TECHNICAL NOTE 131

SGS-ATES

MARCH 1979

M 252 & M 253 RHYTHM GENERATORS FOR ELECTRONIC ORGANS

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This technical note deals with two integrated circuits designed to drive eight electronic musical instruments according to programmed rhythms. Both circuits were developed by SGS-ATES and are manufactured in metal-oxide semiconductor (MOS) technology.
By applying these ICs, a rhythm section, i.e. the percussion instruments, can be incorporated in an electronic organ.
The most significant difference between the two circuits is that the M252 has 15 programmable rhythms whereas the M253 has 12.
The note starts by giving a general introduction to the rhythm generator followed by the particulars of the two devices and their principal electrical characteristics.
The next part deals with the application of the devices. The necessary external circuitry and typical applications are followed by a description of the inclusion of a rhythm section in an electronic organ.

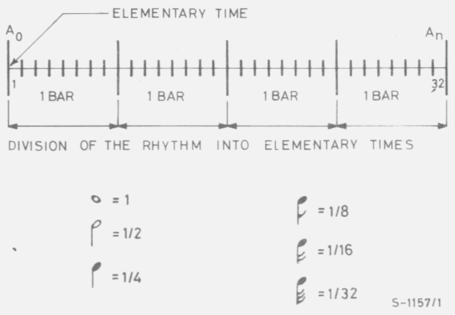
INTRODUCTION

What is a rhythm generator?

The description «Rhythm generator» is used to refer to a system which generates trigger (or excitation) pulses for the oscillators whose amplified, damped outputs simulate the acoustic sensation of the musical instruments in the rhythm section. The rhythm generator, therefore, is not itself a source of sounds, but only a means of timing the switch-on of the oscillator circuits which constitute the true sound sources.
To realize such a system each cycle of the complete rhythm must be divided into a number of «elementary times» using a counting technique. A fixed memory then determines whether or not a given instrument should be triggered during each of these elementary times.
The elementary times (or counter states), which constitute the smallest subdivisions of the rhythm can be grouped into bars or measures (usually 1, 2, 3 or 4). Within the complete rhythm, each of these bars can be programmed differently (e. g. the bossa nova).

Each bar, then, consists of n elementary times in which the beats of each instrument will be programmed to occur. In terms of musical notation the length of these beats is described as a fraction of a known reference period (see fig. 1).

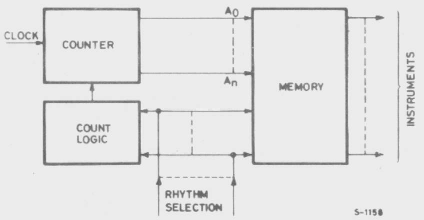
Fig. 1 – Relationship between elementary times and the bars of a rhythm



When the sum of the beats in any bar comes to 4/4, the rhythm is described as 4/4. Similarly it is possible to have a 3/4 rhythm and so on.

The number of elementary times in the bar fixes the minimum duration of each beat; in other words, the greater the number of elementary times the shorter will be the minimum length of the beats and the richer the resulting rhythm.
For example, a 4/4 rhythm programmed in 4 bars over 32 elementary times, i.e. 8 per bar, can only use musical beats of length 1, 1/2, 1/4 or 1/8 and not of 1/16,1/32,1/64.
If the same rhythm is programmed in 2 bars of 16 elementary times each, musical beats of length 1, 1/2, 1/4, 1/8 and 1/16 can be used, 1/32 and 1/64 being still excluded.
The basis of such a rhythm generator is illustrated by the block diagram of fig. 2.

Fig. 2 - Block diagram of a trigger generation system for the oscillator circuits



Counter

The counter must be able to count the number of elementary times corresponding to rhythms of 3/4, 4/4 and 5/4.
This means that the counter must stop and reset to its initial position (to repeat the rhythm) after a certain number of counts which depends on the selected rhythm.
Two characteristics of the rhythm determine the count requirement i.e.
1) the minimum beat length and
2) the number of bars in the complete rhythm.
Table 1 explains this aspect of the system in more detail with three examples.

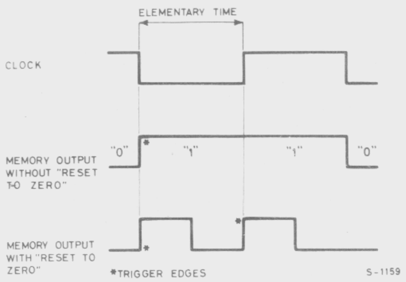
Table 1 - EXAMPLES OF MAXIMUM COUNT CALCULATION

1. a) Rhythm: 4/4
   b) Minimum duration: 1/16
   c) Number of bars per rhythm: 2
   Count = 16 elementary times x 2 bars = 32 counter states
2. a) Rhythm: 3/4
   b) Minimum duration: 1/16
   c) Number of bars per rhythm: 2
   Count = 16x3/4x2 = 24 counter states
3. a) Rhythm: 5/4
   b) Minimum duration: 1/16
   c) Number of bars per rhythm: 1
   Count = 16x5/4x1 = 20 counter states

Memory

The memory (of the «read-only» type-ROM) must have outputs which reset to zero after each «reading» so that the output will always be able to provide the correct trigger edge during the following beat (see fig. 3).

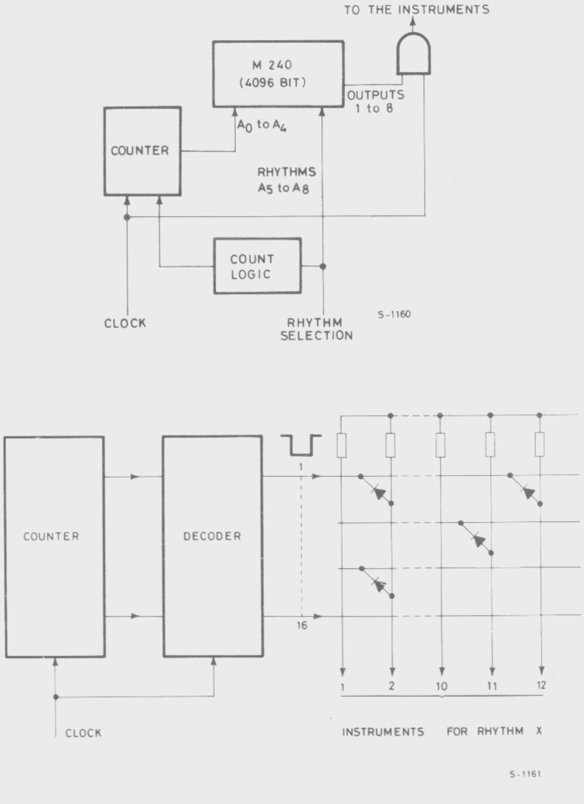
Fig. 3 - "Reset-to-zero" outputs



Making a practical rhythm generator

The system described in principle above can be realized with integrated circuits or discrete devices (see fig. 4).

Fig. 4 - Possible rhythm generator realizations



If ICs are used the counter can be produced in TTL, although due to the large amount of storage required, the memory will almost certainly have to be in MOS.

Using, for exa[illegible] 4096 bit memory such as the M240, organized in 512 words of 8 bits, it is possible to program 16 rhythms (selected by lines A5, A6, A7 and A8) each consisting of 32 elementary times (the counter drives lines A0, A1, A2, A3 and A4).
Since the ROM outputs are not of the reset-to-zero type they must be reset by an external clock before being applied to the instrument oscillators.
If the generator were to be built with discrete components both the memory and the count decoder could be realized with a diode matrix.
The return to zero of the outputs can be achieved by resetting the decoder.
Such a system would lead to the use of a very large number of diodes.
As a result the reliability would be poor and the assembly cost very high.

The ideal rhythm generator

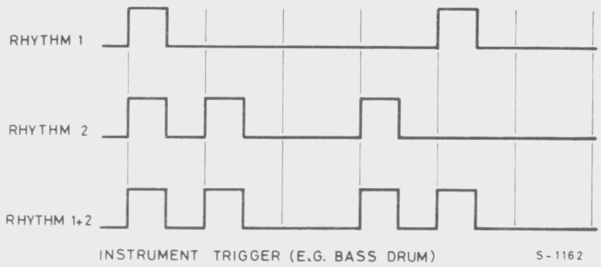
The characteristics of an ideal rhythm generator can be summarized in the following points.

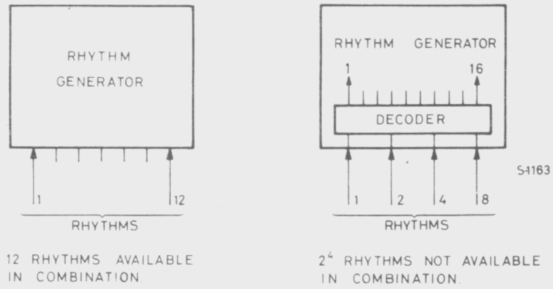
1) The entire system described above would be contained in a single device thereby achieving maximum reliability in the minimum space. The labour required for assembly is also minimized.

2) The counter should have the highest count possible. For a rhythm containing a fixed number of bars this means that the rhythm can be subdivided into shorter beats and will consequently be musically more interesting. Similarly for a given number of elementary times the rhythm can be made up of a greater number of bars (possibly different) resulting, once again, in a more interesting musical effect.

3) The system should provide a large number of rhythms. Here it is necessary to make a distinction between rhythms which can be superimposed and those which cannot, since the concept of superimposition is closely linked to the number of available rhythms. Two rhythms are said to be superimposed when, selecting both simultaneously at the system input, the output commands for each instrument correspond to a combination of the commands that would have been produced by the rhythms selected separately as shown in fig. 5.
Technically, rhythms can only be superimposed if they are selected by means of separate lines and not by a coding technique.
Superimposition, therefore, involves a greater number of input pins (one for each rhythm), but does not call for a very high number of rhythms since the organist can choose any combination of those available.

Fig. 5 – Combinatio[illegible]o rhythms





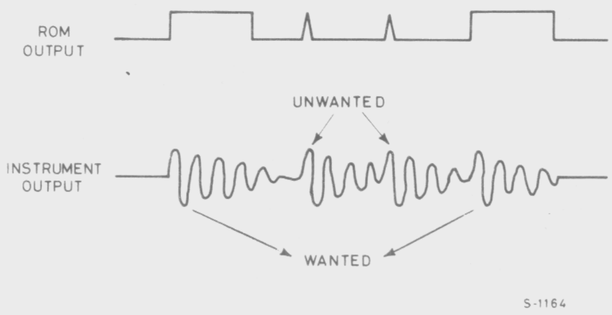
In general, 12 is a sufficient number of rhythms if they can be superimposed, but there have to be more if superimposition is not possible, usually 15 or 16.

4) The system must have a large number of outputs (instruments). The number of instruments programmed for each rhythm will generally vary between 3 and 6.
8 represents a maximum number which is rarely used.

5) The system must be programmable in any time, 3/4, 4/4, 5/4, 6/8. It must therefore be possible to intervene at the mask programming stage, on the reset of the elementary time counter for each rhythm.

6) The system must produce no spikes on the memory outputs caused by momentary coincidence of two successive decoded counter states. This can create undesired triggering of the instrument oscillators as illustrated in fig. 6.

Fig. 6 – Risk of unwanted outputs due to spikes from the decoder



7) The system must provide the possibility of externally resetting the elementary time counter, so that it restarts from the first elementary time of the first beat. This enables KEY or TOUCH operation in which the rhythm generator remains reset until at least one key is played.

8) The system should supply a down-beat output signal corresponding to the first elementary time of the first beat of each rhythm. This signal allows synchronization between the organist and the device's internal counter.

9) The system must be realized with a static form of logic designed for the low frequency operation of a rhythm generator (20 Hz).

10) The system must be input compatible with TTL and DTL level signals so that it can be interfaced with an oscillator realized with such devices.

11) The system must have low dissipation (150 to 300 mW).

12) The system must have a single standardized supply.

Points 2, 3, and 4 together create a single requirement, namely that the system must have a maximum memory capacity in terms of the number of bits.
The maximum number of bits is limited by the die-size of the device which in turn is determined by the cost of the device itself.
Once the memory capacity has been established by economic factors, it follows that a compromise between the number of rhythms, the number of instruments and the number of elementary times will be made. An effective solution is
- a maximum of 32 elementary times
- 8 instruments
- 15 rhythms

with a memory capacity of 3840 bits (32 x 8 x 15).

THE SGS-ATES SOLUTION

SGS-ATES offers two rhythm generators which fulfil all the requirements of the ideal system.

