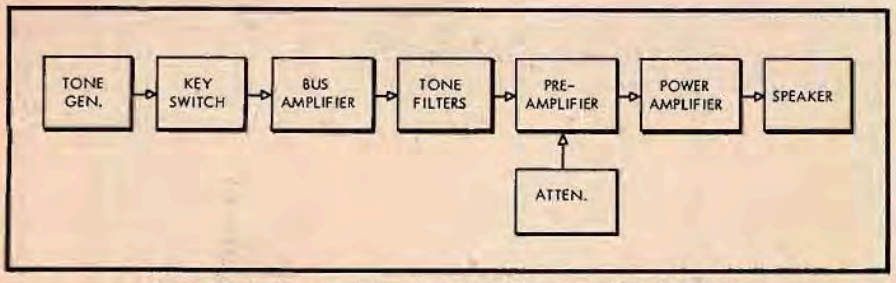

Fig. 5. Block diagram shows the essential sections of the Minshall.

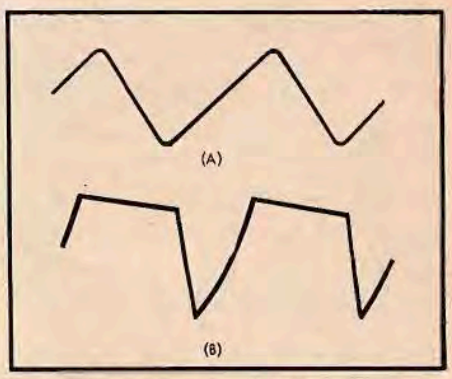

Fig. 7. Waveshape at (A) is that given by the generators proper. The shape at (B) has higher harmonic content and is obtained by differentiation.

and therefore takes the waveform of a sawtooth, as illustrated at (A) in *Fig. 7*. As can be seen, the flyback time of the sawtooth is quite large—at least 20 per cent—and the harmonic content is not very great. This was a fault in earlier models and made it imposible to secure any really bright tone qualities or, indeed, to have any really satisfactory variety of tone colors. In addition, the high-impedance key-switch system had to be of the shunt type because of leakage through the capacitance of open switches.

In the new circuit the plate outputs are not used directly. They are first passed through differentiators, which may be looked on as high-pass filters. They consist of C_8-R_{13}, C_{11}-R_{16}, etc., in *Fig. 6*. They have two functions. First and most important, they change the harmonic structure of the waves, making the harmonics much more prominent with respect to the fundamental, as may be seen in the resulting waveform of (B) in *Fig. 7*. With this improvement, the new models have very satisfactorily bright and interesting reeds and strings and a very good variety of colors. The second function, incidental but useful, is in voicing. By selection of the capacitor elements of the differentiators, the overall level of the higher notes is made greater than that of the lower ones. When all tones are passed through the later formant filters which are mostly of the low-pass type, the total scale tends to have more even loudness from top to bottom than if all incoming tones to the filters were of the same level. This is the same job done in the Baldwin organ by networks between octaves in the keying bus outputs and in the Schober Organ Kits by varying-value resistors in series with each key switch.

There are two additional improvements in the new Minshall generators. The first is that a cathode-bias resistor has been added in each divider stage. There is now less possibility than before that a change in some component or voltage will cause a misfunction, since an unbypassed cathode resistor tends to be a compensating factor, holding the tube at about the same operating point despite changes in other factors. The second improvement is that all the divider grids are direct-coupled. In the former design the grid impedances were extremely high and weather variations would sometimes cause trouble. The new arrange-

