Assembly Manual

Technical Data
W Series
Precision Generator

AM 100 1st Edition (Part)

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3 Generator Functions

Fig. 7 shows the block diagram of the generator G 1 with its control functions.

3.1 Tone Generation

The tone generator G 1 produces 96 tones (8 octaves) which are available "silently" at the outputs until their transmission to the rest of the organ is demanded by the electronic keyers. The master oscillator (approx. 2 MHz) is a stabilized and controlled frequency source. The frequency stabilization is accomplished through a feedback loop with a gain stage (operational amplifier). This makes the oscillator frequency largely independent of temperature changes and supply voltage fluctuations.

All other control signals which have to influence the oscillator frequency also act on the operational amplifier (op amp). The combination oscillator-op amp is thus a voltage controlled frequency source, often called a VCO (voltage controlled oscillator). The control signals affecting the frequency stem from the circuits like vibrato, slalom, master pitch or Hawaii effect.

3.2 Continuous Frequency Vibrato

A sine wave oscillator operates at approximately 7 H z (fast vibrato) or approximately 4.5 H z (slow vibrato). It produces a sinusoidal control voltage for the VCO such that the oscillator frequency and thus all generator tones deviate periodically around their standard pitch. The percentage of frequency deviation is identical for all tones.
DC voltage controlled analog switches determine the intensity of the vibrato in three steps.

3.3 Delayed Frequency Vibrato

The character of solo instruments like trumpet, clarinet or violin can be simulated much better if the tone attack is vibrato-free and if the vibrato builds u p after a certain time. The delay time is continuously adjustable to suit personal tastes. The delay process is started every time the first key of the upper manual is depressed.

3.4 Hawaii Effect

When the "Hawaii contact" is activated (normally through a side pressure on the swell shoe) the pitch of the oscillator and thus of all generator tones rapidly falls by about a half-tone and then returns slowly to the original value. The Hawaii effect circuit also acts on the VCO.

3.5 Slalom

We assume that the trimpotentiometers (trimpots) "Tuning high" and "Tuning low" are set correctly and that the transposer switch is at position "C". The control voltage of the V CO can be varied over a wide range by means of the linear motion control "Slalom". The component values are selected such that the pitch of the entire organ can be shifted continuously up to an exact octave. The normal setting for the "Slalom" control is "high".

The process can be automated by turning on the function "Auto Slalom". The organ's pitch will slew over a full octave every time the upper manual is played (staccato playing required). The direction of the pitch shift is determined by the position of the switch "Auto Slalom U p/Down" and the slewing speed is controlled by the control "Slalom Speed". The total travel of the pitch shift can further be limited to less than an octave by the control "Slalom".

The initial tuning of the end values (spaced exactly an octave apart) is accomplished with the trimpots "Tuning high" and "Tuning low". There are no instruments required to tune a W E R SI organ, even an untrained ear will do just fine.

3.6 Master Pitch

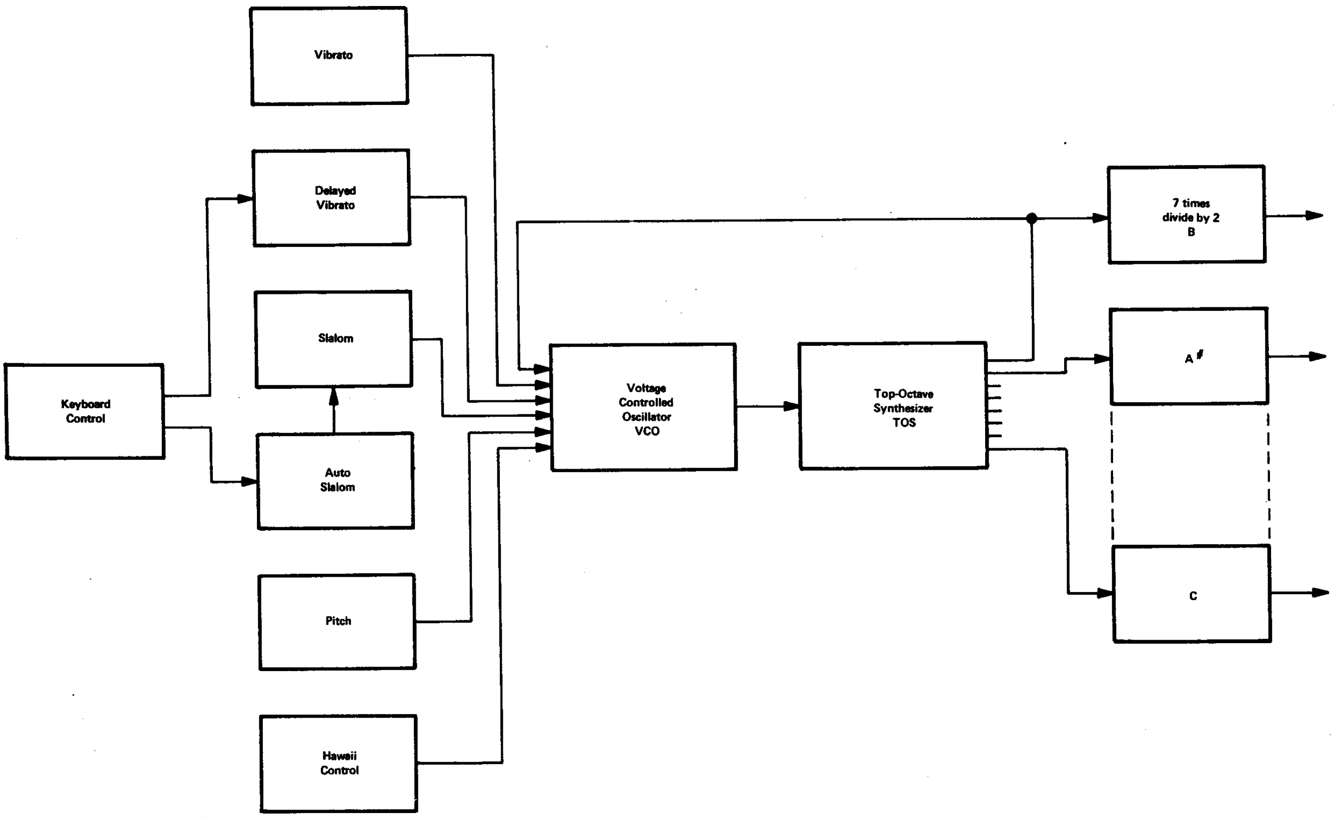
It is often required to adapt the pitch of the organ to the one of another instrument, record player or tape recorder. This is very easily done with a WERSI organ. A single control "Master Pitch" allows you to change the pitch by approximately a half-tone without affecting any other function or the tuning between the keys.

3.7 Transposer

Written music occasionally has to be transposed into a different key, be it for reasons of personal taste or adaptation to another musical instrument.

The transposer of a WERSI organ eliminates the need of re-writing or mental transposition. A rotary switch on the stop board allows you to transpose the organ pitch into any desired key anywhere over an entire octave.