The M253 features
- 12 rhythms which can be superimposed
- 8 instruments for 3/4 or 4/4 time, or 7 instruments for any time
- a maximum of 32 elementary times
- external reset
- down-beat output
- internal anti-spike circuit
- single supply
- minimum dissipation (typically 100 mW)
- can be direct interfacing (clock) with TTL, DTL
- pin to pin compatible with the M250
- fully direct-coupling
- 24-pin plastic or ceramic package

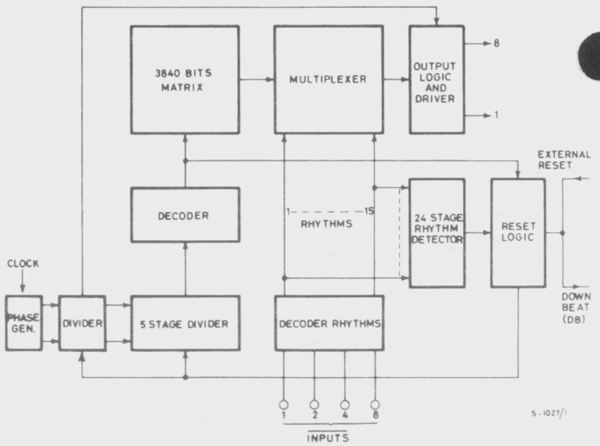
The M252 features
- 15 rhythms which cannot be superimposed
- 8 instruments for 3/4 or 4/4 time, or 7 instruments for any time
- a maximum of 32 elementary times
- external reset
- down-beat output
- internal anti-spike circuit
- single supply
- minimum dissipation (typically 100 mW)
- direct interfacing (input) with TTL and DTL
- fully direct-coupling
- 16-pin plastic or ceramic package

Both of these devices are derived from the same chip which, during the processing stages, is provided with the memory pattern specified by the customer and the ancillary functions that distinguish the particular system.

Operation of the M253 (fig. 7)

The phase generator uses the incoming clock signal to produce the 2 non-overlapping phases at regenerated levels which are required for driving the following divider.

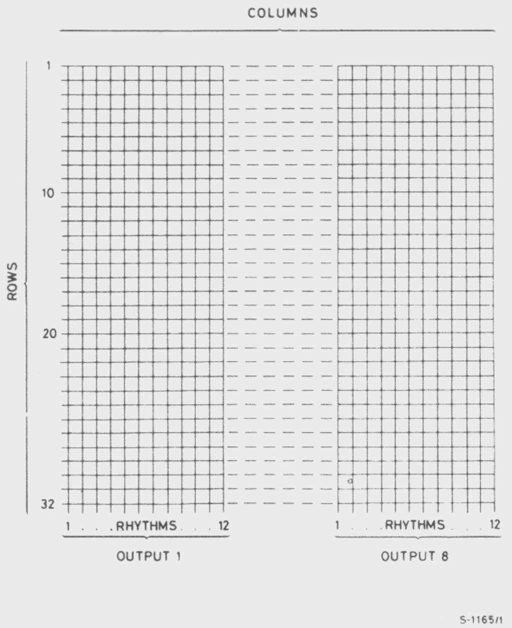
Fig. 7 - M253 block diagram



This divider has to create a reset signal for the return to zero of the outputs. The width of this pulse is independent of the duty cycle of the incoming clock.

The divider's [illegible]s also serve as timing signals for the first stage of the 5-stage counter, which uses master-slave static flip-flops.
The counter states are decoded to drive the rows of the memory matrix. The columns of the matrix are divided into 12 groups of 8, representing the 12 rhythms and the 8 instruments as shown in fig. 8.

Fig. 8 – Memory programming matrix



One particular state, the 24th, is decoded, logically combined with the rhythms in 3/4 time and is used as the counter's internal reset for rhythms programmed in this time. This device is therefore suitable for programming any rhythm in 4/4 time over 32 elementary times or in 3/4 time over 24 elementary times.
This means that when a rhythm is programmed over a single bar the intervals can be as short as 1/32 allowing great musical flexibility.
The counter can also be reset by an external signal which, when driven directly by an output of the M253 itself, sacrificing one instrument, can be used to reset the counter to any position for times other than 3/4 or 4/4. If, for example, we want to reset at the state n for a rhythm x, a beat must be programmed at the elementary time n + 1 at the output of the rhythm to be used as reset (see fig. 9).
The down-beat impulse lasts only for 2 - 3 μs so if it is to be used to drive a lamp it must first be stretched and buffered.
This output, connected at the input of the external reset, immediately zeroes the counter and therefore causes the disappearance of the reset signal (other than the n + 1 beat there should be no program on the output used as the reset).

The columns of the [illegible]e enabled singly or in groups (the rhythms c[illegible] be superimposed) via the buffer according to the rhythm or rhythms selected.

Fig. 9a – Resetting after an arbitrary number of elementary times

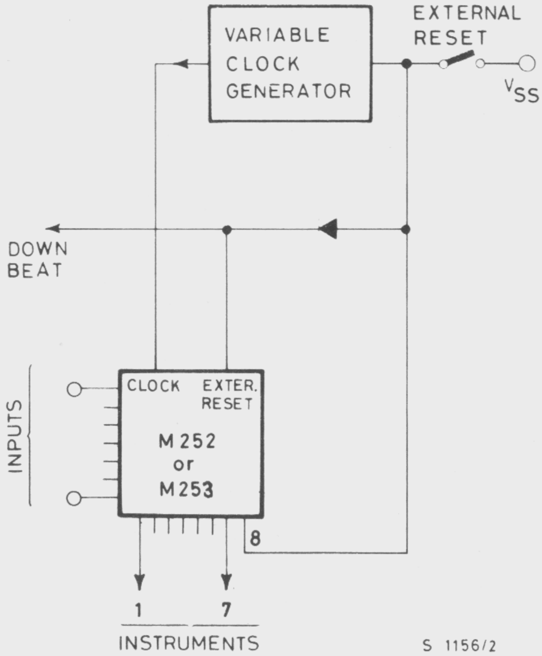
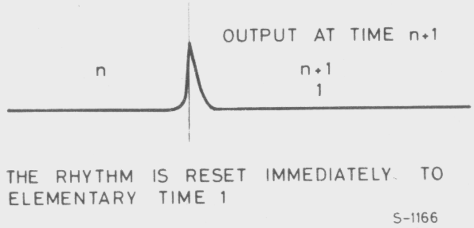
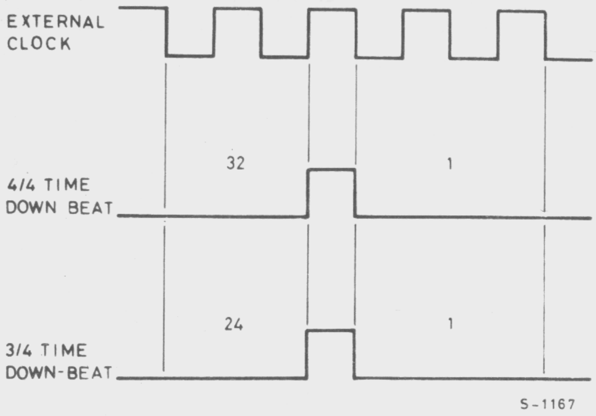


Fig. 9b – Reset from any state n: use of an instrument output as reset



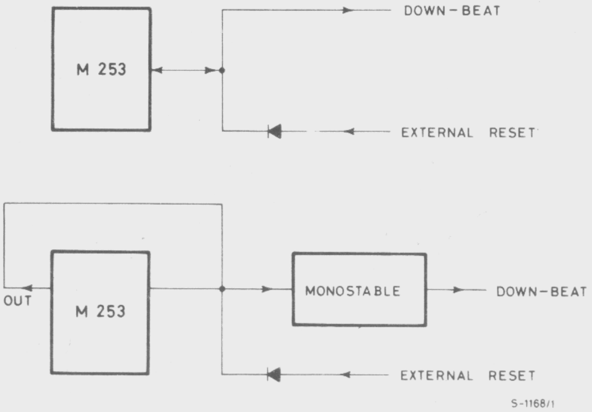
The presence of one rhythm, therefore, does not exclude the possibility of another rhythm being selected contemporarily, and the result on the output of each instrument for each rhythm is the sum of the beats of the single rhythms as already shown in fig. 5.
One particular case is when the rhythms are selected contemporarily with a different matrix e.g. a 3/4 or 4/4 rhythm. In this case the count cycle will correspond to the rhythm with the lowest number of elementary times (in the example the cycle will be of 24 elementary times).
The delayed, decoded signal from the 24th state (3/4 rhythms) and the 32nd (4/4 rhythms) are used as down-beat signals, i.e. as starting signals to indicate the first beat of the first bar (see fig. 10).

Fig. 10 - Down-bea... and duration



This signal, whose usefulness will be seen in the application section, was brought out to a pin already used for an input signal — the external reset signal — since no supplementary pin was available in the package used.
In reality the presence of an external reset signal is compatible with a down-beat signal although the reverse is not true since a down-beat signal must not have the effect of an external reset.
This can be achieved by using a diode to separate the two signals as shown in fig. 11.

Fig. 11 - Using the down-beat signal

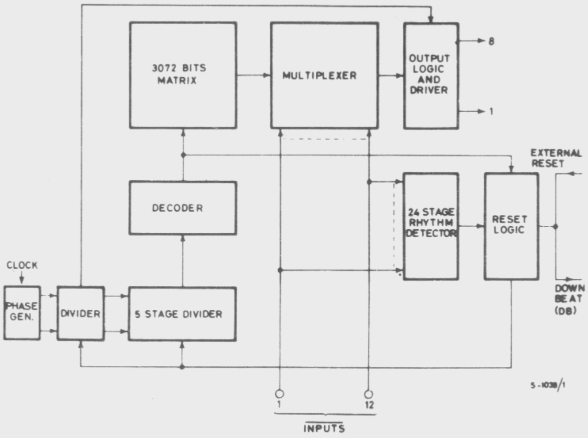


In the case of rhythms other than 3/4 or 4/4, the pulse present at the output connected to the external reset, can be used to trigger a monostable circuit whose output will be the down-beat signal. When no rhythm is selected, the down-beat signal is present and the counter counts to 32.

Operation of the M252 (fig. 12)

The phase generator, the counter, the matrix, the output and reset logic, and the 24th state decoder for the reset in 3/4 time, operate in the same way as in the M253.

Fig. 12 - M252 block diagra...



The difference is in the rhythm command inputs, which are in binary logic using the code shown in table 2.
Given the fact that is impossible to select two different codes at the same time, it follows that it will be impossible to superimpose these rhythms. One code word has been used to indicate «no rhythm selected». In this state, there are no instrument output signals, the down-beat signal is present and the counter counts to 32.

Table 2 - M 252 RHYTHM SELECTION CODE (positive logic)

RHYTHM	CODE $\overline{IN\,8}$	$\overline{IN\,4}$	$\overline{IN\,2}$	$\overline{IN\,1}$
1	1	1	1	0
2	1	1	0	1
3	1	1	0	0
4	1	0	1	1
5	1	0	1	0
6	1	0	0	1
7	1	0	0	0
8	0	1	1	1
9	0	1	1	0
10	0	1	0	1
11	0	1	0	0
12	0	0	1	1
13	0	0	1	0
14	0	0	0	1
15	0	0	0	0
No selected rhythm	1	1	1	1

PRINCIPAL ELECTRICAL CHARACTERISTICS

In this section we present the main characteristics of the M252 and M253.
Table 3 shows the static parameters and table 4 the dynamic parameters. These parameters are valid for both devices.

Table 3 – STATIC ELECTRICAL CHARACTERISTICS

Parameter		Test conditions	Min.	Typ.	Max.	Unit
CLOCK INPUT						
V_{IH}	Clock high voltage		V_{SS}-1.5		V_{SS}	V
V_{IL}	Clock low voltage		V_{GG}		V_{SS}-4.1	V
DATA INPUTS ($\overline{IN1}$ . . . . . $\overline{IN12}$)						
V_{IH}	Input high voltage		V_{SS}-1.5		V_{SS}	V
V_{IL}	Input low voltage		V_{GG}		V_{SS}-4.1	V
I_{LI}	Input leakage current	$V_i = V_{SS}$-10V $T_{amb} = 25°C$			10	µA
EXTERNAL RESET						
V_{IH}	Input high voltage		V_{SS}-1.5		V_{SS}	V
V_{IL}	Input low voltage		V_{GG}		V_{SS}-4.1	V
R_{IN}	Internal resistance to V_{GG}	$V_o = V_{SS}$-5V	400	600		kΩ
DATA OUTPUTS						
R_{ON}	Output resistance(ON state)	$V_o = V_{SS}$-1 to V_{SS}		250	500	Ω
V_{OH}	Output high voltage	I_L = 1 mA	V_{SS}-0.5		V_{SS}	V
I_{LO}	Output leakage current	$V_i = V_{IH}$ $V_o = V_{SS}$-10V $T_{amb} = 25°C$			10	µA
POWER DISSIPATION						
I_{GG}	Supply current	$T_{amb} = 25°C$		7	15	mA

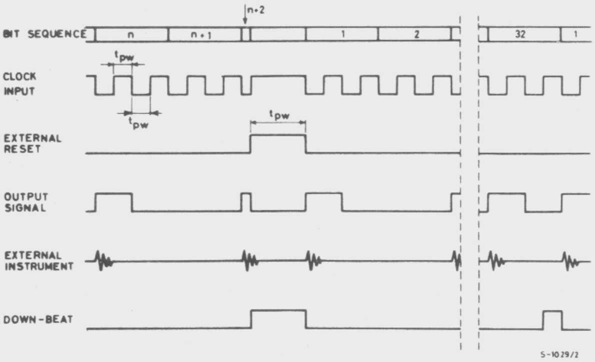
Table 4 – DYNAMIC ELECTRICAL CHARACTERISTICS

Parameter		Test conditions	Min.	Typ.	Max.	Unit
CLOCK INPUT						
f	Clock repetition rate		DC		100	kHz
t_{pw}*	Pulse width		5			µs
t_r**	Rise time				100	µs
t_f**	Fall time				100	µs
EXTERNAL RESET						
t_{pw}	Pulse width		5			µs

* Measured at 50% of the swing
** Measured between 10% and 90% of the swing

The timing waveforms [illegible]n in fig. 13.

