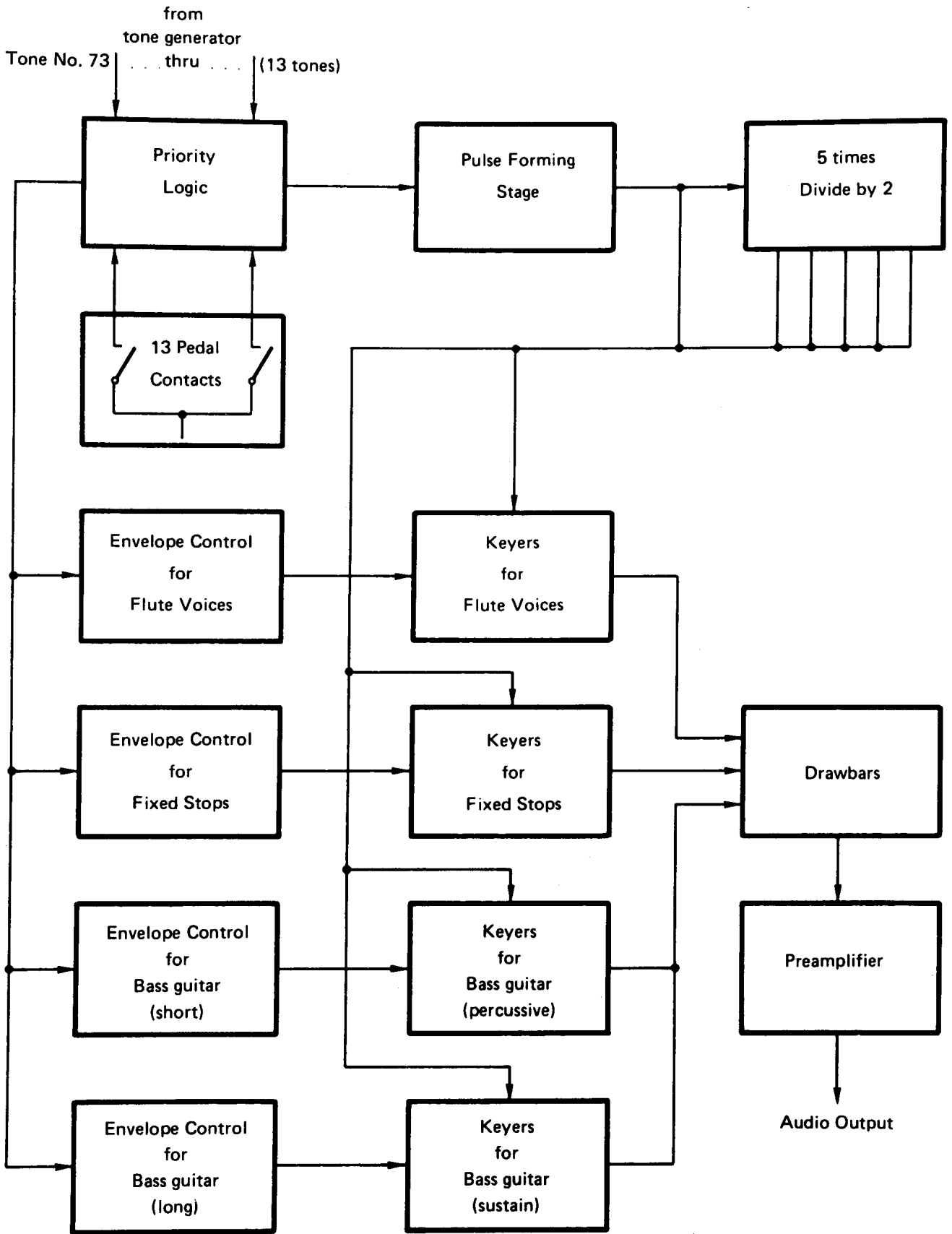




Assembly Manual

Technical Data W Series Digital Pedals

AM 320 1st Edition (Part)



Functional Description

This chapter describes the operation of the electronics and it is intended for the interested reader only. It is not necessary for the successful assembly and use of the pedals that you understand all circuit details. We recommend, however, that you read it nevertheless. You may derive some better understanding of the pedal functions, helping you to use them to their fullest extent while playing.

I. Block Diagram of the P E 1 3 (1 3 pedal clavier)

Fig. 3 shows the block diagram of the P E 13. The tone generator supplies 13 raw tones to the so-called priority logic. The DC control signal, coming from a depressed pedal, causes the priority logic circuitry to pass on one of these tones to the following circuits. Should more than one pedal be depressed, the logic circuitry selects the lowest note. The signal selected by the last depressed pedal is passed through for a few seconds even after the associated pedal was released: This memory feature makes it possible to shape the envelope (sustain) of the signal past the release of the pedal.

The selected signal is fed to a 5-stage frequency divider via pulse forming circuit. The input frequency to the frequency divider corresponds to the $\frac{1}{2}$ ' footage. The divider produces the lower ranks from 1' down to 16'. A total of six footages of square waves are thus available for the ensuing envelope processing and voicing.