Figure 1 Block Diagram of the tone generator G1



4 Technical Description

Recall Fig. 7 to familiarize yourself again with the functional blocks of the tone generator. Fig. 8 shows the detailed circuit diagrams of the generator. We start with the description of the oscillator.

The circuitry lies almost without exception between ground and -15 VDC. We shall use the expressions "positive" and "negative" quite often in the following discussions. For reasons of simplicity use the convention that positive corresponds to the ground potential and negative corresponds to -15 VDC.

4.1 Oscillator

The three inverters IC 3-4, IC 3-5 and IC 3-6, the capacitor C 1, the transistor Q 1, the diode D 4 and the resistor R 4 form the oscillator. Regard the transistor Q 1 as a fixed resistor, for the time being. Suppose further that the input 13 of the inverter IC 3-6 is negative and that C 1 is discharged. The inverter input 9 of IC 3-4 is therefore negative too and its output 8 is positive.

The capacitor C 1 will charge via R 4 and D 4 until the voltage at the inverter input 13 of IC 3-6 reaches the upper switching threshold. The outputs of all three inverters will flip and the charge on C 1 will reverse, but this time via R 4 and the "resistor" Q 1. After a certain time, the inverter input 13 of IC 3-6 will reach the lower switching threshold. All inverters will flip again and the entire cycle will repeat.

The time constants of the charge reversal of C 1 are determined by R 4 and C 1 (D 4 can be neglected) in one direction and by R 4 and R (Q 1) and C 1 in the other direction. We see that the "resistance" of Q 1 influences one of the charge times and thus the oscillator frequency. This feature is used as the controlling element for the frequency (see "Frequency Control").

We suppose first that the oscillator operates at the fixed frequency of 2.0064 MHz.

4.2 Top-Octave-Synthesizer

The oscillator frequency is applied to the integrated circuit IC 2. This IC belongs to the MOS-LSI types and it has a rather complex internal structure. All we need to know here is that the incoming frequency is divided in 12 branches such that the

12 frequencies of the highest required octave appear at its outputs (see Fig. 12). Therefore, the name Top-Octave-Synthesizer (TOS) describes the functions of this IC. Due to the mathematical relationship between neighboring tones of an octave the IC often is called a Twelfth-Root-Two Divider. The frequency at output "A" for example is 7040 Hz.

4.3 Frequency Dividers

Each output of the TOS is fed to an integrated divider IC 1. It divides the incoming frequency 7 times by 2. There is an output after every divider stage. This means that, besides the top octave tone, 7 lower octaves are available too. For example, the IC 1 (A) generates the "middle A" (440 Hz) after 4 divisions and 55 H z after 7 divisions.
The outputs of the TOS as well as all divider outputs are connected to rows of pins which are sequentially numbered from 13 (CO = 32.70 Hz) to 108 (B7 = 7902 Hz)

The output signals are square waves with an on/off ratio of 1:1. The "on" state corresponds to ground potential and the "off" state to -15 V DC. The output signals control the analog switches on the plug-in boards (see "Gating Cards G 2 ").

The outputs of the top octave are also connected to the pins P 97 to P 108. There the 30-pedal electronics will be connected which has its own frequency dividers.

The 13-pedal electronics will be connected to the pins P 73 to P 85 which are fed, via the diodes D 1, from divider output (two octaves below top). The 13th required frequency is taken from a higher octave and connected to pin P 85.

4.4 Frequency Stabilization

Suppose that the inverting input 6 of op amp IC 5-B already receives a certain constant control signal. The output 7 of IC 5-B, therefore, assumes a certain potential (between + and -15 V DC),such that transistor Q 1 has a certain resistance which, in turn, determines a certain oscillator frequency.

The highest output frequency of the TOS (output 108) is fed to the input 5 of inverter IC 3-3. IC 3-3 merely serves as a buffer between the TOS and the control loop. The square wave signal at the output 6 of IC 3-3 is differentiated by R 6/C 2 and rectified by D 3 and D 5. The resulting control current is fed to the inverting input 6 of the o p amp IC 5-B.

This closes the feedback loop. The automatic frequency stabilization can be described as follows: The oscillator frequency increases - the frequency at the output 108 increases - the differentiated pulses on C 2 follow each other at shorter intervals - the current into the input 6 of IC 5-B increases - the voltage at the output 7 of IC 5-B decreases - the "resistance" of Q 1 increases the oscillator frequency decreases.

The capacitors C 4 and C 10 eliminate any residual AC voltages on the control signal.

The input 6 of IC 5-B also receives the control signals from all other circuits.

4.5 Master Pitch Control

The external control "Master Pitch" is connected between ground and -15 V D C. The maximum potential shift of 15 V on terminal B 6 results in a very small control current through R 48 and R 30 to the input 6 of IC 5-B, producing a pitch variation of approximately a half-tone. We assume that the pitch control be at its mid-position for the following discussions.

4.6 Slalom/Tuning low/Tuning high

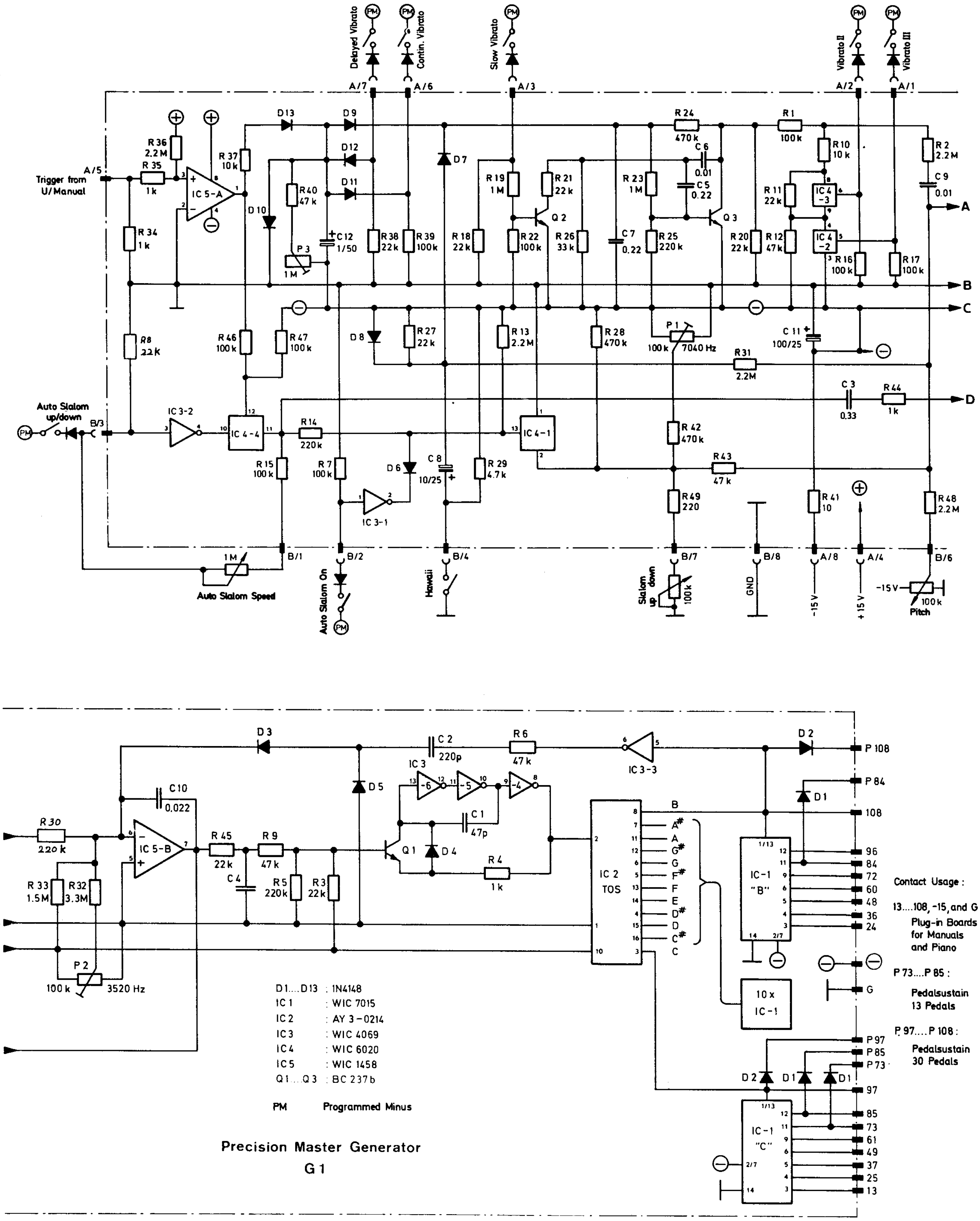
The potential at the tie point between R 28/ R 42/ R43/R49 is determined mainly by the voltage division of R 28 and R 49 + "Slalom" control. The most positive value exists if the resistance of the "Slalom" control is zero (left-hand stop). The said tie point is then almost at ground potential since R 49 is much smaller than R 28.