Fig. 13 – M252 and M253 timing waveforms



For the dynamic characteristics it should be noted that a duty cycle of 50% is not required for the clock signal.

The width of the «mark» of the clock waveform need only be as great as the width of the down-beat impulse internally generated.

All the supplies and levels shown in the electrical characteristics are expressed as a function of V_{SS}. Since V_{SS} can have any value, various power supply formats can be used e.g. V_{GG} = GND, V_{SS} = 17 V; V_{GG} = –12 V; V_{SS} = +5 V, and so on as long as $V_{SS} - V_{GG} = 17 \pm 1$ V.

This makes it very simple to solve the problem of interfacing with input and output devices. The customer, however, must always respect the limits imposed by the absolute maximum ratings given in table 5.

Table 5 – ABSOLUTE MAXIMUM RATINGS

V_{GG}*	Source supply voltage	-20 to 0.3	V
V_i*	Input voltage	-20 to 0.3	V
I_o	Output current (at any pin)	3	mA
T_{stg}	Storage temperature	-65 to 150	°C
T_{op}	Operating temperature	0 to 70	°C

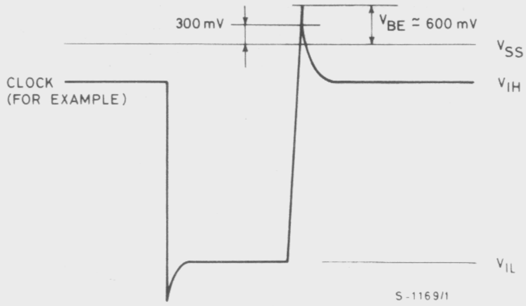
* This voltage is with respect to V_{SS} pin voltage

These voltages, temperatures or currents are values which must never be exceeded, not even momentarily, since the device can be permanently damaged should this occur.

It is of particular importance that the customer keeps a check on the positive overshoot at all the pins with respect to V_{SS} (fig. 14).

If the positive overshoot, which, on the oscilloscope will always appear limited to one V_{BE} when measured on an in-circuit device, exceeds the values quoted in the absolute maximum ratings it causes a parasitic which discharges the surrounding negative nodes, causing incorrect circuit operation.

Fig. 14 – Positive overshoot



More seriously, a fixed positive level more than 300 mV above V_{SS} will probably damage the circuit.

INTERFACING

Encoders

The following gives some examples of encoders which can be used for selecting the rhythms of the M 252.

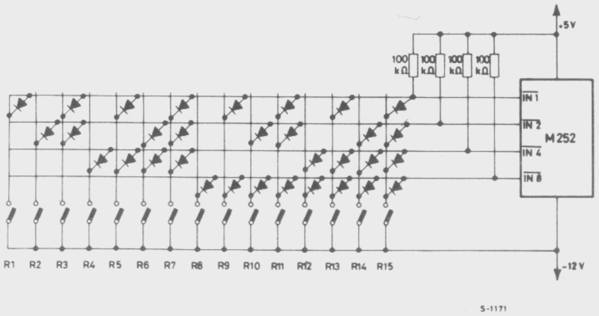
Mechanical encoder

See general circuit of the electronic rhythm section with 15 rhythms.

Encoder using diode matrix (fig. 15)

The diodes are 1N914 types, but any kind would be suitable as long as $V_{(BR)}$ is greater than 20 V and I_R is less than 1 μA at 18 V.

Fig. 15 – Diode matrix encoder

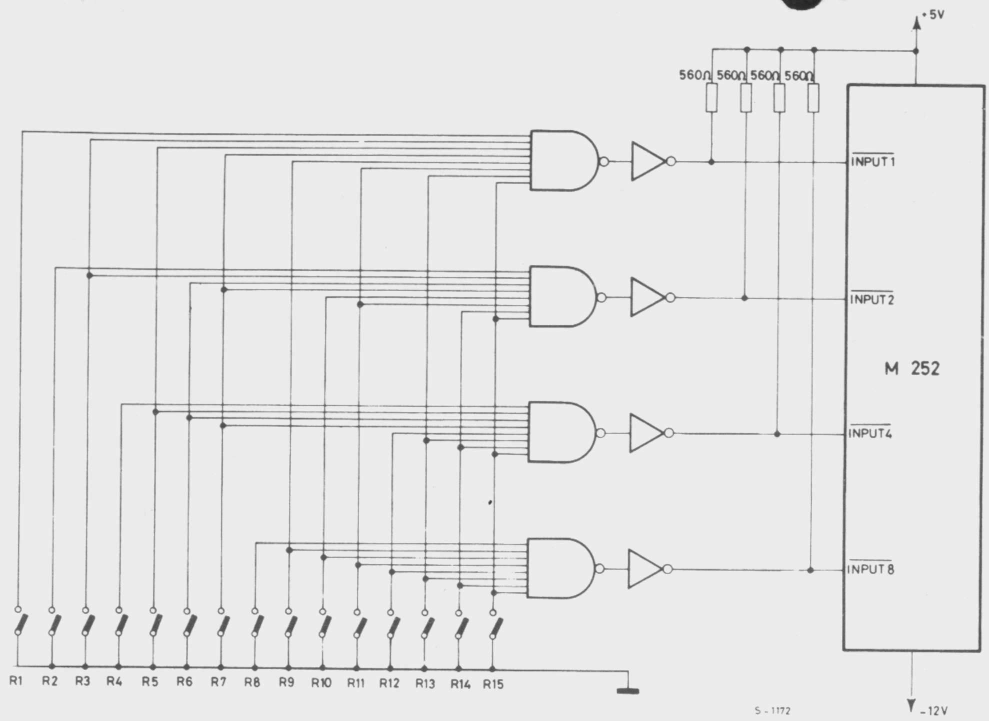


TTL encoder (fig. 16)

T 107 8-input NANDs, and T 116 inverters are used. The four resistors, between the inverter outputs and + 5 V, serve to raise the V_{OH} of the inverter until it is compatible with the V_{IH} level of the M 252. If the inverters are selected with a no load V_{OH} greater than 4 V at V_{CC} = 5 V the 4 resistors are no longer required.

The TTL elements are supplied between ground and + 5 V.

Fig. 16 – T[illegible]der

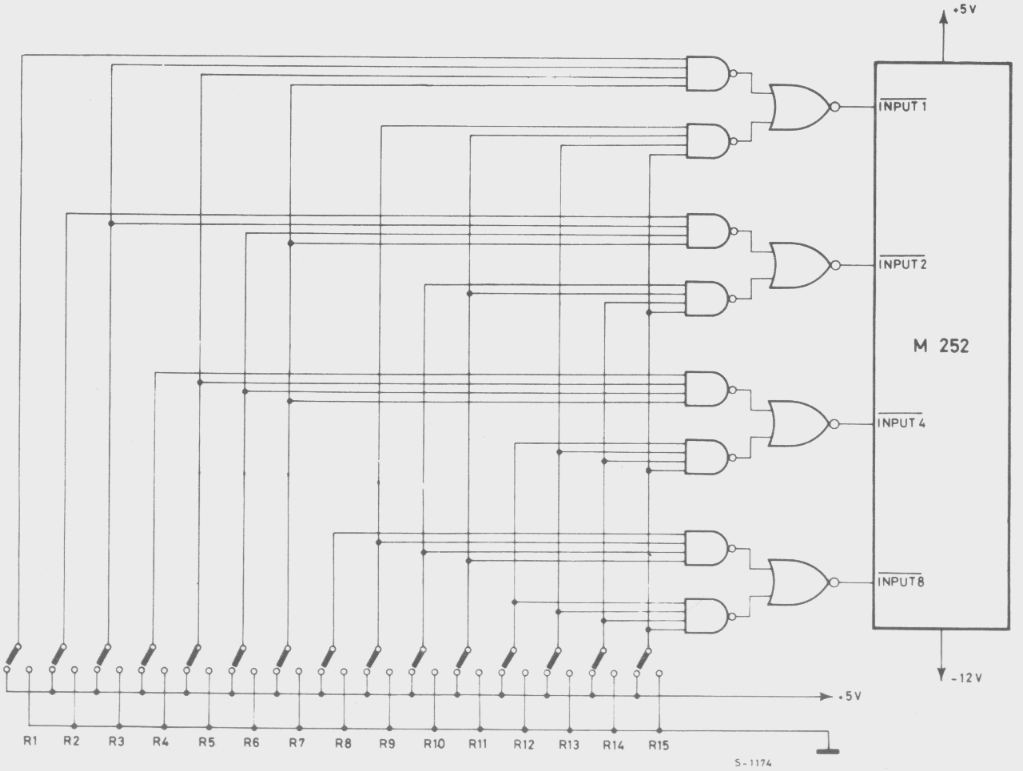


COS/MOS encoder (fig. 17)

HBF 4012A 4-input NANDs and HBF 4001A 2-input NORs are the types used.

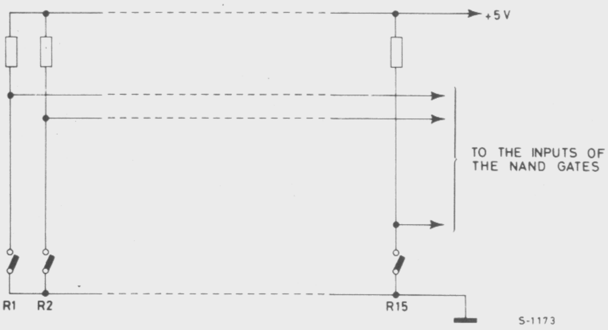
The supply for COS/MOS must be between ground and + 5 V.

Fig. 17 – COS/MOS encoder



If simple single-pole switches are to be used rather than an array of two-way switches, 15 resistors of 100kΩ must be inserted as shown in fig. 18.

Fig. 18 – Modifiyng the COS/MOS encoder for single-pole switches



Clock generator and down-beat circuit....

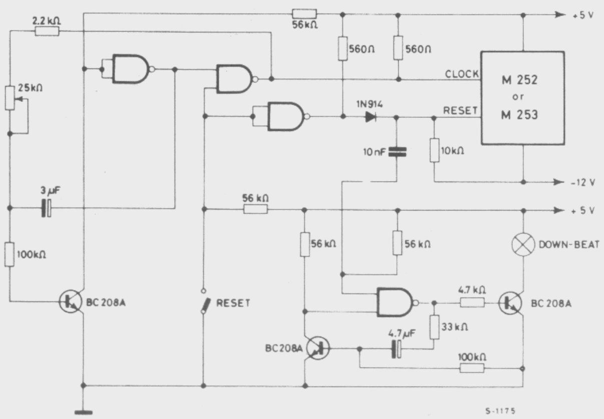
...... using COS/MOS

See general circuit of 12 or 15 rhythm system.

...... using TTL or DTL (fig. 19)

The 2-input NANDs used are T 102 or 9946 supplied between + 5 V and ground. The clock period can be varied by means of the 25 kΩ potentiometer, the variation being from 30 to 360 ms. The down-beat lamp remains lit for 350 ms at the beginning of each bar.

Fig. 19 – TTL or DTL clock generator and down-beat circuit

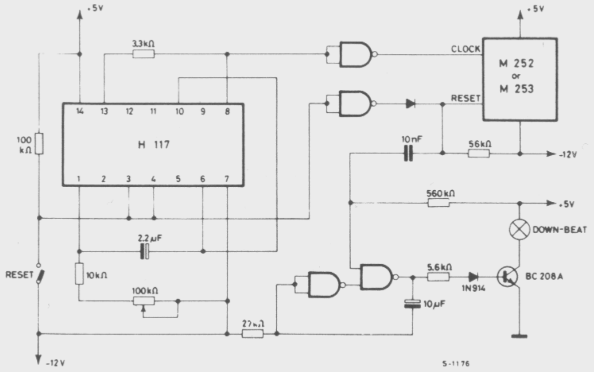


...... using HLL (fig. 20)

An H117 was used for the variable clock generator. The period can be varied by means of the 100 kΩ potentiometer, from 30 to 200 ms. The 2-input NANDs used are H102 devices.
In the case of both the H117 and the H102 the supply is between + 5 V and – 12 V.