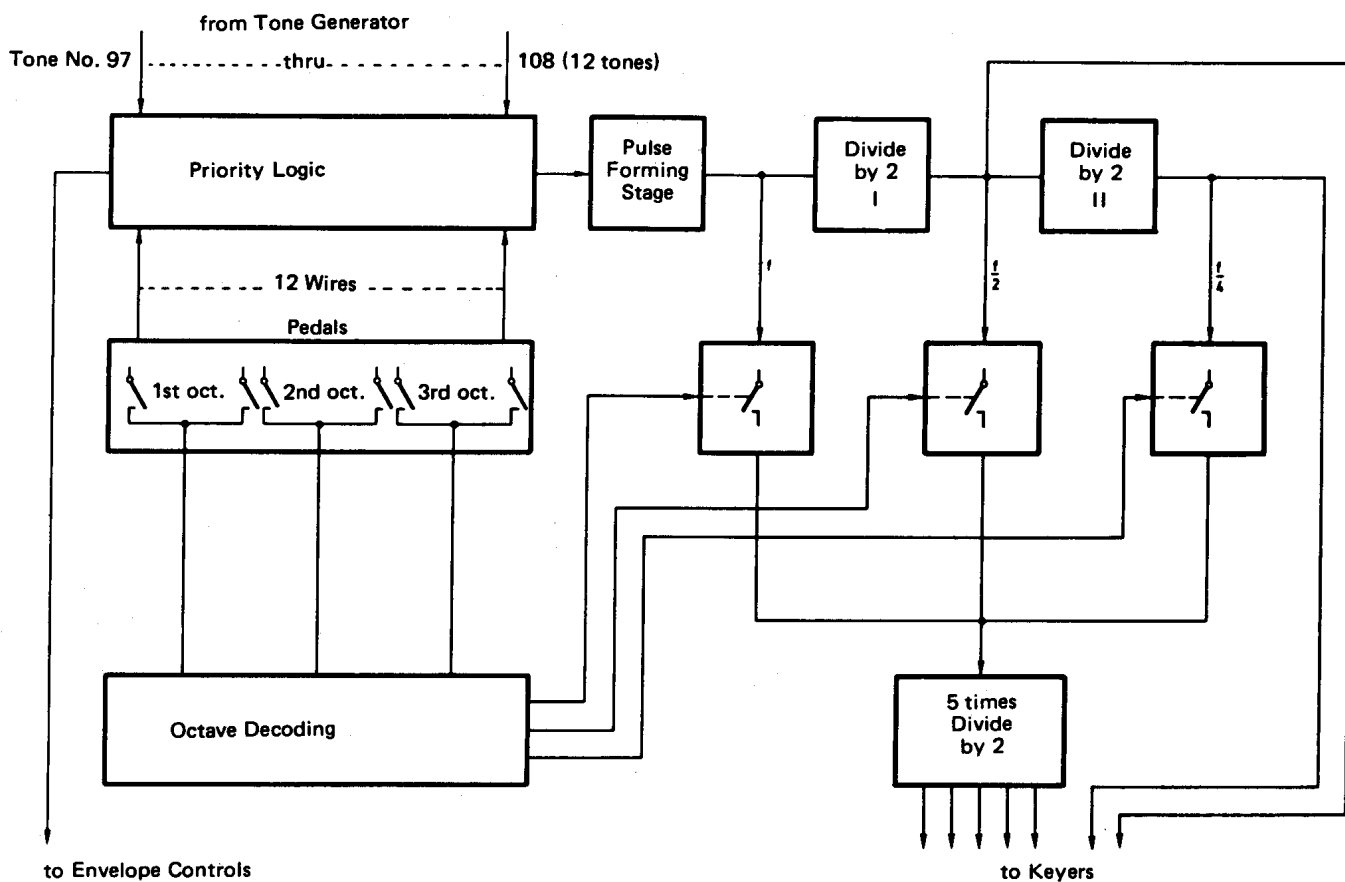
Due to the memory feature of the priority logic these six tones will remain present for a few seconds after the associated pedal was released. The square wave signals are applied to analog gates which, in turn, shape the time dependent volume (envelope) of the signals.

There are four sets of gates, one set each for the sine wave voices and for the fixed stops and two sets for the bass guitar. The tone decay (sustain) is determined by control voltages applied to each set of gates.

The envelope control voltage for the sine wave gates is adjustable to four levels by means of the control switches "Sustain I" and "Sustain II".

The fixed stops are gated on and off almost instantaneously. The associated control voltage is fixed by the circuitry.

Figure 1 Block diagram of the PE 36 (14 to 36 pedals)



The envelope for the bass guitar is composed of a fast decay portion (attack from the pick) and a slow decay tail (sustain of the string tone). Both control voltages are fixed by the circuitry and act on two sets of gates. The total bass guitar voice is created by the superposition of a tone rich in harmonics with a fast decay and of a second softer tone decaying more slowly.

The start of the decaying envelope for the sine waves and fixed stops is triggered by the priority logic as soon as the pedal is released.

In contrast, the percussive decay of the bass guitar is initiated by the priority logic as soon as a pedal is depressed and takes place disregarding whether the pedal remains depressed or is released. If the pedals are played in legato mode the initial attacks of all but the first tone are suppressed automatically simulating gliding fingers on the guitar strings.

If the pedals are played in staccato mode and in a fast sequence any previously sounding tone (during its decay) is totally cancelled prior to the start of the next tone. This eliminates possible dissonances between non-harmonic tones and lends a distinctive transparency to your pedal playing.

II. Block Diagram of the P E 36 (14 to 36 pedals)

The pedal electronics PE 36 designed for more than one octave differs from the single-octave version P E 13 merely in the method of pedal recognition and frequency division. Fig. 4 shows the block diagram of the circuitry sections of PE36 which are different from those of P E 13.

The priority logic selects the proper tone from the set of 12 coming from the tone generator (at frequencies which are higher by 2 octaves than in PE 13) and feeds it to two cascaded divide-by-two circuits. This means that tones of three octaves of the highest footage are available simultaneously. A second logic circuit determines the octave to which the depressed pedal belongs and passes on the proper frequency to the common 5-stage divider.

