Part two of this exciting electronic piano series

LYREBIRD

We describe the touch sensing circuitry

Last month we introduced our Lyrebird 73-note piano which has touch-sensitive keys and soft and sustain pedals. The introductory article discussed the overall concept of the Lyrebird piano and described the circuitry and construction of the tone generator and divider board. In this article we continue by presenting the circuitry and construction of the envelope keying circuit boards.

by LEO SIMPSON & GREG SWAIN

Since the Lyrebird has 73 notes, it has 73 individual sets of contacts which control the keying and envelope of each note. By "keying", in this instance, we mean turning the note source on and off and by "envelope" we mean the way in which the note rises suddenly when first struck (the attack) and then dies away rapidly or slowly (the decay), depending on whether the soft or sustain pedals are used.

The most interesting feature of the keying and envelope circuitry is that it actually responds to the speed at which the individual key is depressed and thus controls the loudness of each note. The mechanism of this action is described below. Refer to Fig. 1.

Each key controls a single-pole single-throw switch, Sk, which is normally connected to earth when the key is not being pressed. When the player presses the key down, the moving contact of the switch takes a finite time between breaking contact on one side and making contact on the other side, to the +30V rail.

It is during this time between breaking and making contact that C1 begins to charge towards +VT via R1 (which is typically 3.3kΩ) and R5, a 56Ω resistor. Then, as switch Sk makes contact with the 30V rail, the positive electrode of C1 is "raised" by 30V and so C2 is charged via D1 to a voltage which is approximately half the difference between 30V and the voltage reached by C1 before Sk made contact. In practice, the voltage reached by C1 will be 14V or less.

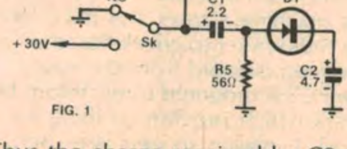


FIG. 1

Thus the charge received by C2 when Sk makes contact is inversely proportional to the time taken for the key to be fully depressed. The voltage on C2 then controls the initial amplitude of the signal fed to the voicing filters. It does this via R6, R7, D4, D5 and the two diodes providing each key output on the divider board described last month. This is shown in Fig. 2.

Remember that last month we stated that these pairs of "diodes and the envelope keying circuit actually form an AND gate for each key". Well it is actually R6 and the two diodes just mentioned that form the AND gate. Current flows from C2 via R6 and R7. When the respective Q outputs on the divider chip are low, the two associated diodes are forward-biased and the junction of R6 and R7 is pulled low. Similarly, when the respective Q outputs are high, the diodes will not conduct and the junction of R6 and R7 will be high.

From the foregoing, it follows that the higher the voltage on C2, the greater the amplitude of the signal fed to the voicing

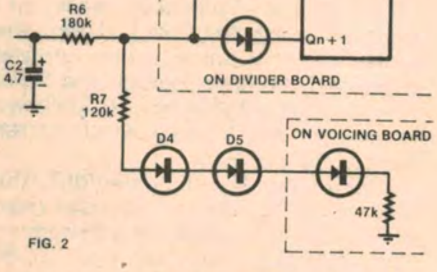


FIG. 2

board via diodes D4 and D5. These two diodes merely provide isolation between the individual keying circuits which feed into common voicing inputs.