The resulting control current through R 43 and R 30 pushes the oscillator frequency downwards. Simultaneously, the trim pot P 1 (Tuning low) and the position of the analog switch IC 4-1 become ineffective.

This (low) frequency is adjusted by means of trim pot P 2 such that the highest "A" (output 106) assumes a frequency of exactly 3520 Hz. Note, that the master pitch control remains effective.

If the "Slalom" control is moved to the other stop (= 100 kOhms) the potential at the tie point R 28/ R 42/R43/R49 becomes more negative; the frequency increases. The exact value is adjusted by trimpot P 1 (Tuning high) such that the highest "A" (output 106) is equal to 7040 Hz. This calibrates the "Slalom" control, that is it enables it to shift the pitch of the entire organ by an exact octave.
The transposer can be connected to pin B 7in lieu of the "Slalom" control. The transposer consists of a switch which selects a series of precision resistances replacing the "Slalom" control. The "high" toning is shifted by one or more half-tone steps (see Fig. 9).

Figure 2 Circuit diagram of the tone generator G1



4.7 Slalomatic (Auto Slalom)

Suppose that the "Slalom" control is "high" (= 100 kOhms) and that the switch "Autoslalom " is open. The input 1 of the inverter IC 3-1 is thus positive (at ground); the output 2 negative such that the diode D 6 clamps the control input 13 of the analog switch IC 4-1 negative. The switch IC 4-1 is thus "open" (= high resistance).
When the switch "Autoslalom " is closed the inverter IC 3-2 flips, the diode D 6 blocks and releases the control input 13 of !C 4-1 from being clamped negative. The control input 12 of the analog switch IC 4-4 is positive (we shall see later why), rendering the switch IC 4-4 closed (= low impedance).

4.8 Slalomatic (Auto Slalom) Down

Suppose that the switch "Autoslalom up/down"is open. The inverter input 3 of IC 3-2 is positive (biased via R 8) and its output 4 negative. This negative potential also appears at the control input 13 of IC 4-1 (via closed IC 4-4 and R 14).IC 4-1 remains open; the frequency is high (normal)

If the control input 12 of IC 4-4 flips negative (see " KeyDown Detector"I the switch IC 4-4 opens. The following processes take place simultaneously and they form a closed feedback loop: A current flows through the "Slalom Speed" control and R 15 into the tie point R 14/13 15/C 3 - the control voltage for IC 4-1 increases - the resistance of IC 4-1 decreases - the control current through R 43 into IC 5-B increases -the output voltage of IC 5-B decreases - a current flows via C 3 and R 44 out of the tie point R 14/13 15/C 3. This feedback loop lets decrease the output voltage of IC 5-B in a linear fashion despite the extreme non-linearity of the transfer function of IC 4-1. The frequency drops almost linearly for an exact octave.

When IC 4-4 closes again (all keys of upper manual released) the process reverses, however, at a much higher speed since the control input 13 of IC 4-1 is driven negative (negative voltage from IC 3-2 through IC 4-4).

4.9 Slalomatic (Auto Slalom) Up

Suppose that the switch "Autoslalom Up/Down" is closed. These are the initial circuit conditions: Input 3 of IC 3-2 negative - output 4 of IC 3-2 positive switch IC 4-4 closed - input 13 of IC 4-1 positive switch IC 4-1 closed - VCO control voltage negative (output IC 5-B) - frequency low (one octave below normal).

When IC 4-4 opens (see "Key Down Detector"): input 13 of IC 4-1 slowly becomes negative - IC 4-1 slowly changes from low impedance (closed) to high impedance (open) - VCC control voltage becomes positive frequency rises slowly by an octave. The feedback loop and the reset work in an analog fashion as described under "Slalomatic Down".

The resistor R 13 biases the control input 13 of IC 4-1 slightly negative. This bias tends to equalize the two speeds "Autoslalom Up" and "Autoslalom Down"

The control "Autoslalom Speed" controls the slewing speed of the octave frequency shift.

4.10 Key Down Detector

The non-inverting input 3 of the op amp IC 5-A normally is biased such that the output 1 swings to +15 V D C. The divider resistors R46 and R 47 are dimensioned such that the voltage at the control input 12 of IC 4-4 is at ground potential. IC 4-4 is thus closed.

Every time a key is depressed on the upper manual the electronic keyers (not shown) send a -2 0 m V D C signal to pin A 5. This signal overrides the positive bias at input 3 of IC 5-A by a factor of 2 to 3, causing the o p amp output to swing to -15 VD C. This voltage also appears at the control input 12 of IC 4-4. IC 4-4 opens.

In short:
No upper manual keys depressed - output 1 of IC 5-A at +15 V D C - IC 4-4 closed.
One or more keys depressed - output 1 of IC 5-A at -15 V D C - IC 4-4 open.

This key down trigger is used to start the autoslalom process as well as the delayed vibrato (see below).

4.11 Continuous Vibrato

Suppose that all vibrato control switches are open. The values of the resistors R 23/R 24/R 25 are chosen such that the transistor Q 3is driven into heavy conduction by the (normally) positive output voltage of IC 5-A. This inhibits the bridge oscillator (Q 3 with C 5/C 6/ R 2 3/ R 2 6) from operating.