This circuit is capable of deriving tones of six footages for a maximum of 36 pedals from a mere 12 incoming tone generator frequencies. It further decodes up to 36 pedals with only 15 wires leading to the pedal clavier.

III. Circuit Description for the P E 13 (and P E 30)

The following circuit description applies to both types of pedal electronics unless noted otherwise.

1. Pedal Priority Logic and Envelope Control (PE 13 only)

Fig. 5 shows the schematic diagram of the pedal priority and envelope control of P E 13. The 40-pin integrated circuit IC 1 plays a key role in this circuit. 13 square wave signals, coming from the tone generator, are applied to pins 15 thru 27. The frequencies span a full octave from C to C and correspond to the $\frac{1}{2}$ footage.

The single pedal contacts are wired, to pins 1 thru 6 and 34 thru 40. Depressing any pedal applies a negative control voltage to the respective IC pin, causing the IC to pass on the corresponding audio input signal to the output pin 9. This condition remains latched whether the pedal is released or not until a new pedal is depressed or until a certain time has elapsed (see below). An internal priority logic in the IC selects the lowest note to be passed on should more than one pedal be depressed simultaneously.

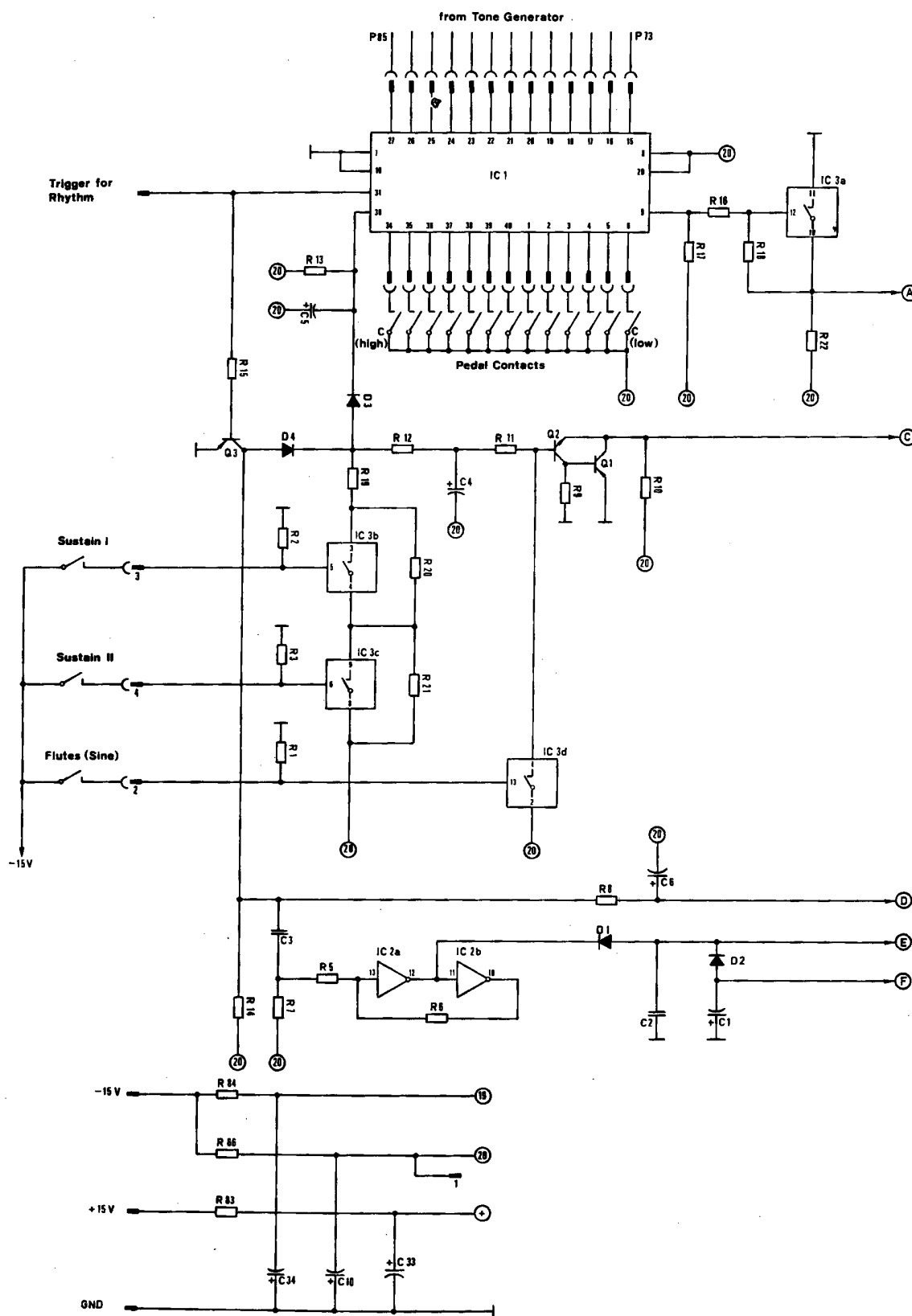
The selected audio frequency remains present at the pin 9 as long as pin 30 ("Inhibit-in") is held at a positive (ground) potential. This condition which makes the IC remember the last depressed pedal must persist at least for a length of time which equals the longest desired decay period of the tone (sustain).

As long as a pedal is depressed pin 31 ("Priority-out") swings to a negative voltage (grounded otherwise). Transistor Q 3 is turned on and capacitor C 5 is charged via diodes D 4 and D 3 pegging pin 30 to a positive voltage. The time constant, determined by C 5/R 13 causes the voltage at pin 30 to decay slowly after the pedal is released such that IC 1 remains latched for approximately 5 seconds.