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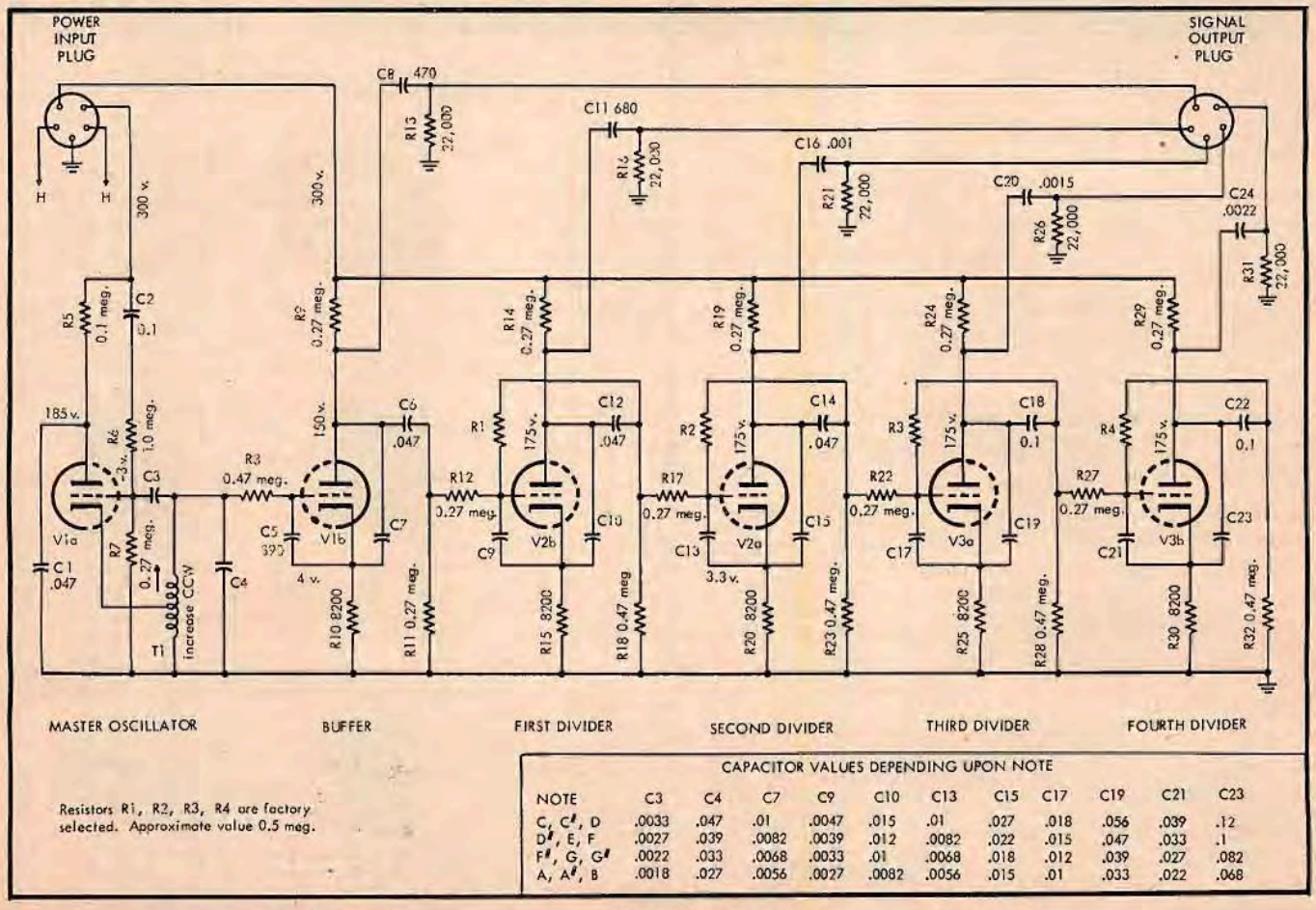
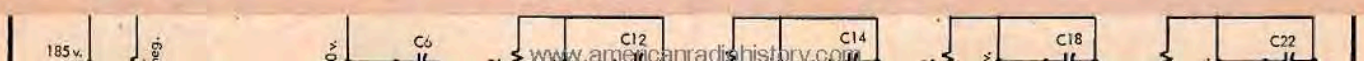


Fig. 6. The new tone generators are similar to the old ones but have several improvements.