When the switch "Continuous Vibrato" is closed the tie point between D 13 and D 9 is changed negative. The transistor Q 3 is now fed via R 20 and the oscillator operates sinusoidally. The transistor Q 2 is conducting switching R 21 in parallel to R 2 6. The oscillator frequency is approximately 6.8 H z (fast vibrato).

The oscillator voltage lies across the voltage divider R 1 and R 10/R 11/R 12. The divider output is taken from the tie point between R1 and R 10. The control inputs 6 of IC 4-3 and 5 of IC 4-2 are positive, the switches IC 4-3 and IC 4-2 are closed, short-circuiting the resistors R 11 and R 12. The outgoing oscillator signal (via R 2) is thus small. The oscillating current through R 2/C 9/ R 30 into the VCO causes the master oscillator frequency to deviate periodically about its mean value = frequency vibrato.

4.12 Vibrato II and III

When the switch "Vibrato 11"is closed the control input 6 of IC 4-3 swings negative. The switch IC 4-3 opens and the resistor R 11 becomes part of the voltage divider; the vibrato control voltage increases.

Similarly, the third vibrato intensity is activated by closing the switch "Vibrato 111".

4.13 Slow Vibrato

With the closing of switch "Vibrato Slow", the transistor Q 2 blocks, isolating R 21 from the oscillator circuit. The resulting vibrato frequency, determined by R 26, is approximately 4.7 Hz.

4.14 Delayed Vibrato

Suppose that the switch "Continuous Vibrato" is open and that the switch "Delayed Vibrato" is closed. The positive output voltage of IC 5-A, clamped to ground by the diode D 10, inhibits the vibrato oscillator from operating. The capacitor C 12 is charged to 15 V.

When the key down detector causes the output of IC 5-A to swing negative (D 13 blocks) the capacitor C 12 discharges through R 40 and trim pot P 3 (delay time). The originally positive bias at the base of Q 3 slowly becomes negative. The transistor Q 3 slowly emerges from the saturated state and begins to oscillate with increasing amplitude.

The delay between "key down" and vibrato start can be adjusted by trim pot P 3 to suit the personal taste. All other vibrato functions like speed and intensity are the same as for the continuous vibrato.

4.15 Hawaii Effect

Normally the capacitor C 8 is discharged. When the switch "Hawaii" is closed a current surge flows into the tie point between R 27/R31/D 8/D 7 and decays exponentially as C 8 gets charged. The resulting V CO control current through R 31 first drops the pitch of the master oscillator rapidly by about a half-tone and then lets it return slowly to normal.

When the "Hawaii" switch opens again the capacitor C 8 discharges via D 8 and R 29 without affecting the VCO.

While the "Hawaii" process takes place a positive current is also fed to the vibrato circuit via D 7 suppressing the vibrato, if used, for the duration of the "Hawaii"

This completes the description of all tone generator functions. The following paragraphs deal yet with the outboard circuits connected to the generator explaining the overall system used in our organs.

4.16 Output Pins

The tone generator can be equipped with a maximum of three parallel rows of output pins. These pins normally are used to receive sets of Gating Cards G 2`as follows:

Organs with a small number of footages (ranks):
Only pin row 1 is equipped with Gating Cards G 2. The keyers of both manuals as well as the piano are connected to these cards.

Organs with a large number of footages (ranks):
Pin rows 1 and 2 are equipped with Gating Cards G 2. The upper manual keyers and the piano keyers are connected to the G 2's of row 1 and the lower manual keyers are connected to the G 2's of row 2.

Organs with polyphonic pedals:
Pin row 3 also is equipped with Gating Cards G 2. The pedal keyersare connected to these cards.

4.17 Gating Cards G 2

Fig. 10 shows the circuit diagram of a Gating Card G 2. The 6 IC's contain a total of 24 analog switches. One switch is required for each generator output. Each tone has 8 octaves fed sequentially to neighboring pins. That means that one Gating Card G 2 is used for every 3 tones. A total of 4 G 2's are required for the 12 tones.

We limit the discussion to the description of a single switch.

As soon as the Gating Card G2 is plugged onto the pins of the generator the integrated circuits IC 1 are powered through pins "-15" and "G ". We take the control input 5 of IC 1-2 as an example. This input is connected to pin 106 (highest "A "). The audio frequency square wave signal at pin 106 alternates between ground and -15 V DC at a rate of 7040 full cycles per second. The analog switch IC 1-2 closes and opens 7040 times a second.

Pin 4 of IC 1-2 (one of the outputs of G 2) is thus alternatingly connected to ground or isolated from ground. Note that there is no voltage appearing at the output (pin 4). This feature has far-reaching consequences and is what we call "silent" tone generator outputs. Only when the associated electronic keyer applies a voltage to this output the voltage is maintained or shorted to ground at the tone frequency rhythm.

The resistance R 1 merely serves to shunt away possible leak voltages appearing on the outgoing wires.

4.18 Piano outputs:

Each two neighboring outputs of a tone cascade are combined by two diodes D 1 (after the analog switches) to form a rectangular waveform with a 3:1 on/off ratio (see Fig. 5). This signal is used for the piano circuitry. Again, these outputs are voltage-free as long as the piano keyers do not apply a negative bias.

Normally, only the outputs of the 2nd to 7th octave are matrixed with the exception of the "C" cascade where the 8th octave is needed to generate the "uppermost C". This arrangement is sufficient to feed a 5 octave piano.

Functionally, the Gating Cards G 2 are part of the electronic keying system. Their assembly will be described in the manual "Electronic Keying".

4.19 Outputs for Pedal Electronics

The electronics for monophonic pedal claviers with 13 and 30 pedals have their own frequency dividers. The monophonic, interlocked, first-come-first-served pedal electronics often is called pedal sustain for short.
The 30 pedal sustain requires the top octave as a frequency source. It is connected to pins P 97 to 108 which, in turn, are fed by the frequencies of the top octave via the diodes D 2. The diodes D 1 and the pins P 7 3 through P 85 are not used in this case.
The 13 pedal sustain requires the 12 tones of the 6th octave plus the "C" of the 7th octave as inputs. In this case, the pins P 97 through P 108 and the diodes D 2 are replaced with the pins P 73 through P 85 and the diodes D 1.

5 Tone Scales and Frequencies

We use 440 H z as the standard pitch for the middle "A". Occasionally, other frequencies are used, e.g. 444 Hz. Since all organ tones are coupled to a single master oscillator it is very easy to adapt the organ's pitch to other standards. The externally accessible control "Master Pitch" allows you to vary the frequency of the middle "A" from approx. 4 20 to 460 Hz.

The nomenclatures used for the tones of the musical scale differ in various parts of the world. We use a sequential numbering system for all tones used in the organ. This should enable you to trace a particular tone through the circuitry. Table 2 lists these numbers in connection with two of the most popular tone scales. The frequencies listed are the mathematically exact values for the equally tempered scale. The minimal and non-audible deviations from using a Twelfth-Root-Two divider are neglected in the table.