If a new pedal is depressed within the 5 second interval its associated frequency is passed on to output pin 9 and the new frequency is "remembered" for 5 seconds after the release of the pedal.

The selected audio frequency signal from output pin 9 passes through IC 3a which serves as a pulse forming stage, improving the steepness of the leading and trailing square wave flanks. This conditioned audio frequency is then available at point "A" for subsequent use

Figure 2 Pedal priority and envelope control of PE 13



We recall that transistor Q 3 is turned on if and only if a pedal is depressed. The collector voltage of Q 3 is used to generate the various envelope control voltages for the different pedal voices.

a) Envelope control for the sine waves (drawbars)

When a pedal is depressed C 4 is charged rapidly. (The small time delay due to R 1 2 serves to eliminate a "key-pop".) Point "C" swings positive (ground potential) allowing the sine wave gates to open completely (see Fig. 6).

The decay rate of the voltage across C 4 and therefore the closing rate of the sine wave gates is determined by the discharge resistance of C 4, namely by R 12, R 19, R 20 and R 21. If the control switches "Sustain I" and "Sustain II" are off (open) the electronic switches IC 3b and IC 3c are closed (biased on through R 2 and R 3 respectively) by-passing R 20 and R 21. The voltage across C 4 decays rapidly producing practically no sustain.

If the control switch "Sustain I" is closed the electronic switch IC 3b opens adding R 20 to the discharge path of C 4 which increases the sustain.

Similarly, closing the control switch "Sustain II" adds R 21 (R 21 is larger than R 20) lengthening the sustain. The two sustain times are obviously additive for a very long sustain.

If the control switch "Drawbars" is off (open) the electronic switch IC 3d is closed clamping the base of Q 2 negative. The entire set of sine wave gates is thus kept open. Closing the switch "Drawbars" enables the sine wave voices.

b) Envelope control for the fixed stops

The rise and fall times of the voltage across capacitor C 6 is determined by resistor R 8. R 8 and C 6 are chosen to produce a rather rapid on/off envelope control voltage which is present at point "D". The fixed stops are thus played without any noticeable sustain.

c) Envelope control for the bass guitar

The positive-going pulse from the collector of Q 3 is differentiated by capacitor C3. The inverters IC 2a and IC 2b, together with the feedback resistor R 6 and the bias resistor R 7 form a mono-stable pulse generator such that the voltage

between the two inverters swings negative for a short period of time every time a pedal is depressed (staccato playing only). This negative pulse charges the two capacitors C 1 and C 2 via the diodes D 2 and D 1 respectively.

The bass guitar envelope is composed of a fast-decay and a slow-decay portion. The value of C 2 is much smaller than that of C 1. The rapidly decaying voltage at point "E" is used for the initial pluck from the guitar pick and the slowly decaying voltage at point "F" simulates the sustain of the string sound. See also Fig. 6.

Note that the bass guitar gating (Fig. 6) is phase-inverted with respect to the gating of the other voices. This little trick eliminates cancellation effects when the bass guitar is played together with the other stops.

The bass guitar is a percussive voice. Its sound decays whether the pedal is released immediately or being held down for an extended period.

2. Frequency Dividers, Gating, Voicing and Controls

Fig. 6 shows the circuit diagram of these sections and applies to both PE 13 and PE 36:

a) Frequency Dividers

The square wave audio signal coming from the pedal priority circuit (Fig. 5) is applied to the input pin 1 of the 7-stage frequency divider IC 4 (divide by 2 in each stage). Only 5 stages, however, are utilized. Together with the incoming frequency, a total of 6 octaves are thus available simultaneously.