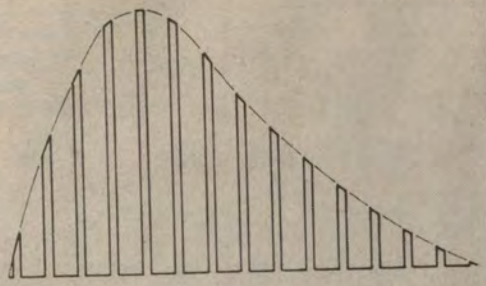


FIG. 3

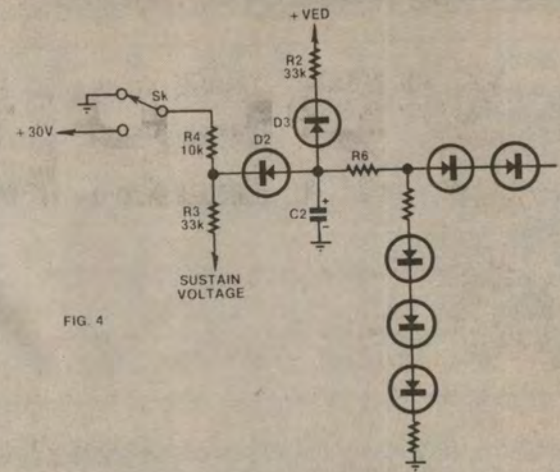


FIG. 4

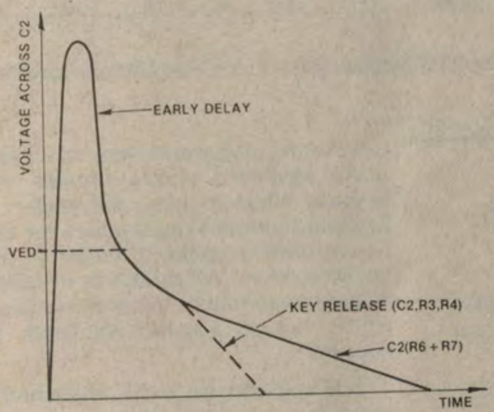


FIG. 5

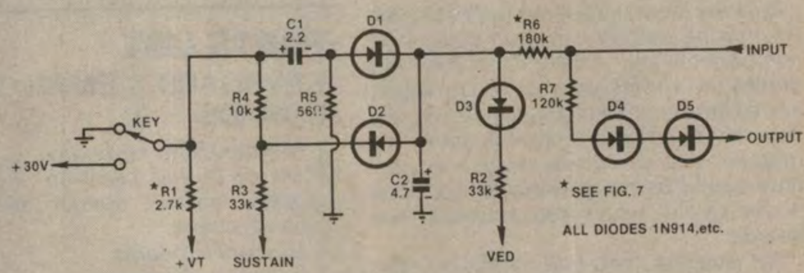


FIG. 6

Well so far we have seen that the circuit consisting of R1, R5, D1, C1 and C2 actually responds to the time taken for a key to be fully depressed and thus provides a voltage which controls the amplitude of the signal. Now we can discuss how the signal amplitude is made to decay. Fig. 3 shows how the signal fed to the voicing board rises and decays.

There are three ways in which the decay of the voltage across C2 is determined. They involve D3 and R2, D2, R3 and R4, and R6 and R7. This is depicted in Fig. 4. When the switch Sk makes contact with the 30V rail, C1 delivers its charge to C2. As soon as this current ceases to flow through C1 and D1, C2 starts to discharge via R2 and D3 to a preset voltage level labelled "VED", regardless of whether the key is held down or not.

"VED" is the "early decay" voltage which determines the percussive nature of the Lyrebird when keys are played in staccato fashion. When C2 discharges down to the VED level, it then continues to decay at a rate determined by R6 and R7, provided the key is still held depressed. While Sk is still connected to +30V, D2 is held in the reverse-biased condition so R3 and R4 cannot augment the discharge of C2.

If the key is released, C2 continues to discharge via D2 and the parallel paths provided by R3 (to the sustain voltage which is normally 0V) and R4 to 0V via Sk. On the other hand, if the sustain pedal is pressed, D2 is reverse-biased by D2, preventing discharge of C2 via this path and so the longer decay time set by R6 and R7 prevails.

The various waveforms generated by the discharge mechanisms described above are illustrated in Fig. 5 while the complete circuit is shown in Fig. 6. This circuitry is duplicated 73 times across the five envelope boards with R6 varying from 82kΩ to 270kΩ to give decay times from two seconds to about 6½ seconds.

(Some readers may be aware of the AY-1-1320 IC made by General Instrument Microelectronics for their electronic piano circuit. This IC performs the same function as the discrete circuitry we have just described, but does it for twelve notes, albeit with four external components per note. The Lyrebird circuit has the considerable advantage of using cheap and readily available components.)

CONSTRUCTION

As supplied for the Lyrebird, there are four envelope boards which accommodate 18 envelope circuits and one board which accommodates three circuits. One board will have to be trimmed so that it accommodates 16 circuits. This will accommodate the circuitry for notes one to 16 while the small three-way board accommodates the circuitry for notes 71, 72 and 73.

R1 and R6 vary across the five boards, as shown in Fig. 7. Note that the transition of the values of R1 and R6 takes place in the approximate middle of each of the four large boards.

Quite a lot of work is involved in the assembly of each 18-note board. It involves the installation of 18 links, 26 PC pins, 36 capacitors, 72 diodes and 126 resistors. Multiply that to give the total for all five boards and you have an

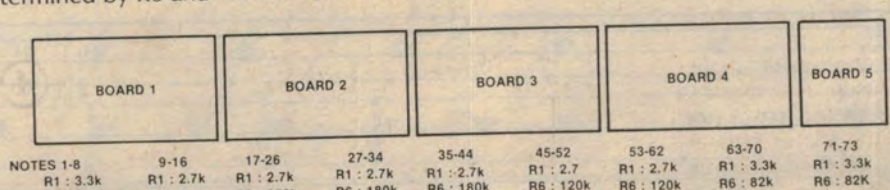


FIG. 7

This diagram shows how the values of R1 and R6 vary across the five envelope boards. R6 determines the decay time of each note.