Figure 3 Test Hookup

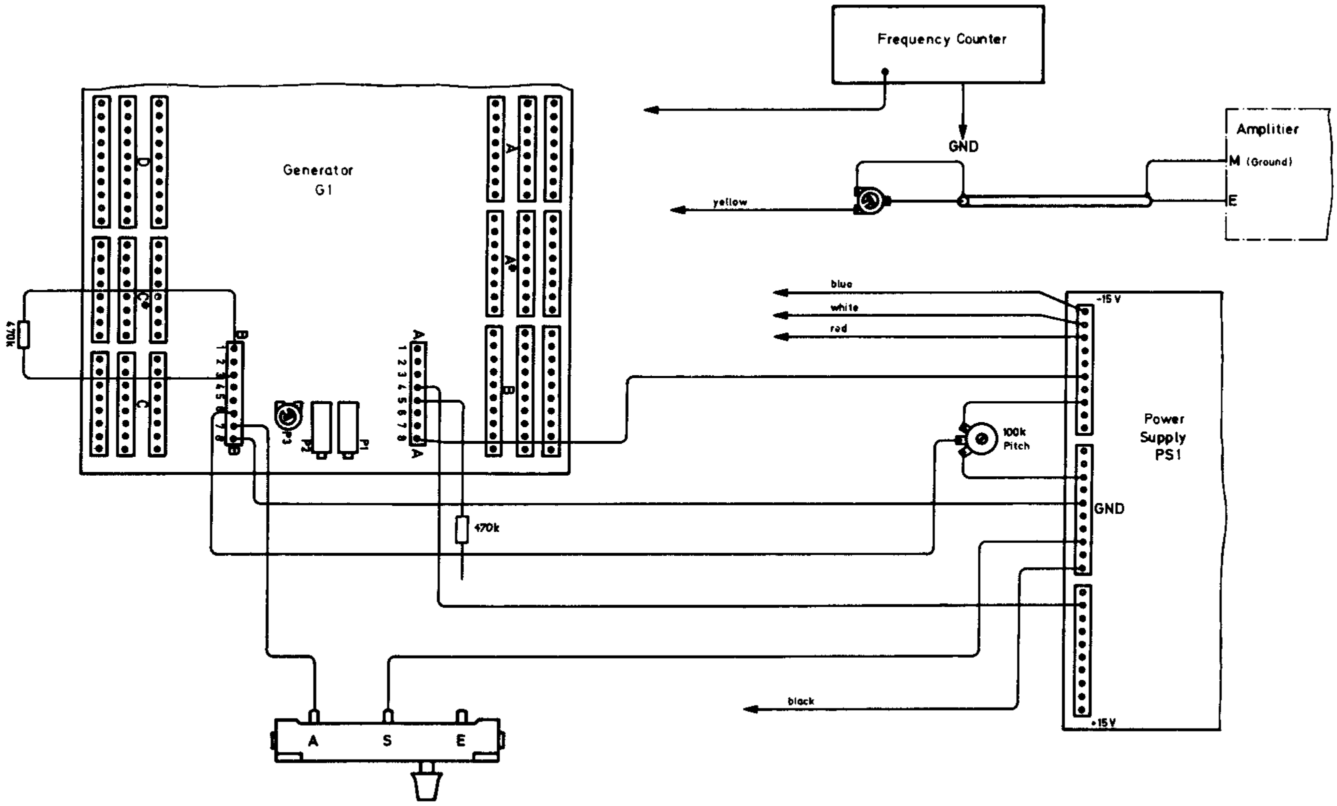
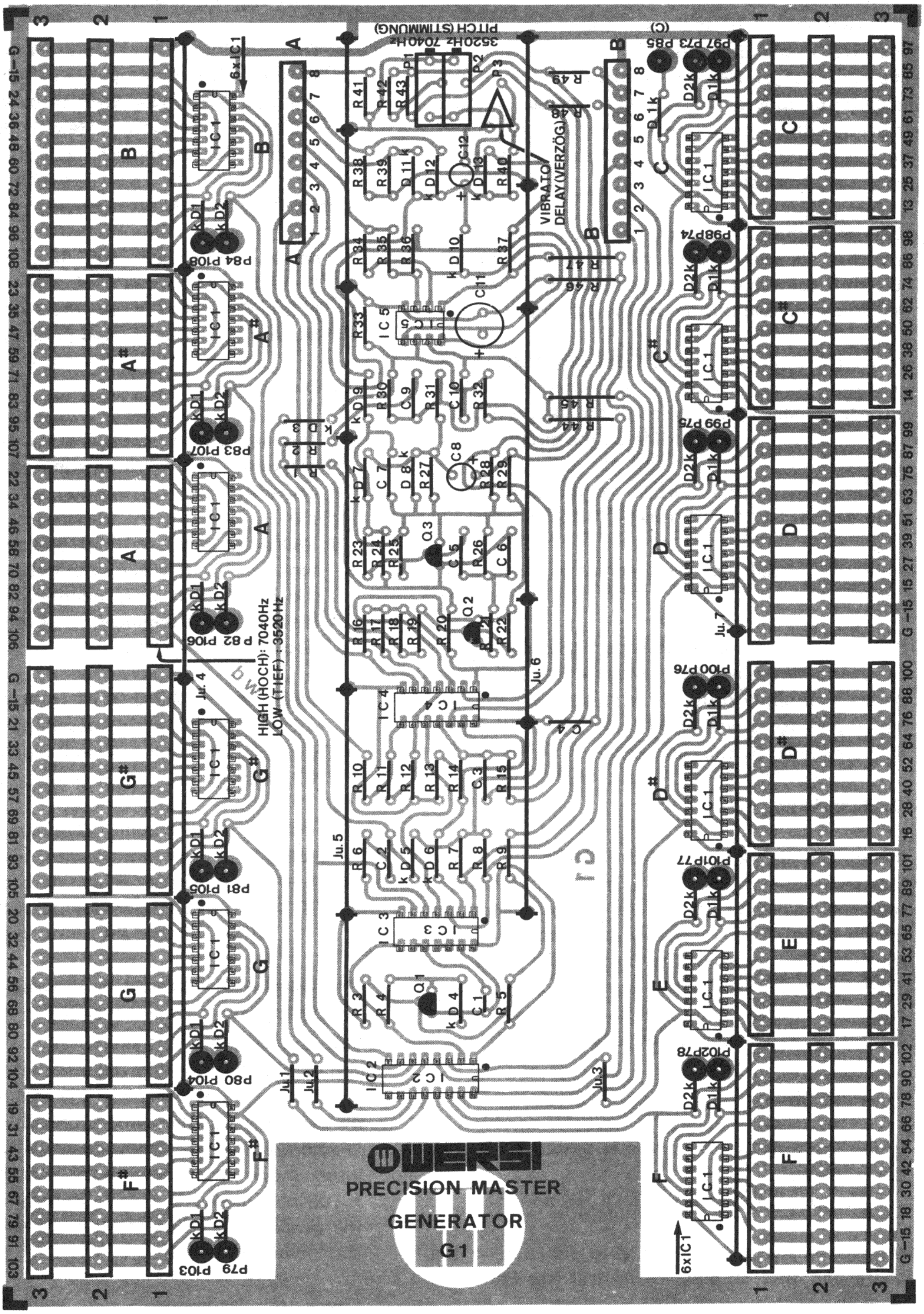