The down-beat lamp remains lit for 350 ms at the beginning of every bar.

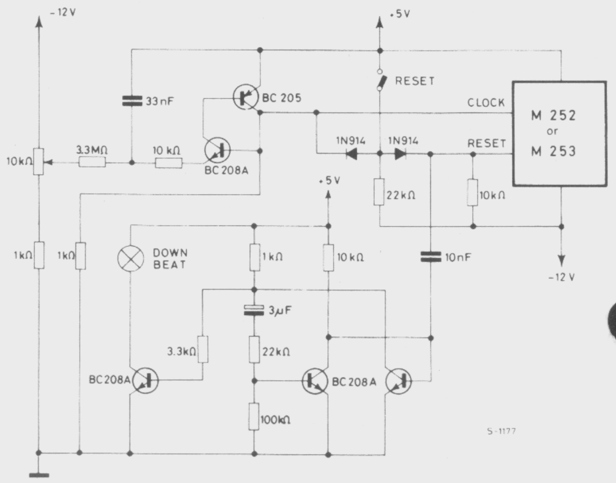
Fig. 20 – HLL clock generator and down-beat circuit



...... using discrete components (fig. 21)

This solution also allows a variation of the clock period, by means of the 10 kΩ potentiometer, from 30 to 200 ms.
The down-beat light remains lit for 350 ms at the beginning of each bar.

Fig. 21 – Discrete component clock generator and down-beat circuit



Percussion instrument simulator ....

...... using COS/MOS

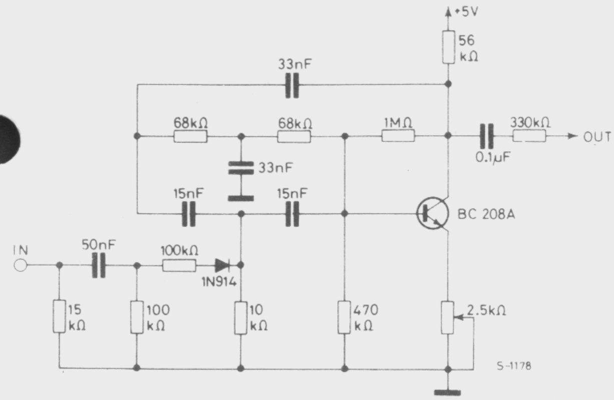
See description of circuit for 15-rhythm system.

...... using discrete components (fig. 22)

This circuit consists of a double «T» sinusoidal oscillator with a transistor as the active device. This is biased below the oscillation level by means of a

25 kΩ potent[illegible], which also allows the duration of the damped output to be controlled so that long or short sounds can be obtained as required. This circuit, with the component values indicated, reproduces the sound of the bongo, but by varying the values of the capacities it is possible to obtain various other sounds e.g. the conga, bass-drum, claves, etc.

Fig. 22 – Discrete component percussion instrument simulator

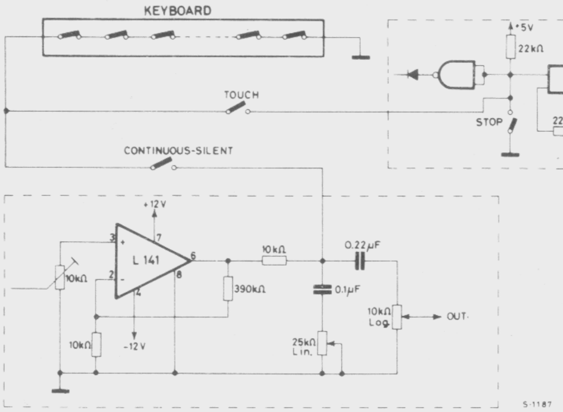


APPLICATIONS

How the rhythm section works in an electronic organ

In order that the rhythm section may be inserted in the organ, a signal must be available which indicates whether one or more keys on the organ key board have been played.
This signal, which we shall call the key played, starts the rhythm section. When a key is played the rhythm section can be arranged to start at the beginning of the bar (touch or key operation), i.e. the playing of a key removes the reset from the clock and from the M252 or M253.
Alternatively it can be arranged to start at any point in the bar (continuous or silent operation) i.e. the rhythm generator runs continuously, but its output is enabled by the «key played» signal. In continuous operation, therefore, the down-beat indicator is indispensable since it allows the first key to be played when the bar begins.
A third method (continuous free running) allows the unit to operate without playing any of the keys. This is done simply by selecting a rhythm on the push button array of the rhythm section.
Neither the touch key nor the continuous silent key must be on when this method is used.
Fig. 23 is an illustration of the insertion of the electronic rhythm section into an organ. The two parts within dashed lines are details of the rhythm section, of interest for the connections to the keyboard of the organ.

Fig. 23 – Insertion of [illegible]ythm section in the organ



Electronic rhythm section with 15 rhythms and 9 instruments (M252AA)

The electronic rhythm section described here was realized with the M252AA, programmed with 15 different rhythms, in such a way that each rhythm can use up to a maximum of 8 of the 9 instruments available (fig. 24).
The 15 rhythms programmed are the Waltz, Jazz Waltz, Tango, March, Swing, Foxtrot, Slow Rock, Pop Rock, Shuffle, Mambo, Beguine, Cha Cha, Bajon, Samba and Bossa Nova.
These rhythms can be brought in one at a time by means of the key-board.
The instruments available are the bass drum, snare drum, claves, high bongo, low bongo, conga drum, long cymbals, short cymbals and maracas.
The three controls are Volume, Tone and Tempo. In addition, a switch allows the rhythm to be started at the beginning of the bar or stops the rhythm.
The assembly is carried out on two printed circuits, one (fig. 25) contains the sound generators and preamplifier, and the other (fig. 26) contains the supply, the M252AA, the variable clock generator and the monostable for driving the down-beat lamp.
Let us divide the circuit into 4 parts, the sound generators, the variable clock generator, the down-beat monostable and the key-board.
The operation of the M252AA has already been described in the first part, but some further details will be given towards the end of this description.

1) SOUND GENERATORS

These generators are designed to reproduce as faithfully as possible the sounds made by percussion instruments. They can be divided into two broad groups, namely, sounds consisting of damped, sinusoidal waves, like drums, and those consisting of damped white noise, like cymbals.

Fig. 24 - Rhythm section with 15 rhythms and 9 instruments using the M 252AA

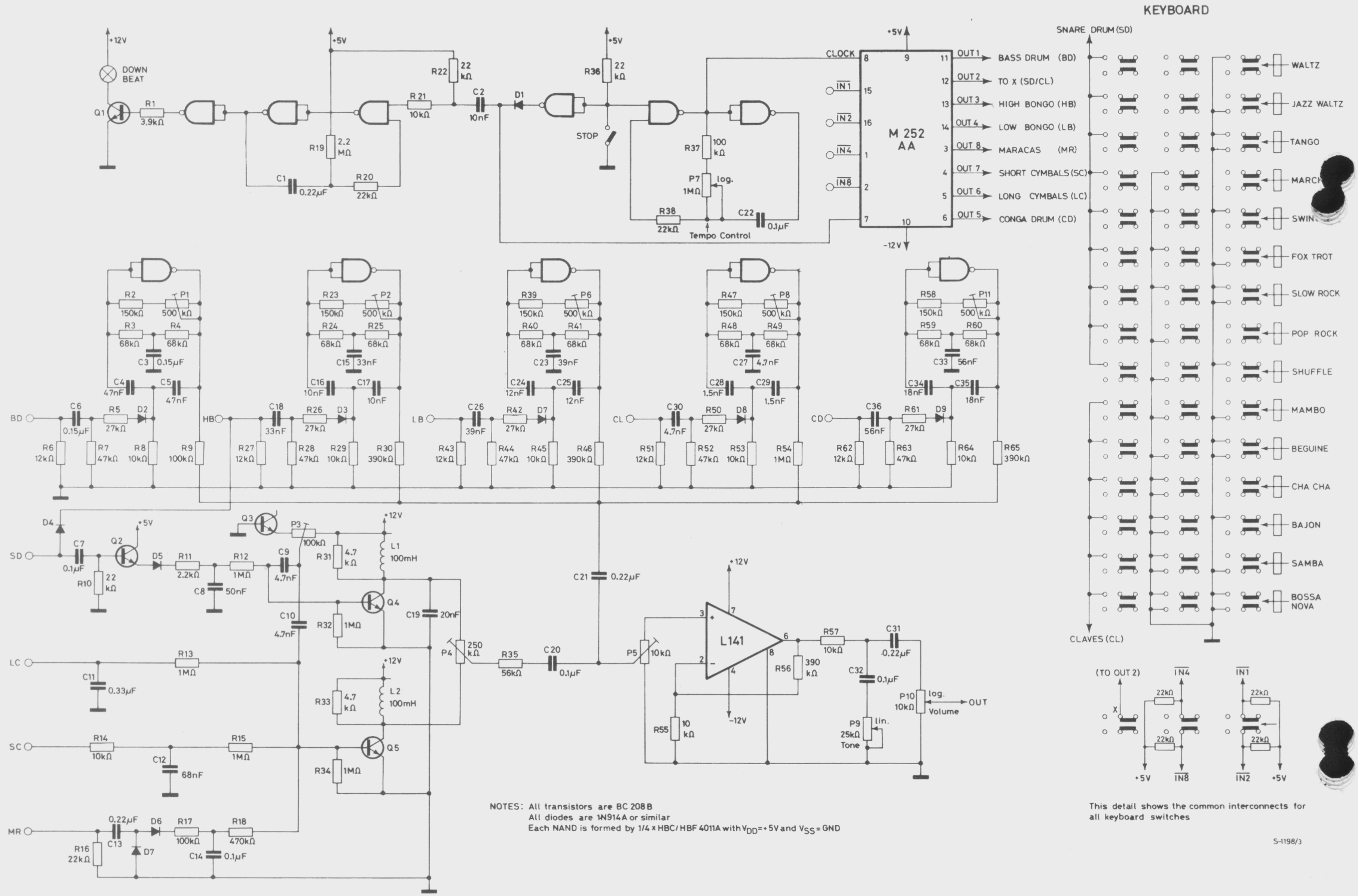


Fig. 25 – P.C.[illegible] and component layout for sound generators and preampl[illegible] 1 scale)