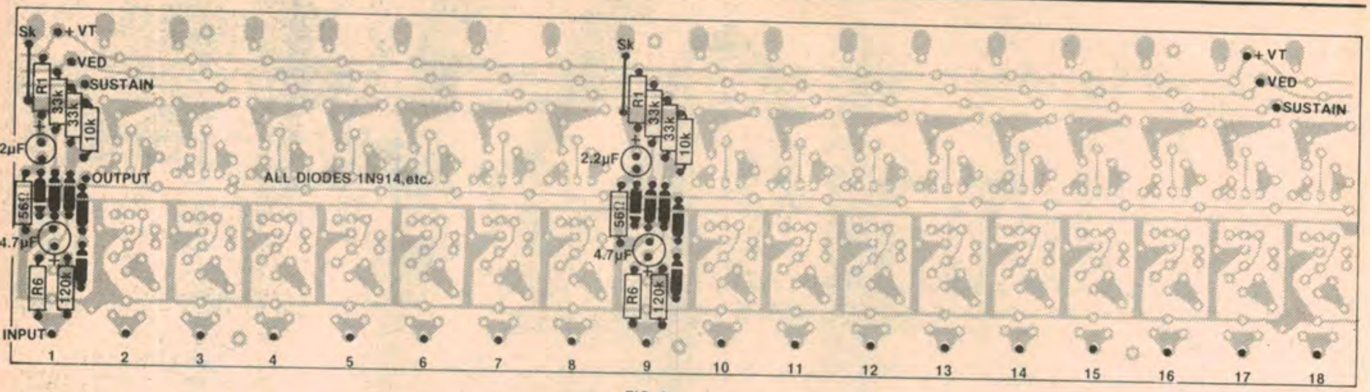


FIG. 8

For simplicity, only two of the 18 sets of components are shown on this envelope PC board. The VT, VED and Sustain points are linked across to the adjacent envelope boards.

extremely large number of opportunities for making mistakes in inserting wrong components and putting capacitors and diodes the wrong way round. You might like to amuse yourself by calculating just how many different combinations of mistakes that you could make but your time would be better spent in resolving to be careful when you assemble the boards.

We suggest that you work on one board at a time to avoid confusion. Start with board one which has to be trimmed to accommodate the 16-note circuit. Install the links and PC pins first, then the resistors and diodes. Remember that for notes one to 16, R1 is 3.3kΩ and R6 is 270kΩ. For notes nine to 16, R1 is 2.7kΩ and R6 is 220kΩ.

The links should be inserted and soldered so that they are about 1mm proud of the board surface. The links actually provide a soldering point for the contact spring associated with each note. While we mention the contact springs now, they are not to be soldered to the boards until the boards and busbars are assembled onto the keyboard chassis.

All the envelope boards should be very carefully inspected for assembly errors and poor soldering. Be very thorough as it is difficult to detect and correct mistakes once the boards are installed on the keyboard chassis.

KEYBOARD ASSEMBLY

The keyboard assembly requires a fair amount of mechanical work, so you can put away your soldering iron for the time being and take out your electric drill. But before you start brandishing the drill about, more mundane tasks beckon, such as disassembling the keyboard. Why do that when it is supplied in beautifully assembled form? Because the keyboard "action" is too light for a piano is why.

As supplied, the keyboard has one light spring to restore each key to its normal position when pressed. This gives such a light action that you need only brush a key to make a note sound. For a person used to the inertia and "feel" of a normal piano keyboard which requires some physical effort to play, this makes the keyboard virtually unplayable. Put simply, we have to make it harder to press the keys down. We do this by installing a layer of foam rubber under the keyboard which has a suitable thickness and density.

Each key can be easily detached by removing the small spring at the rear, detaching it from its lug on the keyboard chassis. Note that each key is labelled with a moulded legend such as B4/6 or whatever. This should be noted on a sheet of paper or on the keyboard chassis itself so that when you re-assemble the keys it will not be like a giant jigsaw puzzle. Having removed all the keys you can then proceed to take pencil and rule and mark up the underside of the keyboard chassis with the hole positions shown in Fig. 8.

All the hole positions should be centre-punched and drilled with a 3/32-inch drill bit.