Figure 4   Component layout and foil pattern (X-ray view) of the tone generator G1



6 Initial Testing of the Tone Generator

6.1 Test Set-Up

Required equipment:

-Organ power supply (tested)
-Amplifier (organ amplifier, Hi-Fi amplifier, radio or the like)
-Voltmeter (with at least a 20 to 50 V D C range)

Optional equipment:

-Frequency counter (100 Hz to 10 kHz)

- Prepare 5 test connectors as follows: Cut off 46 pieces of bare solid hookup wire 2 5 mm (1") long. Crimp and solder a connector insert (item # 41-5) to one end of each wire. Push the connector inserts into the 3 connector housings WF-10 (item # 41-3) and into the 2 connector housings WF-8 (item # 41-4). Refer to the manual "General Instructions", chapter "Connectors" for information on connector assemblies. Bend the wires to alternate sides as shown in Fig. 12.
- I Plug the 10-position connectors onto the pins of the power supply, one each to +15 V, G N D and -15 V.
- I Plug the 8-position connectors onto the pins labelled "A-A" and "B-B" on the tone generator board.
- Solder a 47 0 kOh ms resistor (yellow-violet-yellow) between pins "B 1" and "B 3" of the generator. See Fig. 13.
- Solder one end of another 470 k0 h ms resistor to pin "A 5 ".
- Use suitable lengths of hookup wires for the following connections.
- Solder a yellow hookup wire from the pin "B 6" to the center lug of the 100 kOh ms control "Master Pitch".
- Solder a yellow hookup wire from the "lower" lug of the pitch control to the power supply "GND".
- Solder a yellow hookup wire from the "upper" lug of the pitch control to the power supply -15 V".
- Solder a yellow hookup wire from the pin "A 4 " of the generator to the power supply "+15 V ".
- Solder a yellow hookup wire from the pin "A 8" of the generator to the power supply "-15 V ".
- Solder a yellow hookup wire from the pin "B 8" of the generator to the power supply "GND".
- Solder a yellow hookup wire from the pin "B 7" of the generator to the linear motion control "Slalom", lug A.
- Solder a yellow hookup wire from the lug S of the "Slalom" control to the power supply "GND ".
- Solder one end of a black hookup wire to the power supply "G N D " and solder an alligator clip to the other end.
- Solder one end of a blue hookup wire to the generator "-15 V " and solder an alligator clip to the other end.
- Do thesame with a white and a red hookup wire.
- Run a shielded audio cable between the test ampli fier and the100 kOh mstrimpotasshownin Fig. 13.
- Solder one end of a short yellow hookup wire to the third lug of the 100 k Oh ms trim pot and solder an alligator clip to the other end.

6.2 Testing

- Connect the negative (common) test lead of your voltmeter (20 to 50 V DC range) to the long bus bar "Ju 6"and the postive test lead to pin "A 4" of the tone generator. Turn on the power supply for a brief period. You should read 15 ± 1 V D C.
- Connect the negative test lead to the long bus bar "Ju 5" and the postive test lead to the bus bar "Ju 6". Turn on the power supply. You should read 14.5 ± 1 V. Leave the voltmeter connected. Turn off the power supply.
- Check whether the power supply and the test amplifier are grounded. If one or both units are not grounded connect a wire between the power supply " G N D " and the chassis of the amplifier. Turn on the power supply.
- Touch any of the generator pins 13 thru 108 with the yellow test lead. You should hear a tone. Adjust the volume with the trim pot.
- Sequentially touch all output pins of the generator. Neighboring outputs within a tone cascade (e.g. pins 13 thru 97 at "C") should be spaced by an octave each. Should some or all tones of a cascade be inaudible verify the solder joints in this area. Interchange, if necessary, a couple of IC 1's (without power applied!).

6.3 Tuning by Ear

- Connect the yellow test lead to pin 7 0. Adjust the "Slalom" control to the left-hand stop (left-hand in Fig. 13 of the linear motion control). Set the control "Master Pitch" to the center of its range. Adjust the tone at the output 70 to exactly 440 Hz by means of trimpot P 2 ("3520 Hz"). Use another musical instrument, tuning fork, or any other "A" source for comparison.
- Connect the yellow test lead to pin 58. There, the "A" will sound lower by an octave. Move the "Slalom" control to the right-hand stop. The tone will rise approximately by an octave. Tune this tone again to exactly 440 Hz (middle "A") by means of trimpot P 1("7040 Hz").
- Verify the octave shift by moving the "Slalom" control from end to end.
- Remark: Your generator is now tuned to the middle "A" standard of 440 H z and the "Slalom" control is adjusted for an exact octave shift. Should you decide later on to change the overall pitch you can do this by means of the "Master Pitch" control which is accessible from the outside of the organ. The adjustment range is approx. 420 to 460 Hz.

6.4 Tuning with Frequency Counter

- The tone generator may be tuned with the help of a frequency counter. If you own or have access to a counter (100 Hz to 10 kHz) perform the following adjustments.
- Connect the chassis of the frequency counter to the power supply "G N D".
- Connect the counter probe to pin 106 (top "A") of the generator. Move the "Slalom" control to the left hand stop. Adjust the frequency to 3520 Hz by means of trim pot P 2.
- Change the "Slalom" control to the right-hand stop. Adjust the frequency to 7040 Hz with trimpot P 1.
- Connect the yellow test lead to pin 58. Verify the octave shift by ear when moving the "Slalom" control from end to end.
- Verify the action of the "Master Pitch" control. It should cover a little more than a half-tone total. Return the pitch control to its mid-position. Remove the frequency counter.

6.5 Hawaii Effect

- Touch the pin "B 4" with the black test lead while listening to the tone at output 58. The tone should drop rapidly by approximately a half-tone and then return slowly to its original pitch. If you remove the test end prior to the completion of the cycle the tone should return to normal more rapidly. Remove the black test lead.

6.6 Continuous Vibrato

- Connect the blue test lead to pin "A 6 ". There should be a fast vibrato (approx. 7 Hz) imposed on the tone. The intensity of the vibrato should below.
- In addition, connect the white test lead to pin "A 2". The intensity of the vibrato should increase.
- Change the white test lead to pin "A 1". The vibrato intensity should be higher yet.
- In addition, touch the pin "A 3 " with the red test lead. The vibrato speed should change to "slow" (approx. 4.7 Hz).
- Change the blue test lead to pin "A 7". The vibrato should disappear.

6.7 Delayed Vibrato

- Touch the free end of the 470 kOh ms resistor (connected to pin "A 5") with the red test lead. (There are test leads connected already to pins "A 7 " and "A 1".) The vibrato should appear after a certain 'time delay (approx. 1 second). The time delay can be adjusted with trimpot P 3. We recommend to perform the final adjustment after the organ is completely assembled, playing a solo instrument (e.g. trumpet). Remove all test leads except the yellow one.