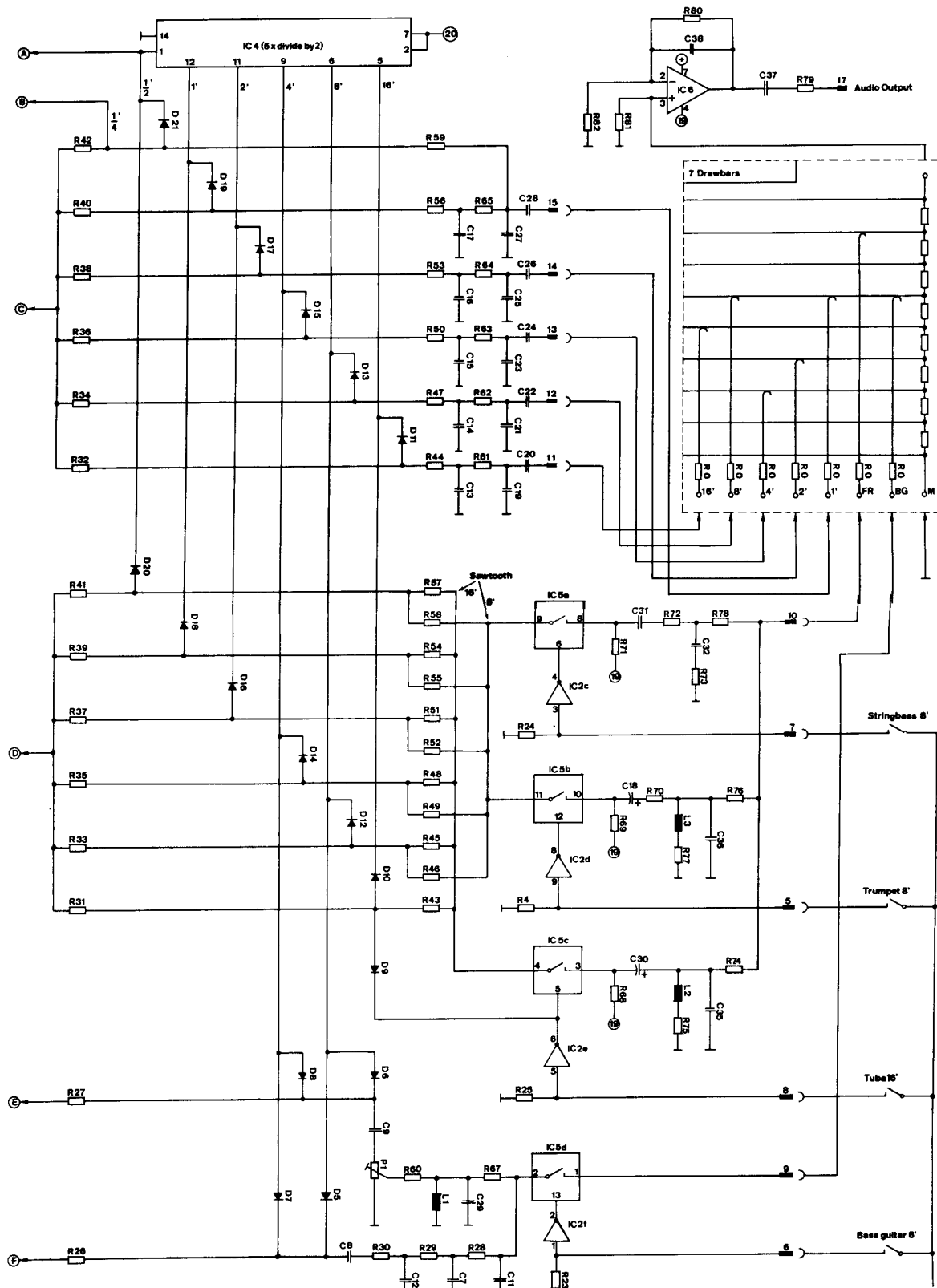
b) Gating

There are a total of 16 proportional gates formed by the diodes D 5 thru D 8 and D 10 thru D 21. These gates pass on two or more footages to the voicing filters. The amplitudes of the gated audio signals are directly proportional to the envelope control voltages present at points "C" thru "F".

c) Voicing

Low-pass filters translate the gated square waves into sine waves for the sine wave drawbars. The output pins 11 thru 14 thus carry sine wave signals of the footages 16', 8', 4' and 2'. A mixture of 1' and 1/2' (+ 1/4' for PE 36) is applied to output pin 15.

Figure 3 Frequency dividers, gating, voicing and controls for PE13 and PE 36



The gating diodes D 10, 12, 14, 16, 18 and D 20 are followed by two resistor matrices. R 43, 45, 48, 51, 54 and 57 combine the square waves of the different footages into a quasi sawtooth wave by "staircasing", corresponding to a 16' rank. Similarly, R 46, 49, 52, 55 and 58 form a sawtooth wave at the 8' rank.

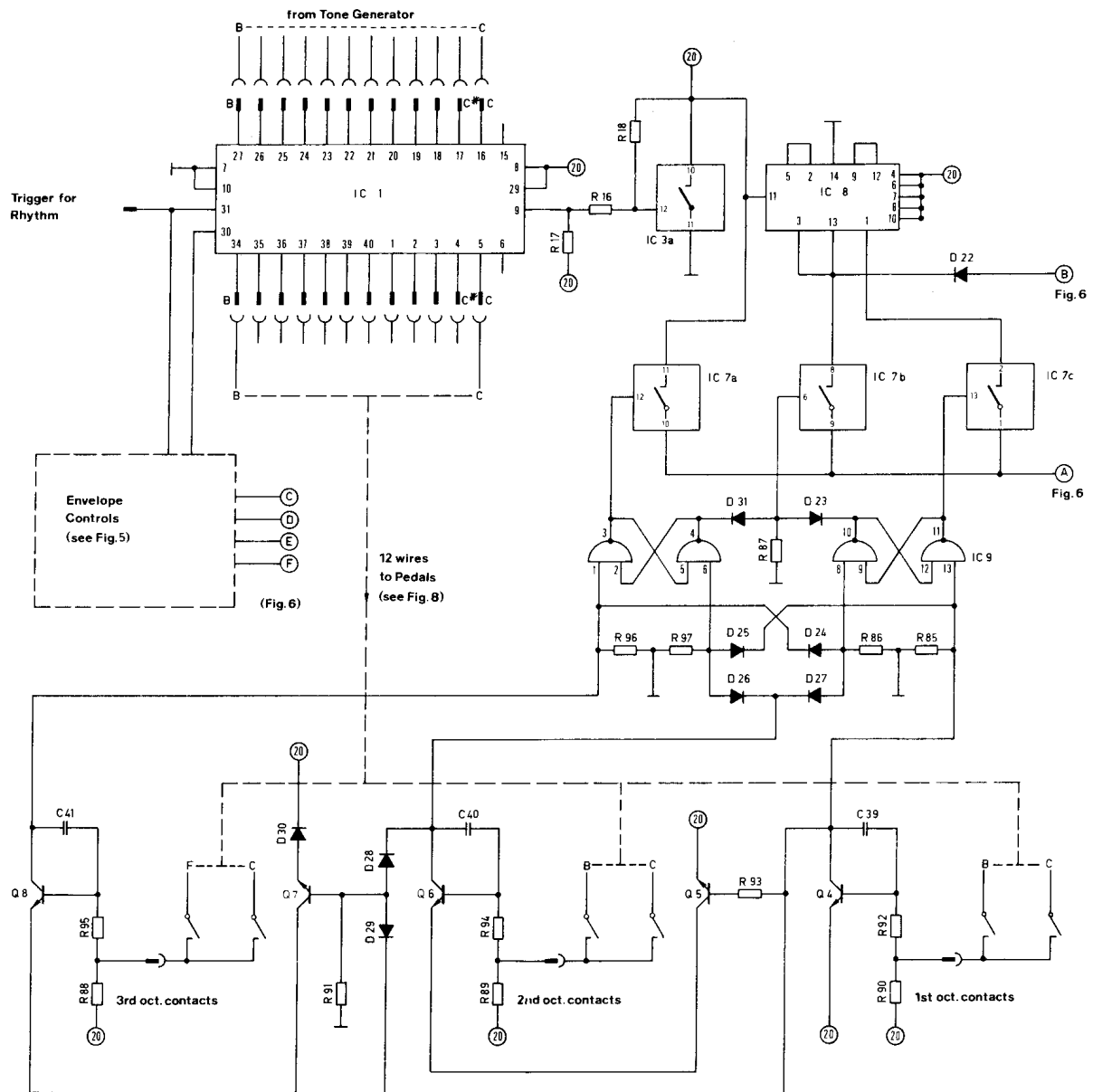
The 16'sawtooth wave is filtered by an L/C combination into the voice "Tuba 16" if the analog switch IC 5c is on. IC 5c is turned on if the switch "Tuba 16" is closed. The inverter IC 2e is necessary to make the polarity of the control voltage compatible with the convention adopted throughout the organ.