ADDING FOAM RUBBER

With drilling complete, you can install the busbar blocks and busbars, using self-tapping screws which are not longer than 25mm. With busbars in place you can then install the five boards using 6mm spacers and self-tapping screws. Then you can install the foam rubber. We recommend a foam weatherstrip measuring approximately 15mm square, made by Engels (normally used for weatherproofing of doors and windows). This tape is run along the front edge of

PARTS LIST
KEYBOARD & ENVELOPE BOARDS

1 73-note piano keyboard
1 set of busbar hardware including spacers, contact springs and self-tapping screws
4 18-way PC boards
1 three-way PC board
1 metre of adhesive-backed foam, 15mm square (Engels)
4 hinges to suit keyboard
111 PC pins
73 2.2uF/25VW PC-mounting electrolytic capacitors
73 4.7uF/25VW PC-mounting electrolytic capacitors
365 1N914, 1N4148 small-signal silicon diodes
RESISTORS (10% tolerance, ½W rating) 8 x 270kΩ, 18 x 220kΩ, 18 x 180kΩ, 91 x 120kΩ, 11 x 82kΩ, 146 x 33kΩ, 73 x 10kΩ, 19 x 3.3kΩ, 54 x 2.7kΩ, 73 x 56Ω.

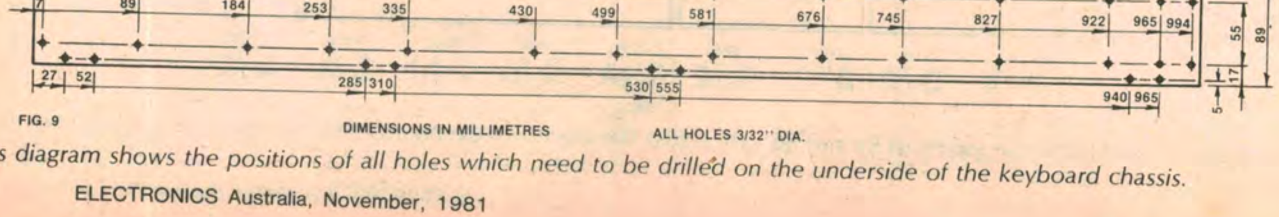


FIG. 9
DIMENSIONS IN MILLIMETRES
ALL HOLES 3/32" DIA.

This diagram shows the positions of all holes which need to be drilled on the underside of the keyboard chassis.