6.8 Slalomatic (Auto Slalom)

- Set the "Slalom" control to the right-hand stop. Connect the blue test lead to pin " B 2".. Touch the free end of the 470 k0 h ms resistor (connected to pin "A 5 ") with the white test lead. The tone should slowly change its pitch until it sounds lower by an octave. lfthe white test lead is removed, the tone should jump back to its original pitch.
- Connect the red test lead to pin "B 3". The tone should be heard at the low end of the octave.
- Touching the resistor lead again with the white test lead should cause the tone to rise by an octave and it should fall back down when the white test lead is removed.
- The upper limit of the "Slalomatic" can be set to any other pitch within an octave, namely with the "Slalom" control. Try different settings and repeat the two preceding steps.

This completes the testing of the tone generator G 1. Before you disassemble the test hookup you may want to test the transposer in conjunction with the generator. This is useful, especially if you are using a frequency counter.
The installation into the organ is described in the appropriate organ assembly manuals.

6.9 Tuning of the Transposer

It is important that the generator is tuned properly before the transposer trimpots are adjusted.
If you use a frequency counter, connect its test probe to pin 106 of the tone generator. If you use an audible method connect the test amplifier to pin 58. Set the "Master Pitch" control to its mid-position and perform the following tests:

- Set the transposer switch to "C" and move the "Slalom" control "low". You should verify the "Tuning low" (3520 H z = one octave below middle "A" at pin 58). If necessary touch up the tuning with trim pot P 2 on the tone generator.
- Move the "Slalom" control to the "high" position and verify the "Tuning high" (7040 Hz = middle "A" at pin 58). If necessary adjust the frequency with trimpot P 1 on the generator.
- Leave the "Slalom" control at the "high" position. Adjust the transposer trim pots according to table 3. (The adjustment is quite touchy at times.)
  The Table 3 shows the frequencies at pin 106 vs the transposer settings.
  If you adjust the transposer by ear you have two possibilities:
  a) Leave the test amplifier lead (yellow) connected at pin 58 and listen for the tones up and down the scale as the transposer switch is rotated.
  b) Move the yellow test lead to the pins shown in Table 3 as you change the switch positions. That way you will always adjust for the same tone, namely middle "A".

Figure 5 Circuit diagram of the Transposer

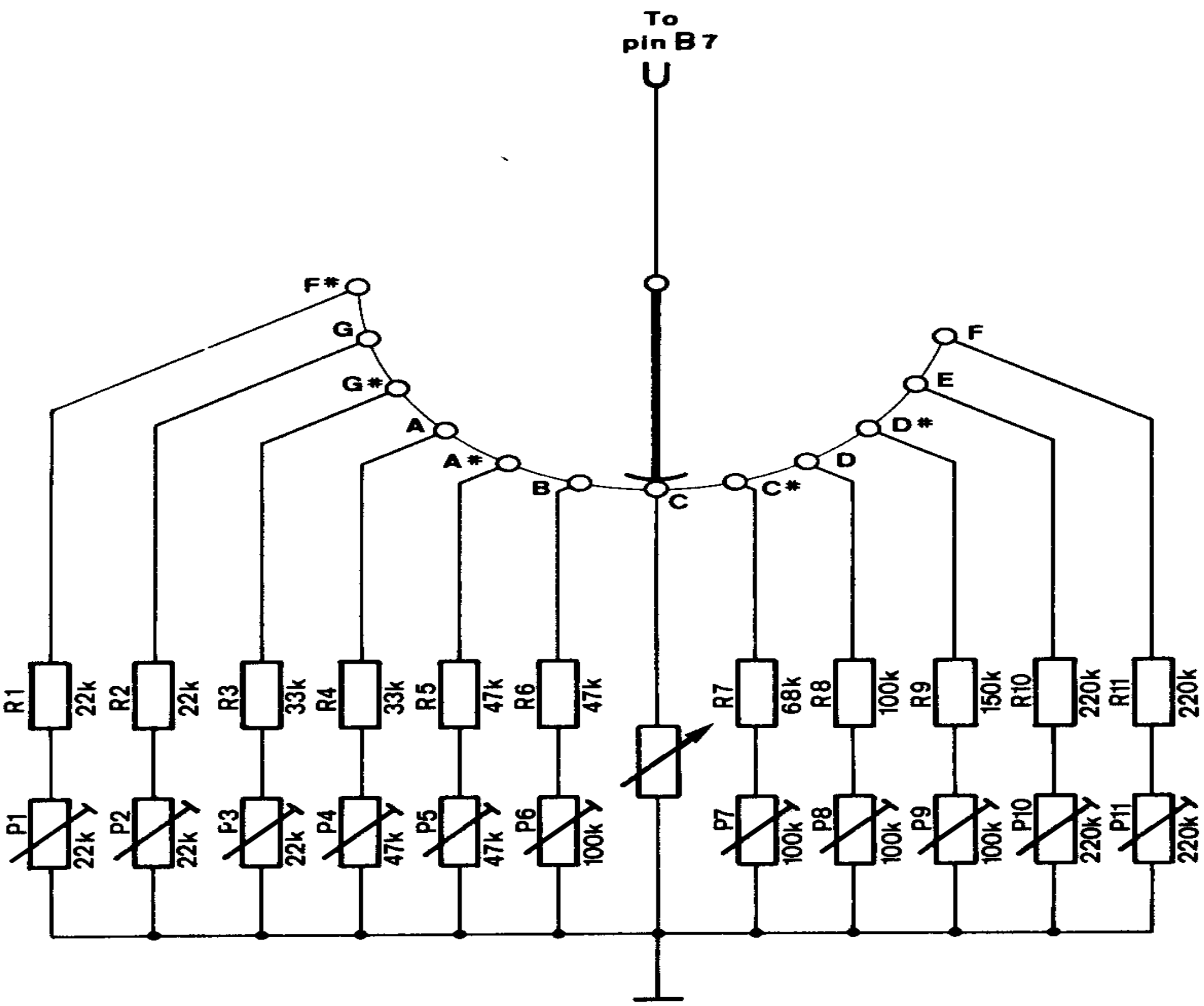


Table 1 Transposer Tuning

Transposer Switch Position	Trimpot to adjust	Frequency at pin 106 in Hz	Tone heard at pin 58	Connect to pin to hear "A"
F#	P 1	4978	D#	64
G	P 2	5274	E	63
G #	P 3	5588	F	62
A	P 4	5920	F#	61
A#	P 5	6272	G	60
B	P 6	6645	G#	59
C	-	7040	A	58
C#	P 7	7459	A#	57
D	P 8	7902	B	56
D#	P 9	8372	C	55
E	P 10	8870	C#	54
F	P 11	9397	D	53