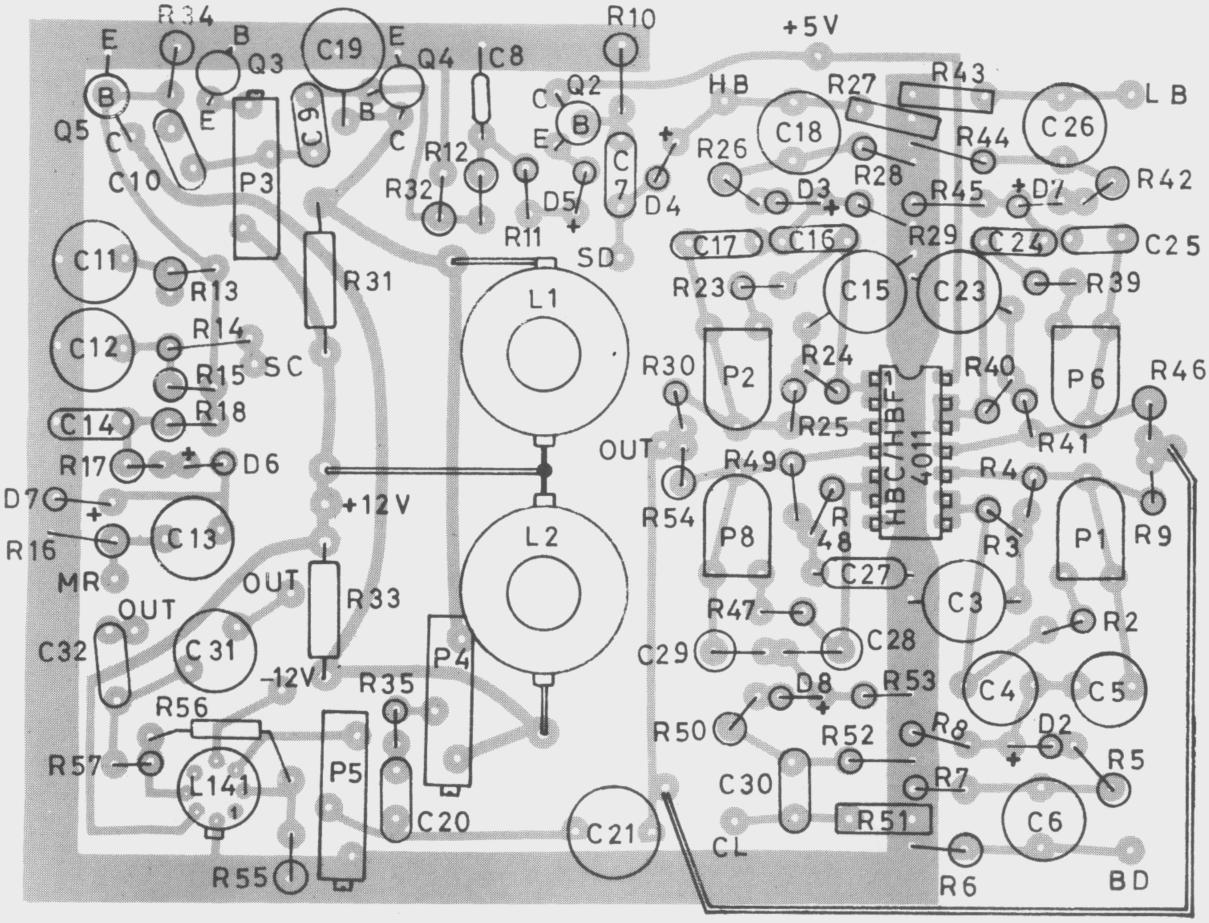


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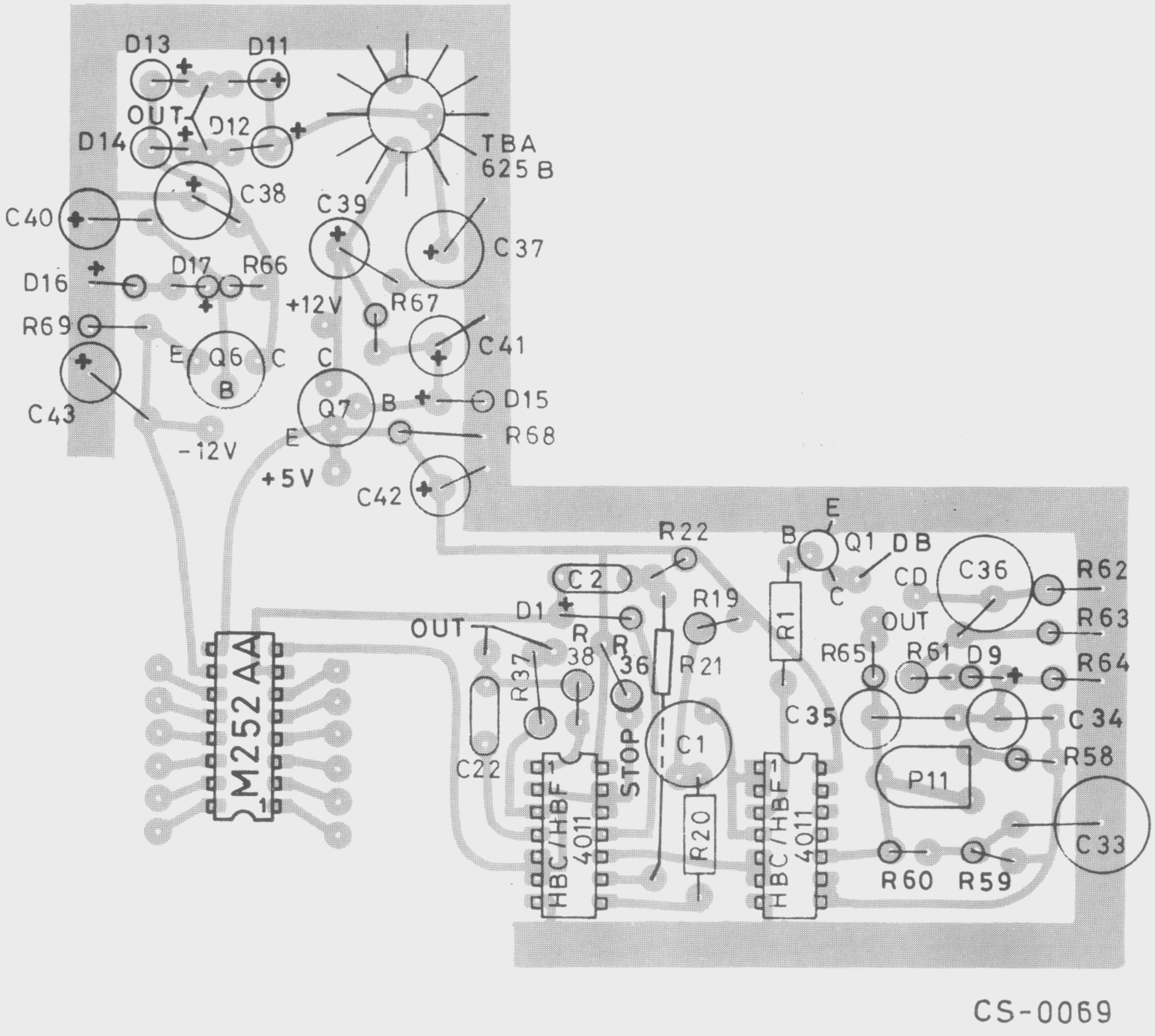
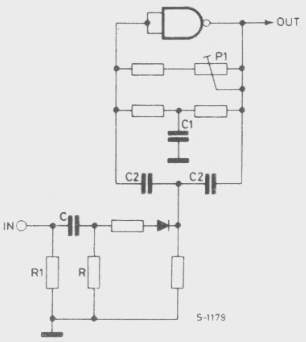
Fig. 26 – P.C. board a[illegible]ponent layout for the M 252AA, power supply, variable [illegible]enerator and down–beat monostable (1:1 scale)



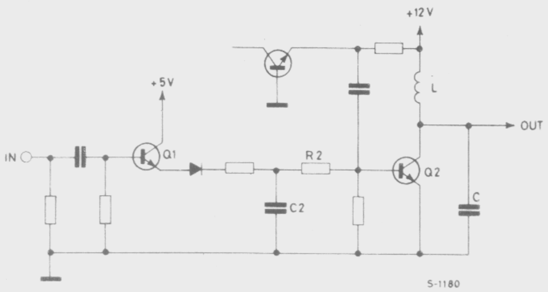
In the first category we can include the bass drum, high bongo, low bongo, conga drum and the claves, for which the basic circuit is as shown in fig. 27.

Fig. 27 – Sinusoidal instrument simulator



This circuit is a simple double-T oscillator with active COS/MOS element kept slightly below the point of oscillation by P1.
To obtain the effects of different instruments you only have to select the right values for the capacitors C1 and C2. In this way the frequency of the instrument required can be obtained.
The potentiometer P1 also regulates the length of the damping, so that longer or shorter sounds can be obtained.
Since the M252 produces a square wave, the differentiator RC must be introduced so that a fairly short pulse arrives at the oscillator, which should not interfere with the damping of the oscillation but should be sufficient to activate the oscillator itself.
The resistor R1 keeps the input at earth in the absence of a command, otherwise it would remain floating since the outputs of the M252AA are open-drain types.
In the second category we find the long cymbals, short cymbals and maracas, for which the basic circuit is of the kind shown in fig. 28.

Fig. 28 – White-noise instrument simulator

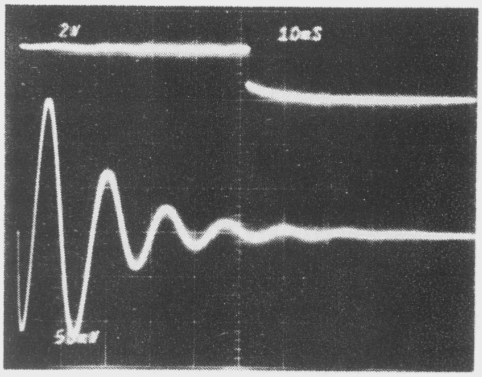


The transistor Q1 charges the capacitor C2 during the short command pulse. This capacitor then discharges through R2 and the base of the transistor Q2.

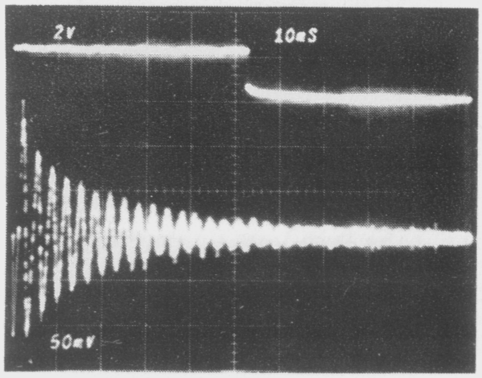
The white noise produced by the zener effect of the base-emitter junction of a transistor is applied at the base of Q2. During the discharge of C2, therefore, transistor Q2 can amplify this noise. The level of amplification, however, will follow the discharge curve of C2 and therefore a damping effect of variable length will be obtained according to the values of C2 and R2.
The inductor L and the capacitor at the collector of Q2 allow partially selective amplification to be obtained so that some harmonics can be boosted and an effect more similar to the instrument being simulated can be obtained.
As can be seen from the photographs of the signals (fig. 29), almost all the instruments used in this rhythm section start immediately with maximum amplitude and decrease exponentially. The only exception is the maracas simulator, whose signal increases progressively and then decreases like the others. This effect was achieved by means of the integrator-differentiator circuit (fig. 30) which allows controlled amplification of the white noise.
The snare drum is obtained by adding a signal of the second type, i.e. a metallic sound, to a drum sound. As can be seen from the photographs and the waveforms shown earlier, each sound starts on the positive edge of the control pulse.

Fig. 29 – Instrument waveforms

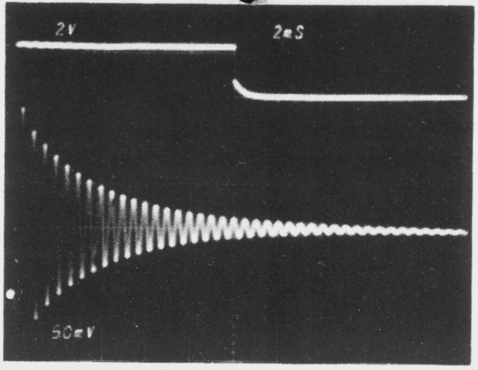
a) Bass drum



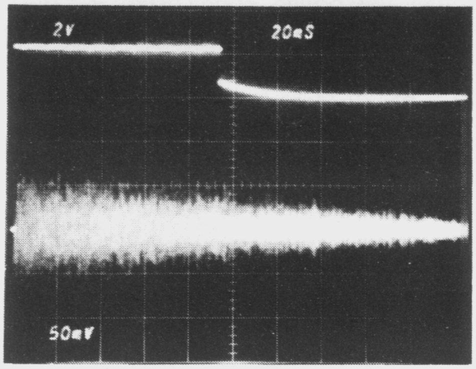
b) Snare drum



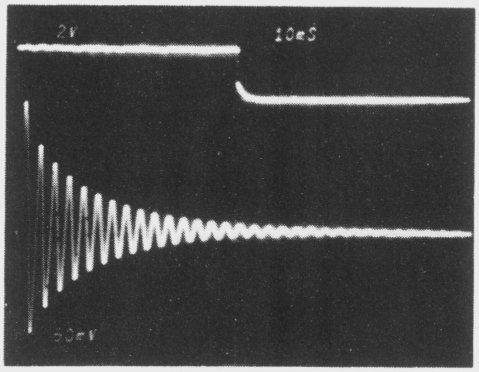
c) Claves



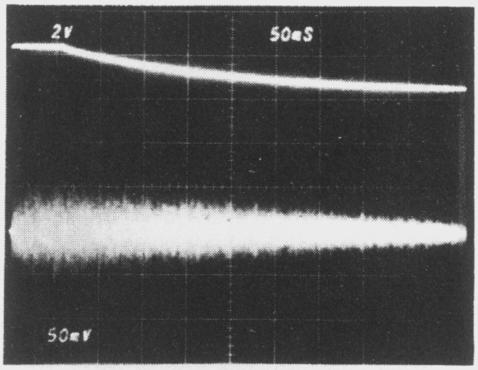
g) Short cymbals



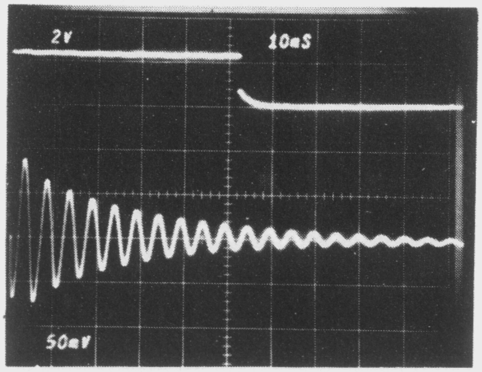
d) High bongo



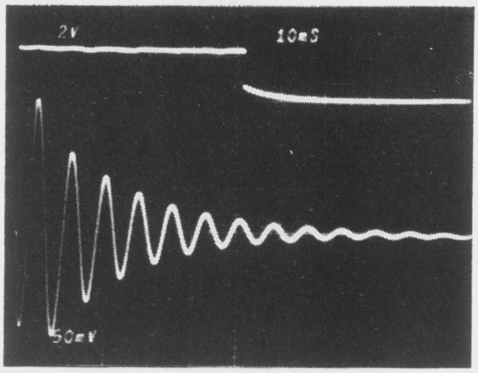
h) Long cymbals



e) Low bongo



i) Conga drum



f) Maracas

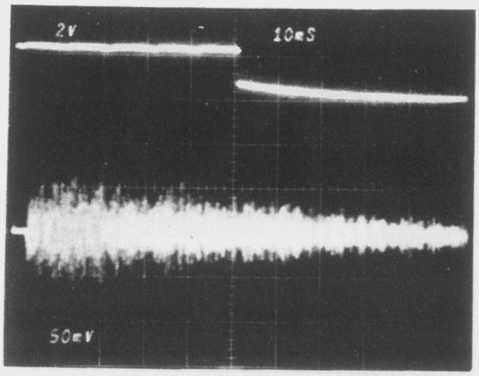
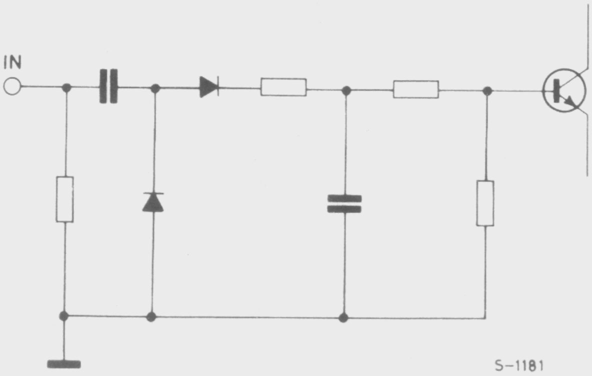