The 8'sawtooth is used to generate the other two fixed stops, namely "Stringbass 8" and "Trumpet 8". Again, the voices are controlled on/off by electronic switches.

The gating for the 16'square wave (D 101 is inhibited via D 9 if the 16' stop "Tuba" is not used. This eliminates any 16' feedthrough (via R 4 3 etc.) into the 8' voices if 8'stops are the only ones used.

The bass guitar voicing is divided into two independent filters. D 6 and D 8 gate the 8' and 4'square waves with a rapidly decaying envelope. The narrow band-pass filter consisting of L 1/ C 29 translates the incoming

Figure 4 Pedal decoding and priority logic of PE 36



frequency mixture into a sound which is almost independent of the pitch. Therefore, the "pluck" portion of the bass guitar will sound similar across the tone range of the instrument.

The long sustain portion of the bass guitar (gated by D 5 and D7) is achieved through low-pass filtering (R 30/C12, etc.). The combined voice is on/off controlled by the electronic switch IC 5d.

d) Volume Controls

The five sine wave voices, the fixed stop combination (Tuba + Trumpet + Stringbass) and the bass guitar are fed to 7 drawbars (organ models W 1 use 16' and 8' only = 4 drawbars). The drawbars allow the individual mixing of these voices into an almost unlimited number of combinations.

The summed signal is post-amplified by IC 6 and is available at the output pin 17.

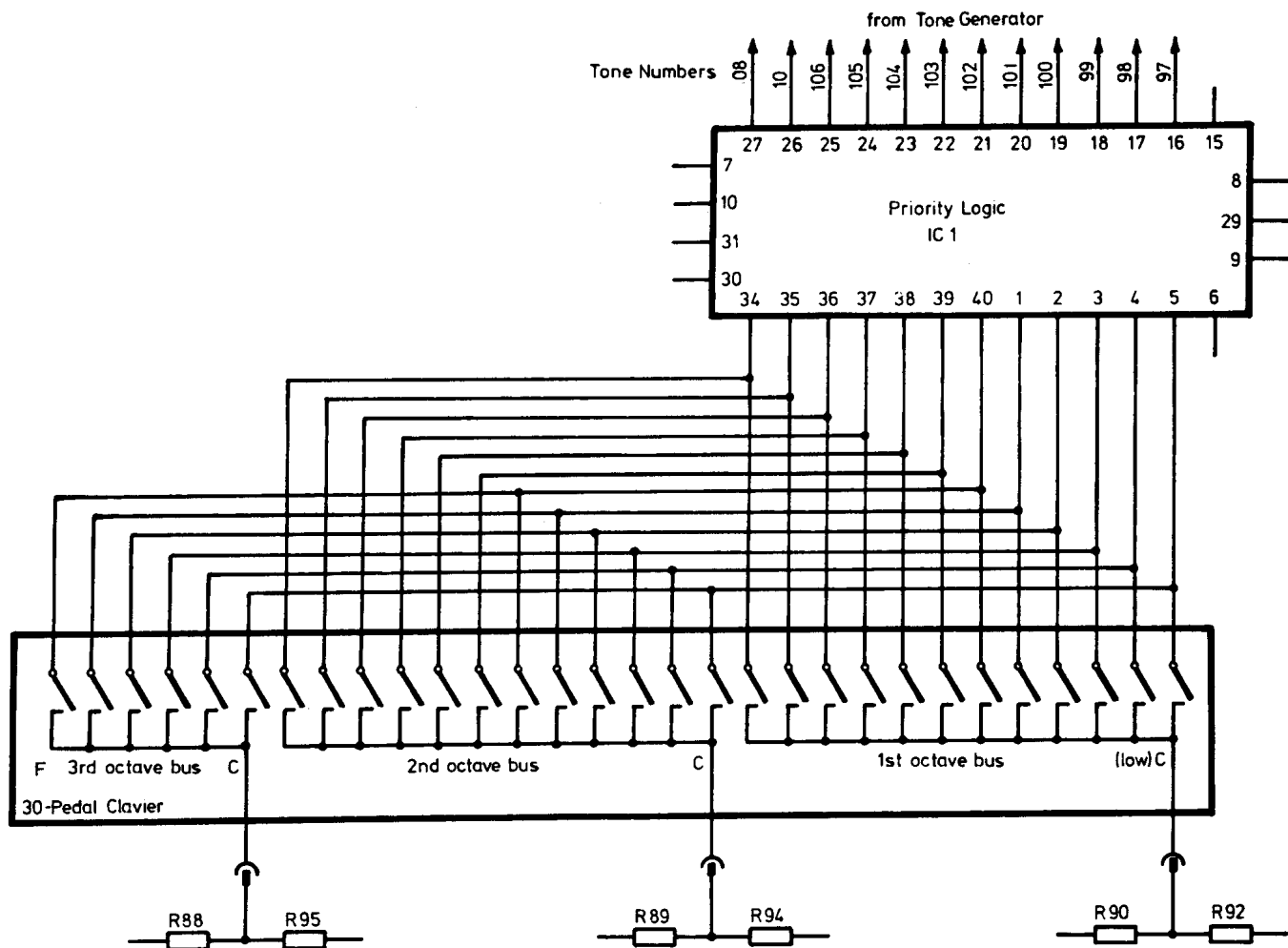
Figure 5 Pedal switch connections for a 30 pedal clavier