Figure 6 Circuit Diagram of the Gating Card G2

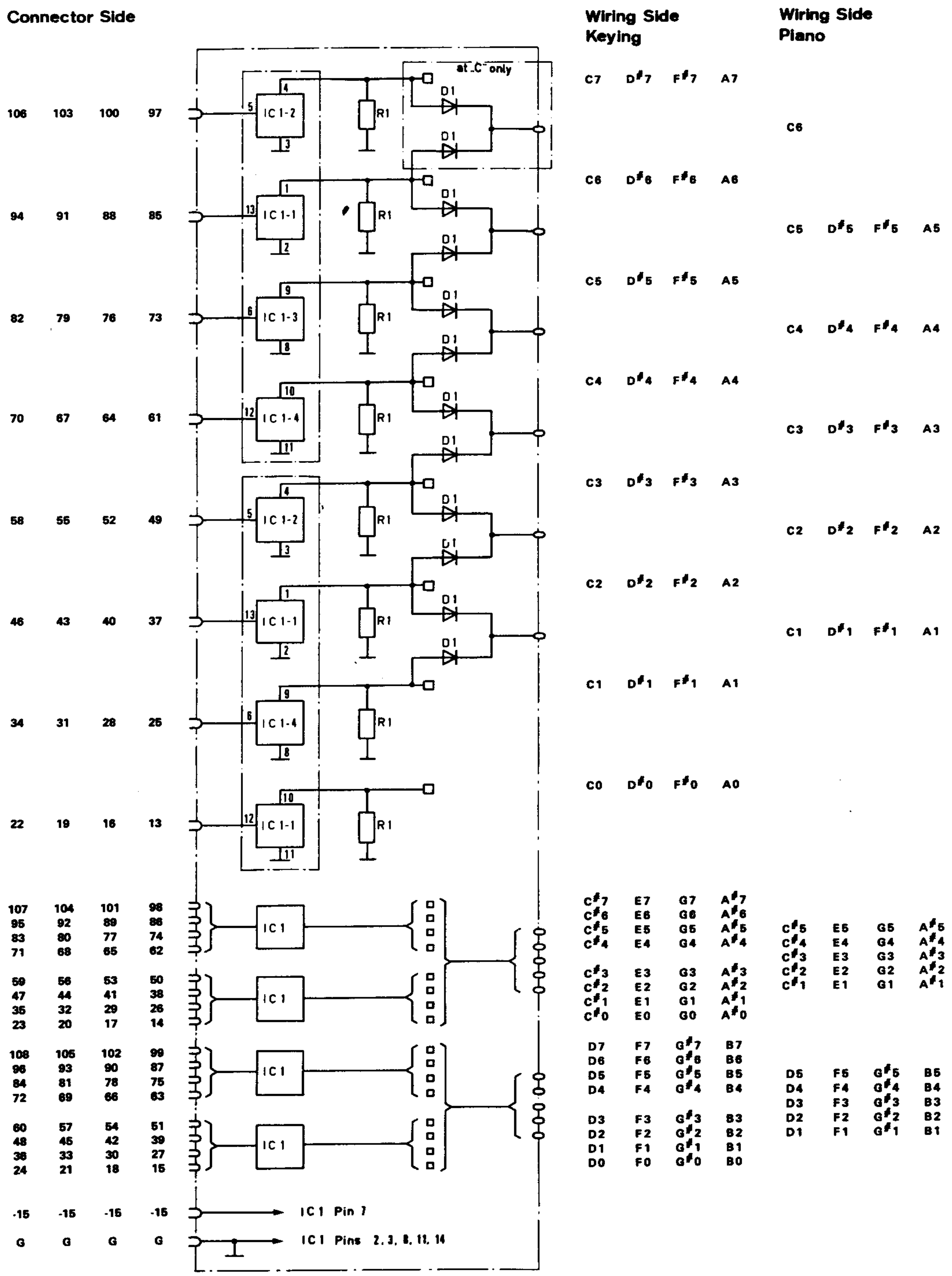
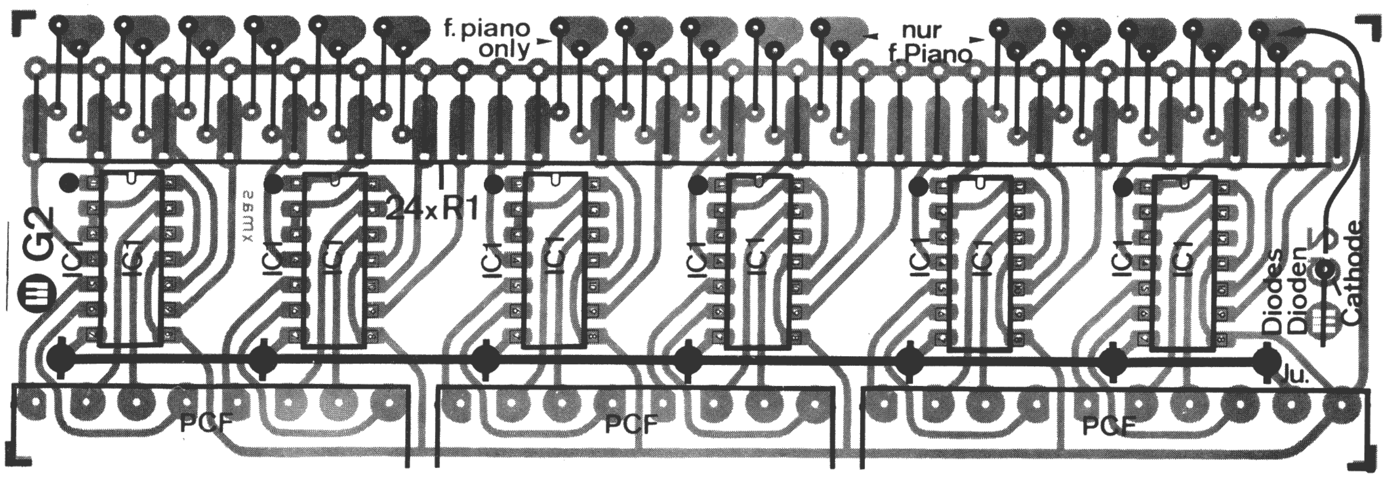


Figure 7 Component layout and foil pattern (x-ray view) of the PC board G2



7   Testing of the PC boards G 2

- Referring to the assembly manual AM 100 "Precision Master Generator", set up the tone generator for operation.
- Insert 4 PC boards G 2 onto the connector pins of row 1 of the tone generator.
- Set up the test hookup as shown in Figure 8.
- Clip the test wire "A" to "-15 V ".
- Sequentially touch all output pads on the plug-in boards G 2 (oblong foil pads near the top of the board) with the test wire "S".
- You should hear all 96 tones. (The trimpot serves to adjust the volume from your loudspeaker.)
- Similarly touch the triangular pads at the very edge of the G 2 boards (those equipped with diodes only). You should hear tones at all locations where diodes are installed.
- Remove test wire "A" from "-15 V" and clip it to "GND".
- Sequentially touch all output pads (oblong pads and triangular pads on the plug-in boards G 2. No tones should be heard (except for some "scratchy" leakage). In case of difficulties swap integrated circuits and check the health of the diodes. Handle IC's and diodes with power off only. (Each IC is responsible for four output signals; trace the foil.)
- If applicable, test additional plug-in boards G 2 by using pin row 2 (or 3) on the tone generator.

Figure 8 Test hookup for the generator gating boards G2