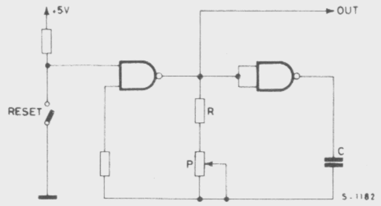
Fig. 30 – Detail of maracas simulator



2) VARIABL[illegible]K GENERATOR (fig. 31)

This generator is realized with two COS/MOS gates. The tempo can be regulated by means of the potentiometer P. When closed, the switch sets the generator in such a way that the output remains at «1» and at the same time the M252AA is reset. By opening this switch the bar begins i.e. the output immediately goes to «0» so generating the negative edge necessary to cause the first command pulse or pulses to be produced by the M252AA, according to the rhythm selected.

Fig. 31 - Variable clock generators

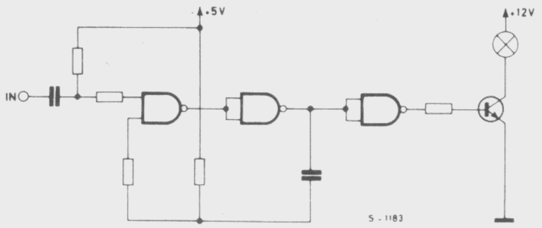


3) DOWN-BEAT MONOSTABLE (fig. 32)

This too is made with two COS/MOS gates. The down-beat pulse supplied by the M252AA is too short to light a lamp. Also it occurs at the end of the bar whereas the lamp should be lit at the beginning.

This monostable, therefore, which starts on the negative edge i.e. at the beginning of the bar, operates with an auxiliary transistor in such a way that the lamp lights for a sufficient period of time to indicate the beginning of each bar.

Fig. 32 - Down-beat monostable



4) KEYBOARD

The keyboard must be considered as a separate system having a precise logic function, namely that of encoder.

In fact by playing any key the code corresponding to that rhythm is obtained and is applied at the four inputs of the M252AA, $\overline{IN1}$, $\overline{IN2}$, $\overline{IN4}$, and $\overline{IN8}$, thus selecting the rhythm required according to table 6.

The keyboard also has the function of connecting the second output of the M252AA to the snare drum or to the claves according to the rhythm selected.

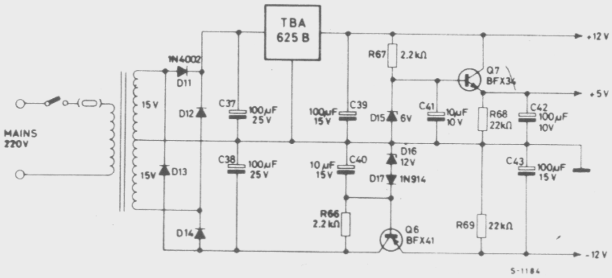
Table 6 - M 252 AA[illegible]HYTHM SELECTION CODE (positive logic)

RHYTHM	CODE $\overline{IN\ 8}$	$\overline{IN\ 4}$	$\overline{IN\ 2}$	$\overline{IN\ 1}$
Waltz	1	1	1	0
Jazz Waltz	1	1	0	1
Tango	1	1	0	0
March	1	0	1	1
Swing	1	0	1	0
Foxtrot	1	0	0	1
Slow Rock	1	0	0	0
Pop Rock	0	1	1	1
Shuffle	0	1	1	0
Mambo	0	1	0	1
Beguine	0	1	0	0
Cha Cha	0	0	1	1
Bajon	0	0	1	0
Samba	0	0	0	1
Bossa Nova	0	0	0	0
No selected rhythm	1	1	1	1

5) SUPPLY (fig. 33)

The supply which is of the usual type, supplies the three voltages required by the rhythm section.

Fig. 33 - Power supply circuit



Rhythm section with 12 rhythms and 8 instruments (M 253AA)

This rhythm section was realized with the M253AA in which 12 different rhythms are programmed, each rhythm being able to drive simultaneously a maximum of 7 out of the 8 instruments available (fig. 36).

The 12 rhythms programmed are the Tango, Waltz, Shuffle, March, Slow Rock, Swing, Pop Rock, Rumba, Beguine, Cha Cha, Samba and Bossa Nova. These rhythms can also be combined, two more can be selected contemporarily.

The instruments are the same as for the preceding unit with the exception of the conga.

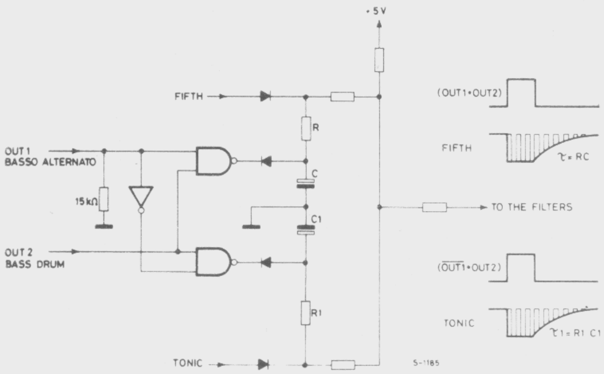
The adjustments too are equivalent, and the assembly is similarly carried out on two printed circuit boards, one of which is identical to that used for the M252AA (fig. 25). The second circuit board is shown in fig. 37.

The sound generators, variable clock generator and monostable for the down-beat, are the same as for the preceding rhythm section.

The keyboard no longer has the function of encoder, only that of connecting the snare drum or the claves to the third output of the M253AA, according to the rhythm selected.

The last important difference between this and the preceding unit lies in the first and third outputs of the M253AA. The first output is not programmed to drive an instrument but controls the alternating bass (basso alternato) of the electronic organ, (fig. 34).

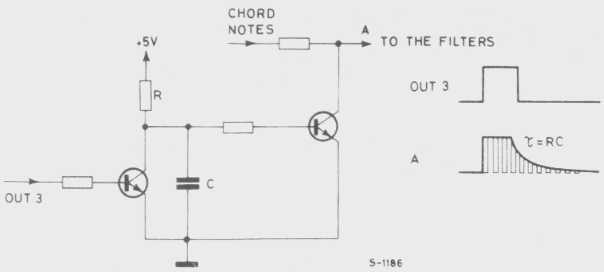
Fig. 34 – Basso alternato driving circuit



As this diagram shows the tonic appears when the OUT1 signal is absent and the OUT2 signal is present. The fifth on the other hand comes out when both output 1 and output 2 are present. To conclude, each time that there is a beat of the bass drum (OUT2) a note comes from the basso alternato. The OUT1 serves only to establish which of the two notes will be played.

The third output is programmed to drive one instrument, in this case the snare drum or the claves, and simultaneously to control the output of the chords played on the keyboard of the organ (fig. 35).

Fig. 35 – Chord driving circuit



Clearly, when using this rhythm unit on its own, i.e. not inserted in an organ, output one and the second possibility of output three will not be used.

Notes on the operation of the rhythm section

a) By resetting the clock generator to zero instead of to one (positive logic) the bar will begin half a clock-period later than the release of the reset.

b) By leaving the clock generator free, i.e. resetting only the M252 or M253, two things can happen at the release of the reset:
   1) if the clock is in "0" position the rhythm starts immediately from the beginning of the bar
   2) if the clock is at "1" the bar begins as soon as the clock switches over, therefore there is a random delay which varies from about zero to half a clock-period.

c) For both the M252 and M253 with no reset applied, the clock running and no rhythm selected, the down-beat signal occurs every 32 elementary times or every 64 clock pulses.

Fig. 36 - Rhythm section with 12 rhythms and 8 instruments using the M 253AA

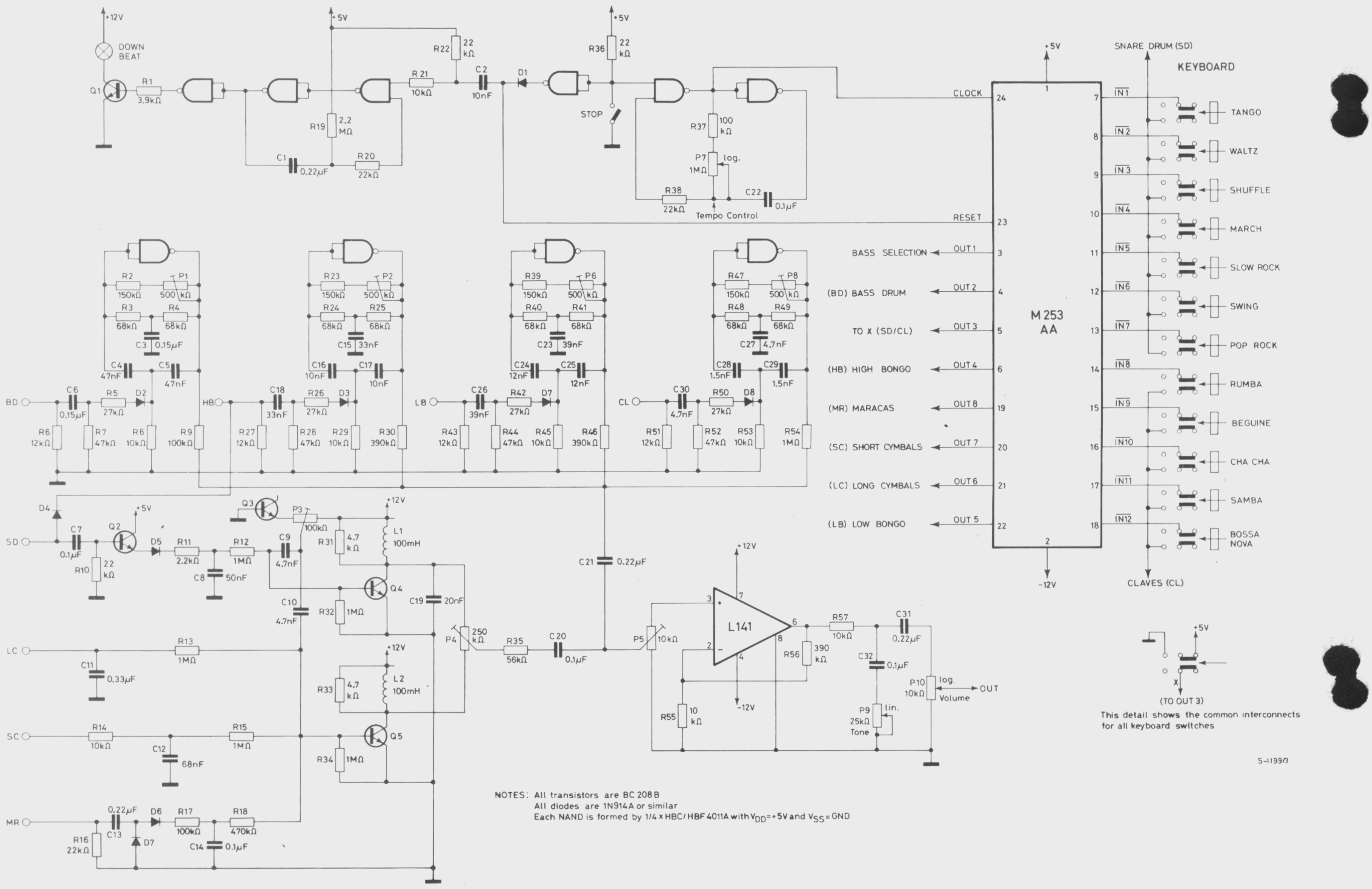


Fig. 37 – P.C. boar[illegible]omponent layout for the M 253 AA, power supply, varia[illegible]k generator and down-beat m[illegible]stable (1:1 scale)