THE MINSHALL ORGAN

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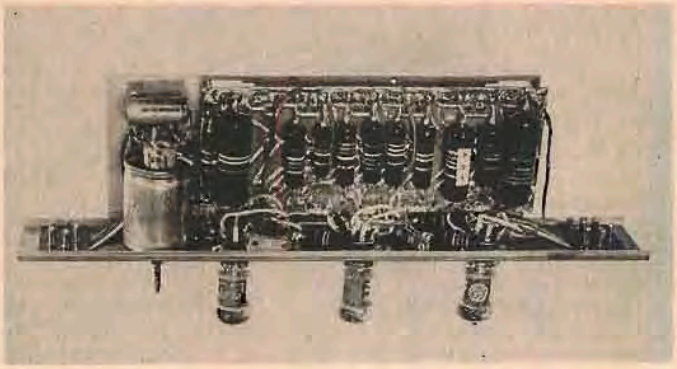

Fig. 8. Side view of a tone-generator chassis shows the printed circuit which holds most of the components.

ment brings grid impedances down to normal equipment values and this problem is eliminated.

Figure 8 shows how a tone-generator chassis looks. Notice that almost all the resistors and capacitors are mounted on a printed-circuit panel. The printed circuit makes for neat and inexpensive production and easy servicing since each component may be lifted or removed without disturbing others and may even be put back again without harm if found to be good. Minshall, at Mr. Hadden's instigation, has been among the first in the organ field to make extensive use of printed circuits and this organ probably contains more than any other in its tone generators and keying circuits, except for the Scholer Electronic Organ Kit which employs 130 all told. The generator chassis is extremely easy to replace when necessary because of good mechanical design. *Figure* 9 shows the rear of the organ. To remove a generator, the divider strap is loosened and the generator is simply pulled out; it is held in place only by the power and output plugs on its ends.

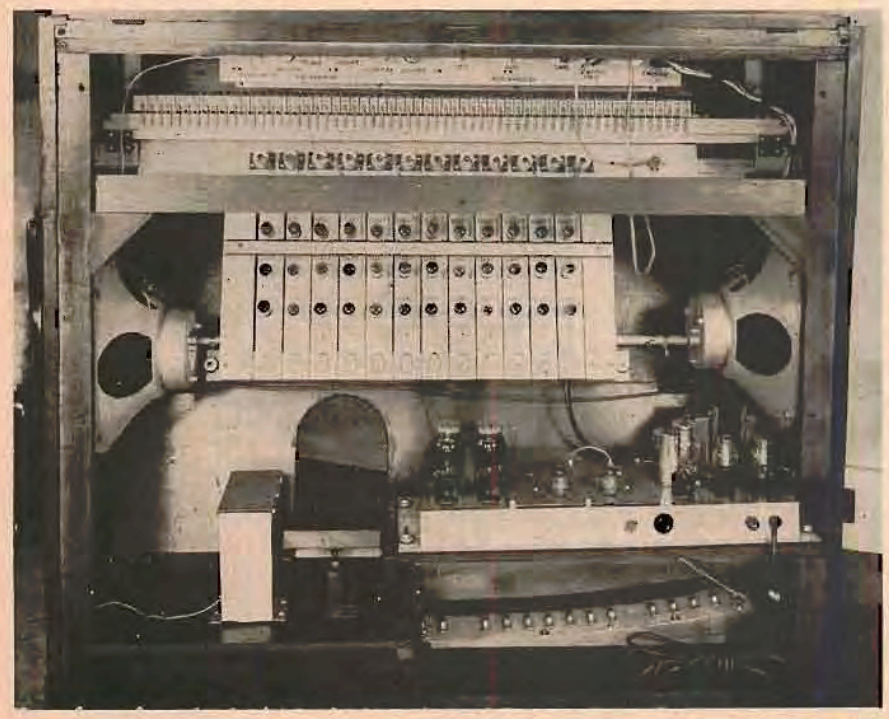

Fig. 9. Rear view of the Model L, showing the tone generators, power-supply and power amplifier, and tablet-board chassis.

Glinka—Kamarinskaja