3. Pedal Priority Logic and Octave Decoding of PE 36

Fig. 7 shows the schematic diagram of the pedal priority logic and the octave decoding used for PE 36. The operation of the integrated circuit IC 1 is identical to the one described in paragraph 1. IC 1 selects and latches on to an input audio frequency which corresponds to a particular depressed pedal without discriminating between octaves.

Fig. 8 shows the interconnection between the pedal contacts of a 30 pedal clavier, Depressing, for example, a D- pedal in any of the three octaves applies a negative control voltage to pin 3 of IC 1 causing the input frequency No. 99 to be passed on to the output pin 9. The input frequencies are higher by two octaves compared to the ones used for P E 13, since a 3-octave pedal clavier, for example, requires these higher frequencies.

The output signal of IC 1 (pin 9) is fed to a 2-stage frequency divider IC 8 via the pulse forming stage



IC 3a. The input frequency of IC 8 and two divided frequencies are applied to the electronic switches IC 7a thru c.

The negative bus of the pedal switches is divided into 3 sections, each corresponding to an octave (see Fig. 8). The current sensing resistors R 88 thru R 90 (Fig.7) turn on that transistor among Q4, Q6 and Q8 which corresponds to the pedal octave containing the depressed pedal.

Should more than one pedal (belonging to different octaves) be depressed simultaneously the pedal of the lowest octave is assigned priority. (The turned on Q 4 turns off Q 5 and Q 7 inhibiting the turn on of Q 6 and Q 8; the turned on Q 6 turns off Q 7 inhibiting the turn-on of Q8).

The negative voltage at the collector of the turned-on transistor Q4, Q 6 or Q 8 is inverted and latched by the flip-flops of IC 9 such that the corresponding electronic switch among IC 7a thru c closes passing on the proper audio frequency to point "A" (Fig. 7).

Summarizing all this, the frequency at point "A" corresponds to the 1/2' rank of up to 36 (3 full octaves) of pedal notes.

The remaining circuitry of PE 36 (5-stage divider, gating, voicing and controls) is identical to the one shown in Fig. 6 and it operates as described in chapter 2. Exception: If a pedal of the lowest octave is depressed the frequency at point " B " (Fig. 7) is twice that of point "A". In that case the diode D22 serves as a gate for the 1/4' rank added to the sine wave mixture which already contains 1/2'and 1' footages.

Figure 6 Component layout and foil pattern (X-ray view) of the circuit board PE13