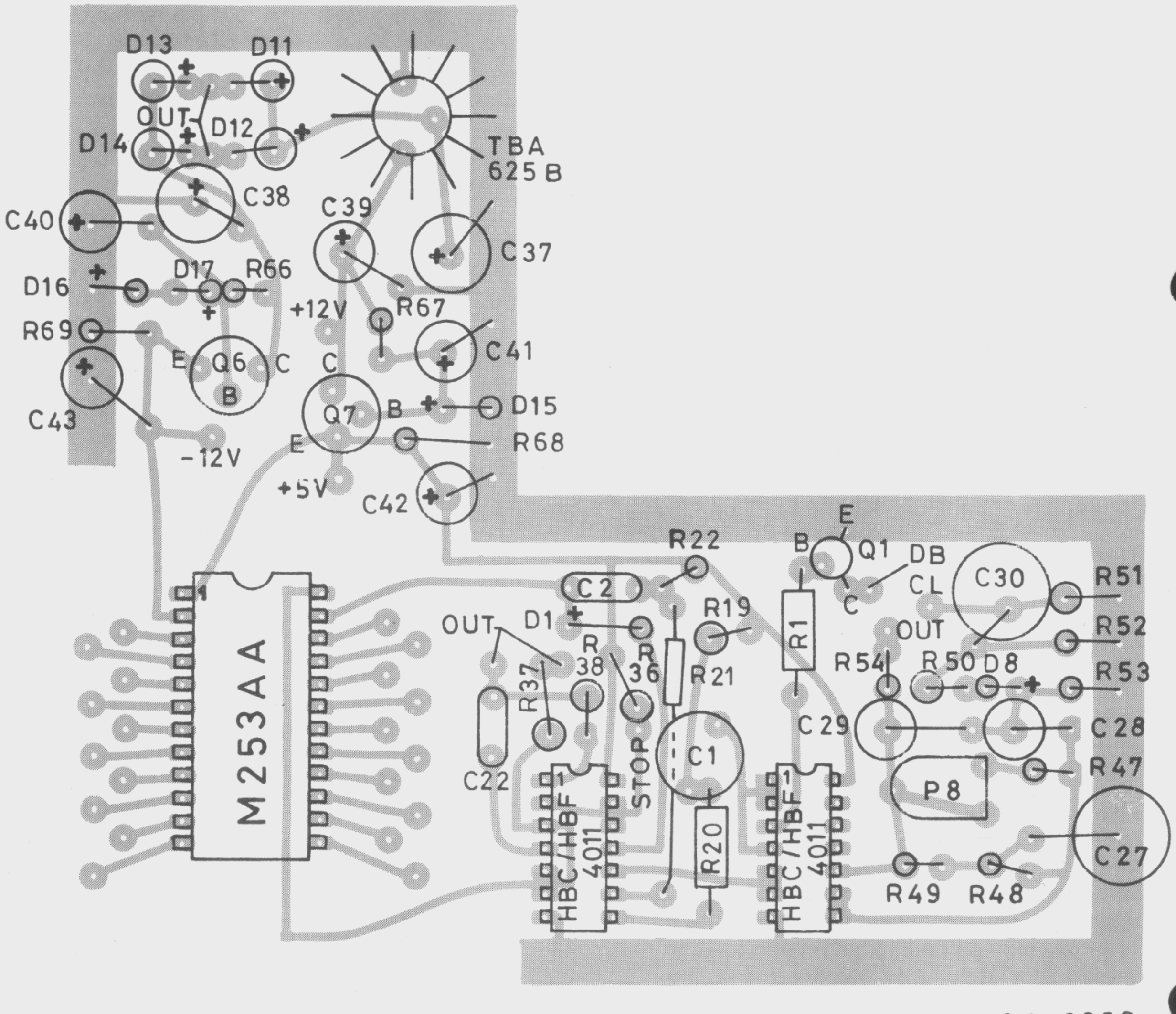


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Fig. 38 – Rhythm section with 15 rhythms a[illegible]0 instruments using the M 252 AD

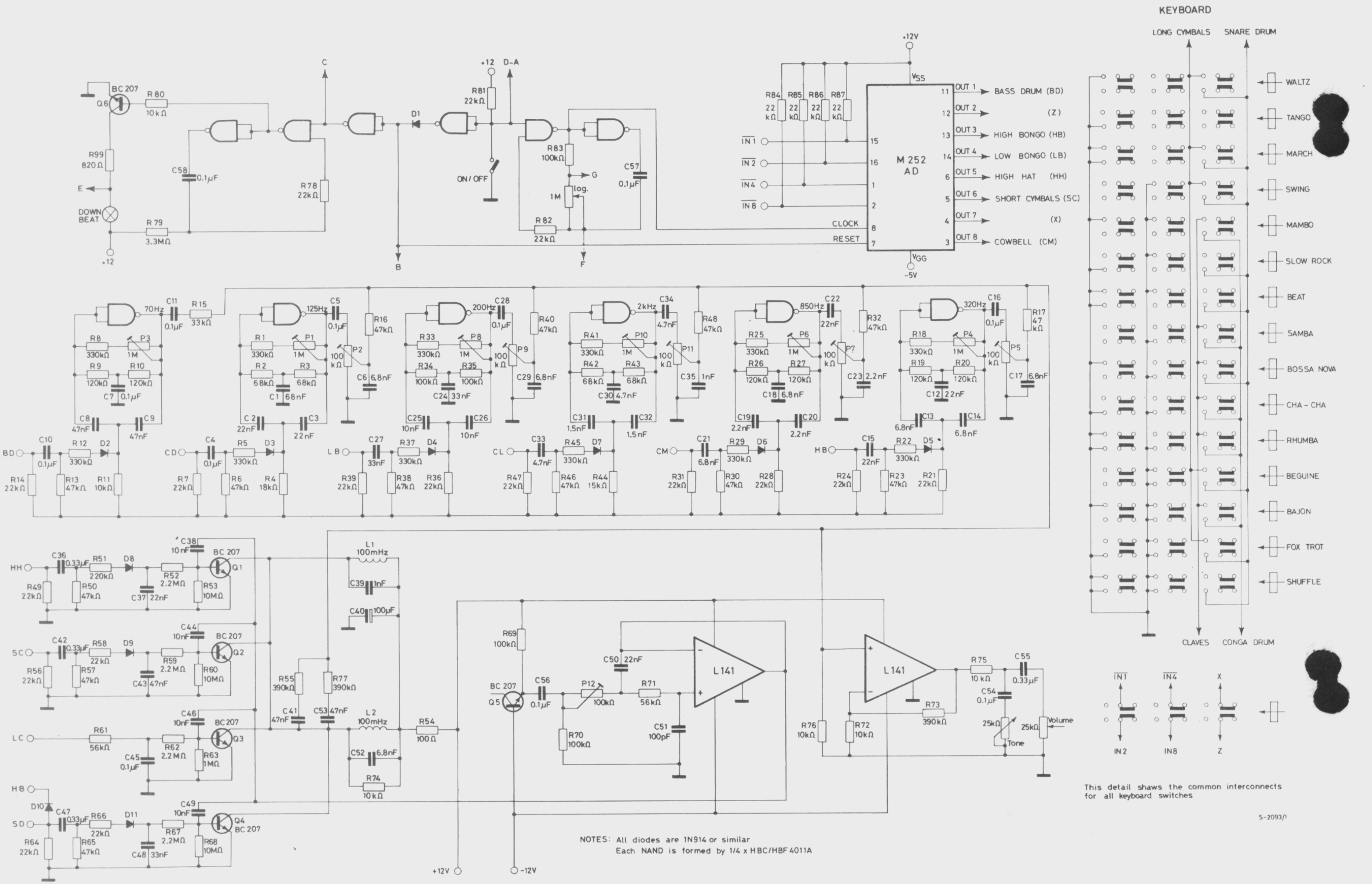

Fig. 39 – P.C. board and component layout for the M 252 AD, power supply, variable clock generator and down-beat monostable, (1:1 scale)

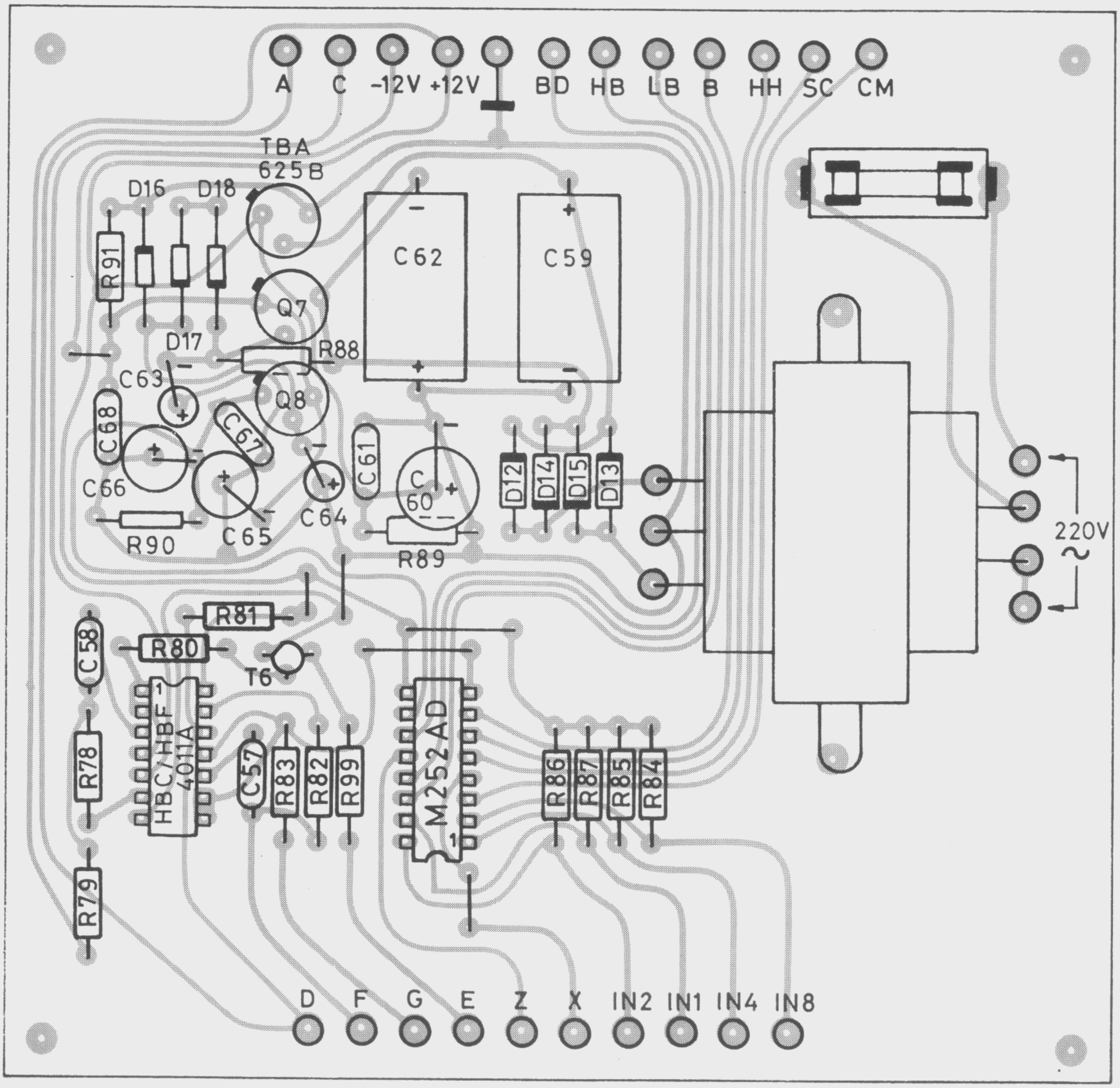

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Fig. 40 - Rhythm section with 12 rhythms and 10 instruments using the M 253 AC