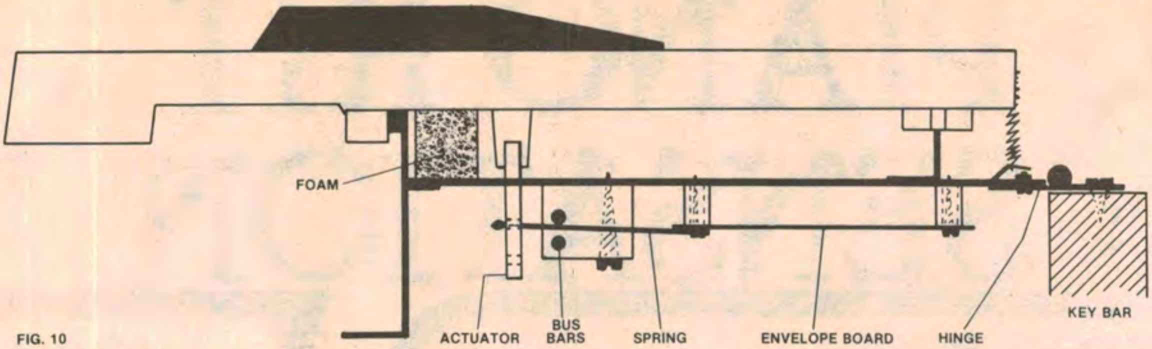
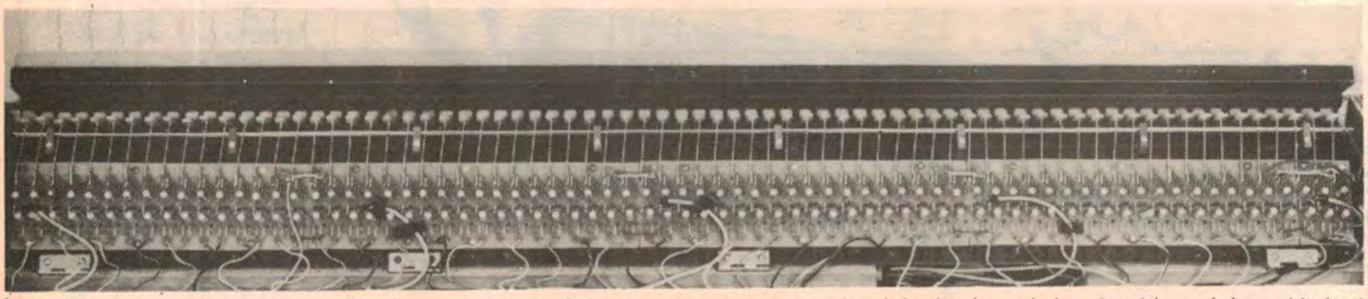
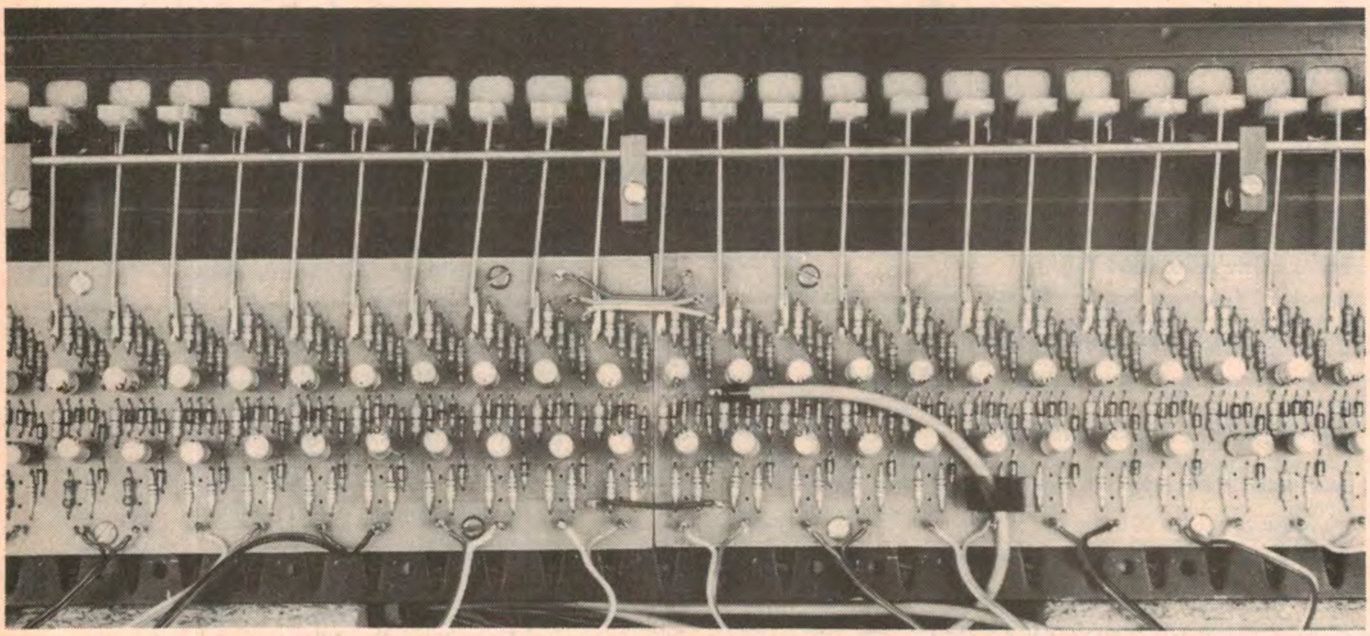


FIG. 10

This end elevation of the keyboard shows how the foam rubber is positioned and the mounting details of the envelope boards.



This photo shows the five completed envelope boards installed on the underside of the keyboard chassis with each board linked to its neighbour.



Detail of the envelope boards and busbar mounting. Note the long contact spring running from each link to each key actuator. Each envelope board should be very carefully checked for soldering and component positioning before it is installed on the chassis as it is difficult to make alterations once the contact springs are attached.

the keyboard chassis so that it sits just in front of contact actuators.

Now reassemble the keys and you are ready to solder the spring contacts to the envelope boards. As supplied, the springs are about 50mm long (in the unstretched state) and they have a formed head at one end. Position the spring so that its head just protrudes through the busbars and hold it temporarily against the appropriate link with a small alligator clip and solder the two together.

Now gently stretch the spring by hand and set the head into the key actuator recess. Do not use pliers for this task as you will damage the springs. Fig. 10 shows an end elevation of the keyboard showing how the boards and springs are assembled. Note that the spring should be in contact with the upper busbar when the key is in the rest position and should contact the lower busbar when the key is pressed. Make sure that the springs do not rub against the busbar mounting blocks. This should not normally be a problem.

Finally, you may trim away the excess spring from the boards, using a pair of side cutters. That is all for this month. Next month we shall describe the voicing filter circuitry and construction of that PC board.