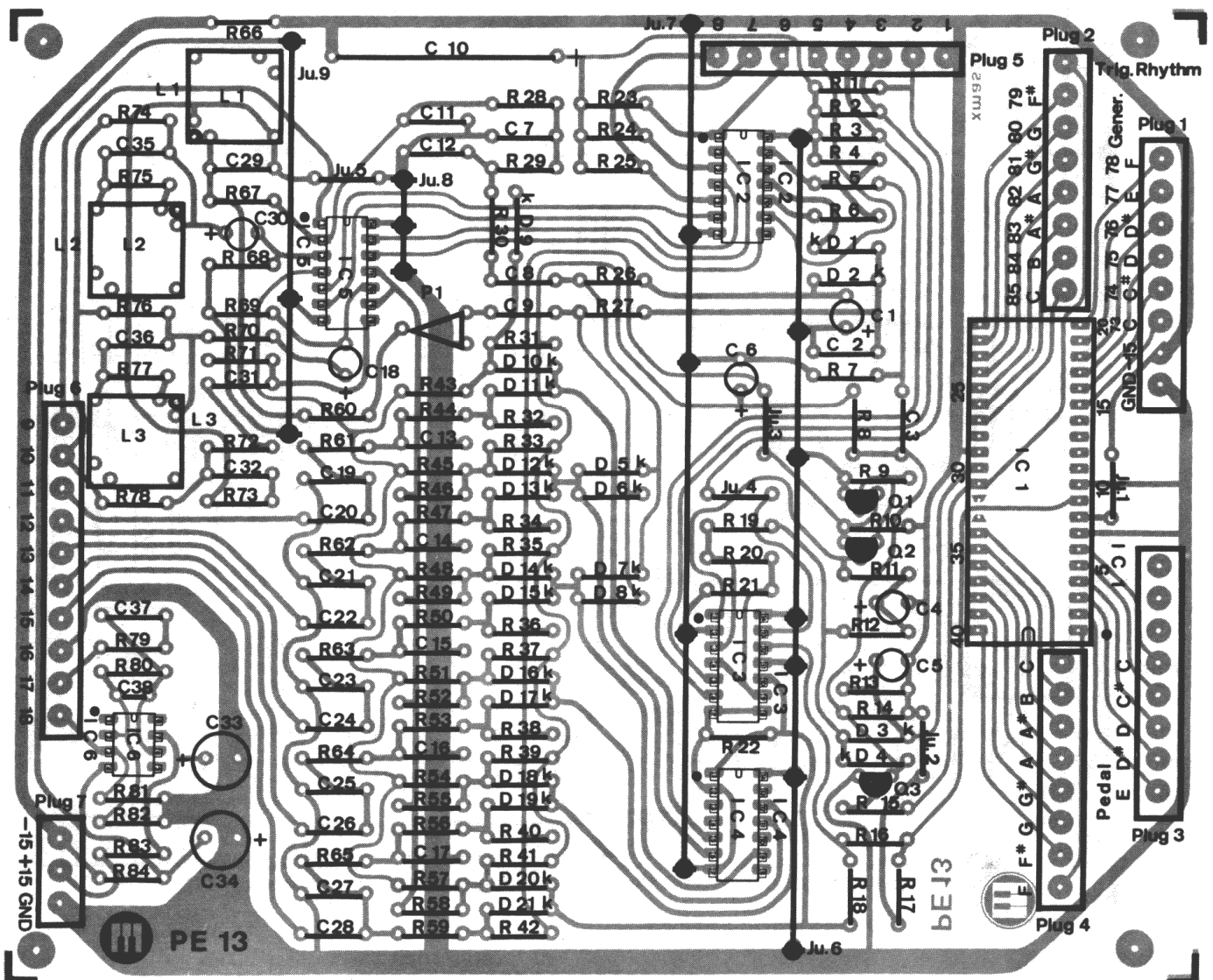
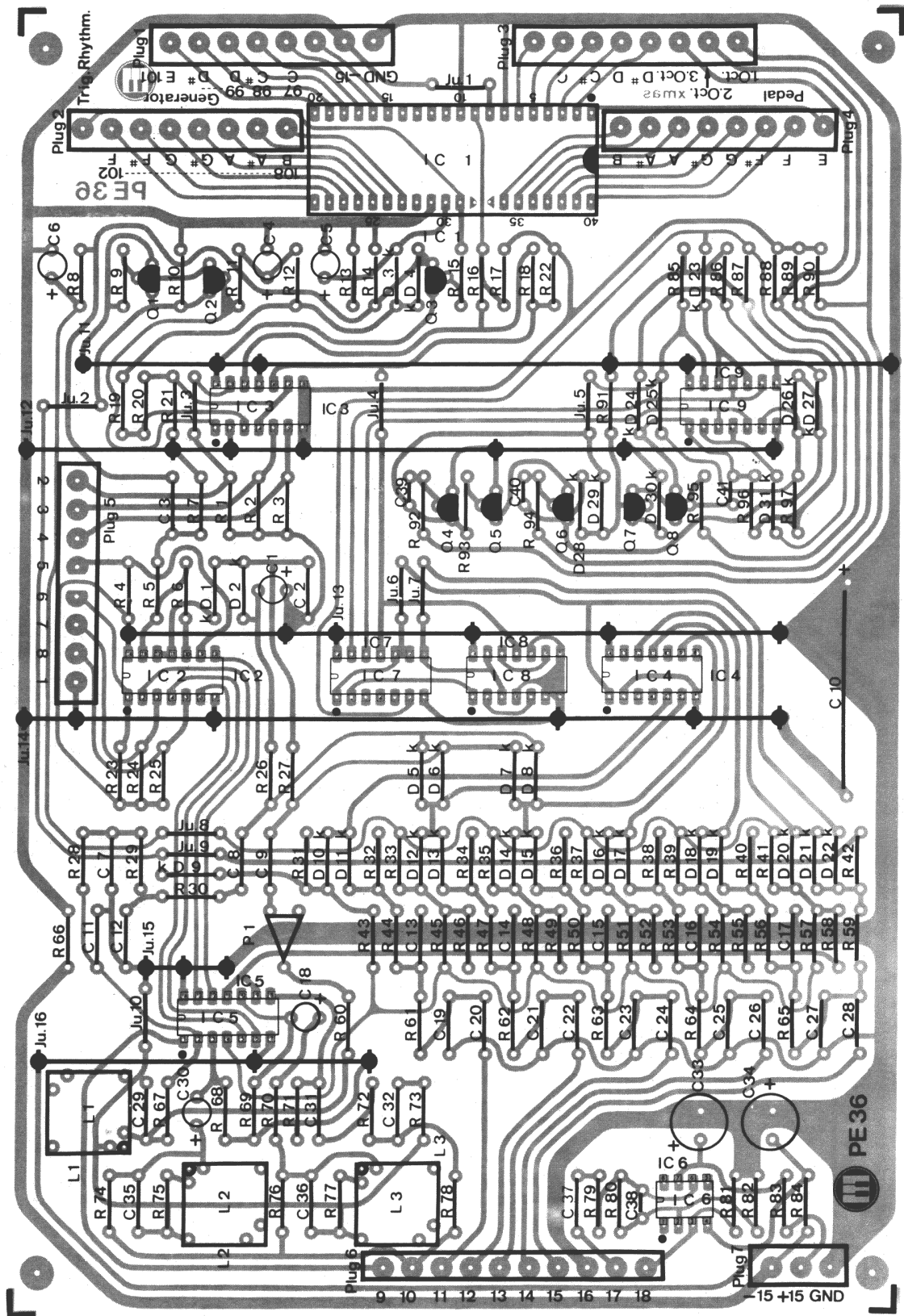


Figure 7 Component layout and foil pattern (X-ray view) of the circuit board PE36



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