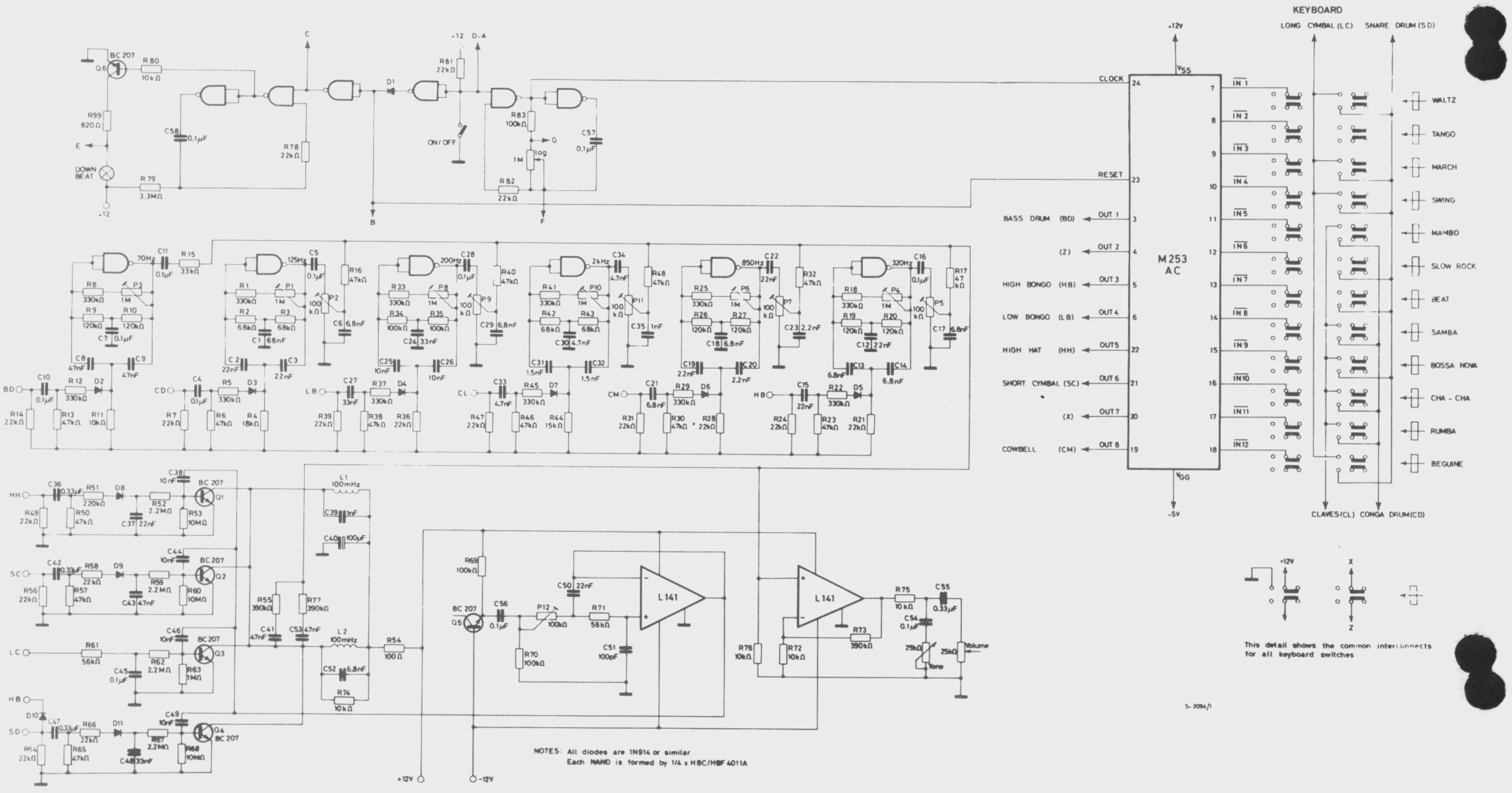

Fig. 41 - P.C. boar[illegible]omponent layout for the M 253 AC power supply, var[illegible]ck generator and down-beat monostable (1:1 scale)

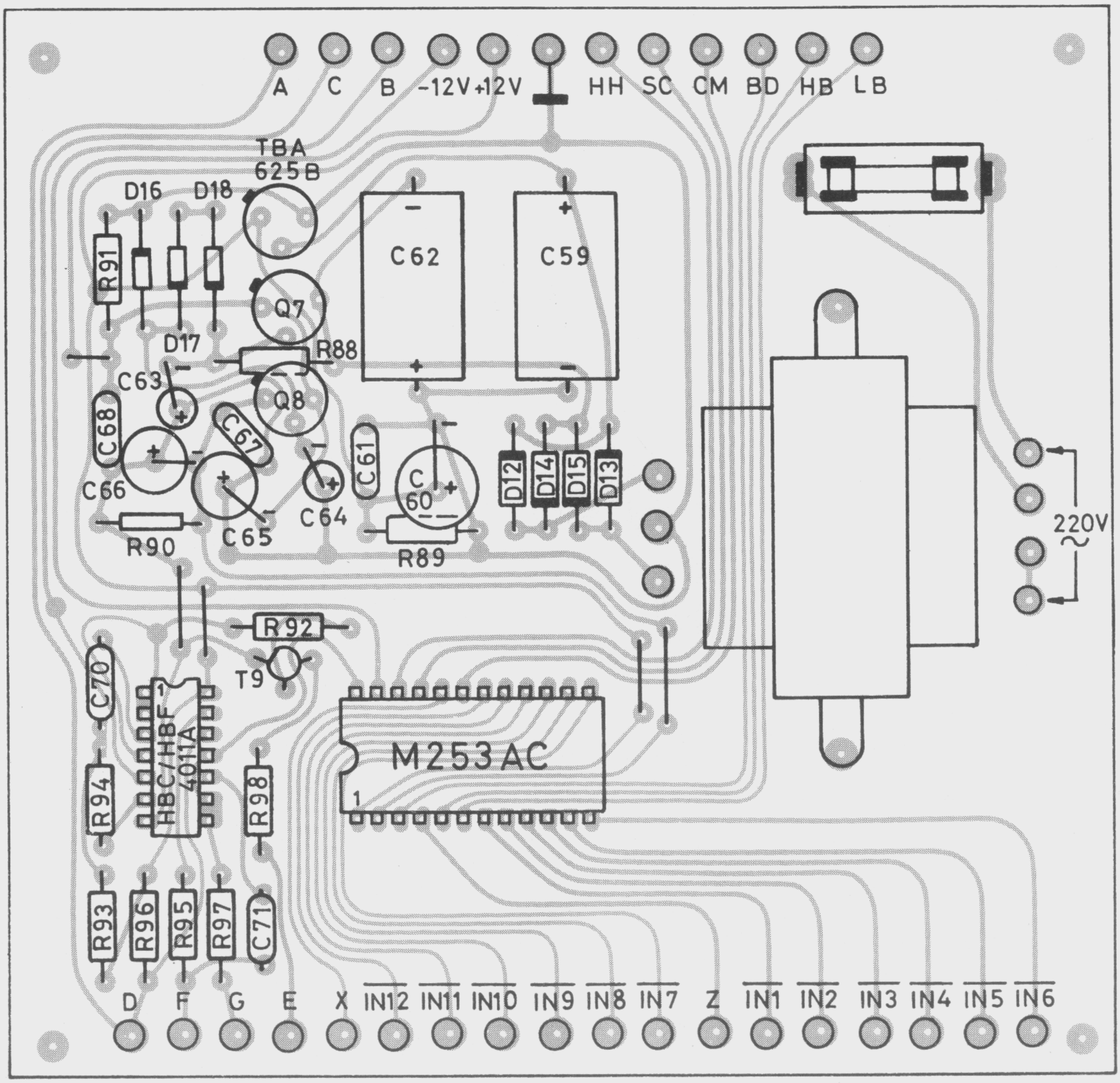

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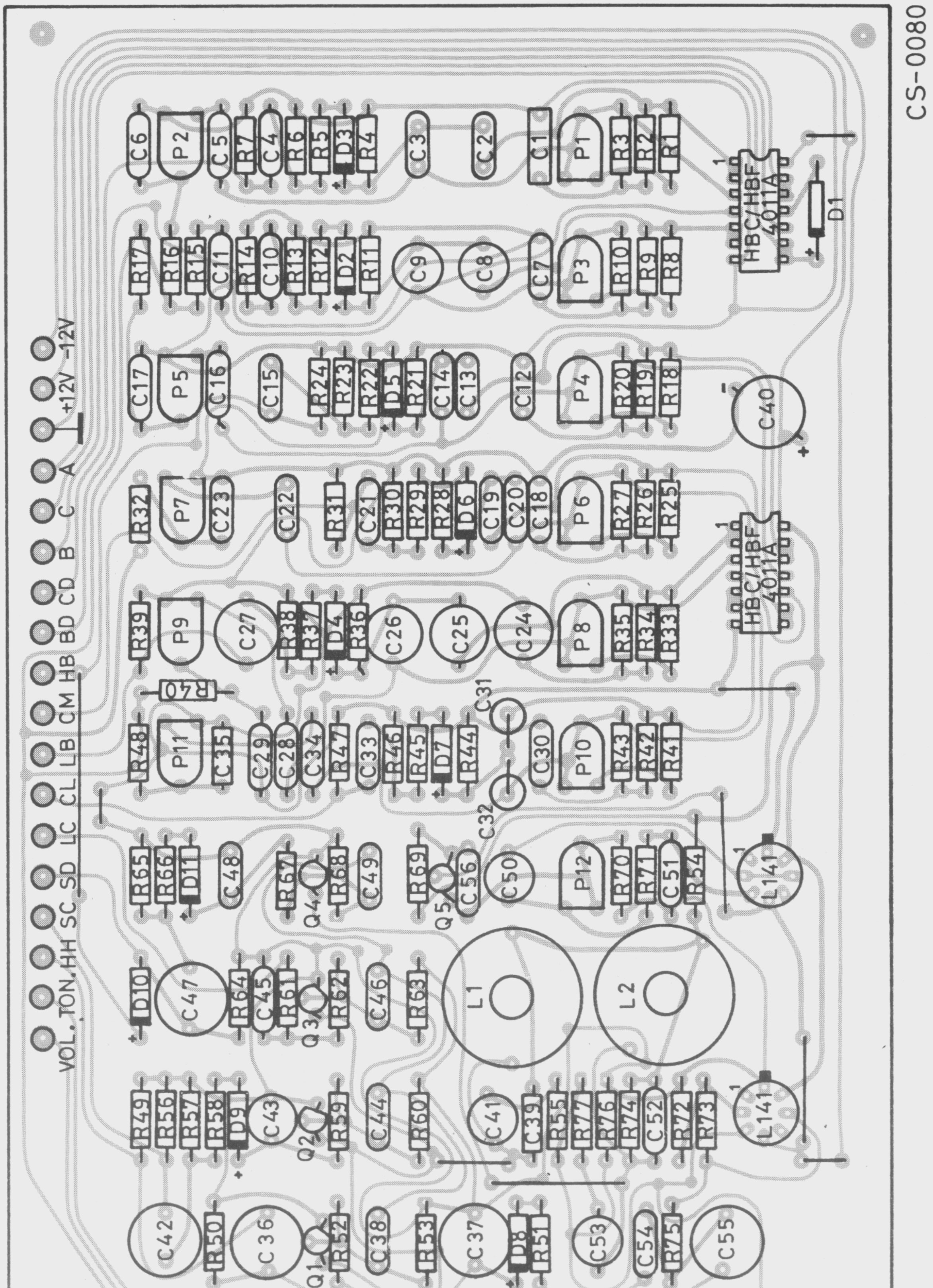
Fig. 42 – P.C. … nd component layout for sound generators and preamplif…

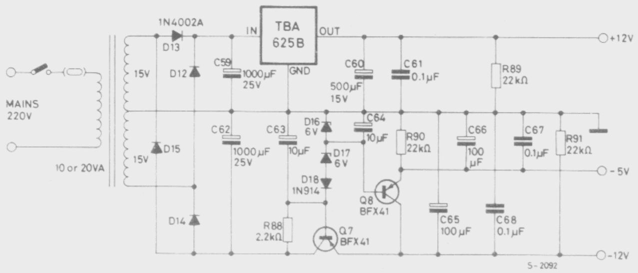


Rhythm sections [illegible] M 252 AD and M 253 AC

A different music content has been programmed in M 252 AD and M 253 AC and two rhythm sections using these devices have been realized.
The complete circuit diagrams are shown in figs. 38 and 40 for M 252 AD and M 253 AC respectively.
Similarly to what was done for M 252 AA and M 253 AA the assembly is carried out in two printed circuit boards: one common to both M 252 AD and M 253 AC containing the sound generators and the preamplifier (fig. 42), and one board containing power supply, block generator and down-beat monostable (fig. 39 for M 252 AD and fig. 41 for M 253 AC).

Table 7 – M 252 AD RHYTHM SELECTION CODE (positive logic)				
RITMO	CODE			
	IN 8	IN 4	IN 2	IN 1
Waltz	1	1	1	0
Tango	1	1	0	1
March	1	1	0	0
Swing	1	0	1	1
Mambo	1	0	1	0
Slow Rock	1	0	0	1
Beat	1	0	0	0
Samba	0	1	1	1
Bossa Nova	0	1	1	0
Cha Cha	0	1	0	1
Rhumba	0	1	0	0
Beguine	0	0	1	1
Bajon	0	0	1	0
Foxtrot	0	0	0	1
Shuffle	0	0	0	0
No selected rhythm	1	1	1	1

Fig. 43 – Power supply circuit for M 252 AD, M 253 AC



Increasing the number of rhythms, instruments or elementary times

By combining 2 M252s or M253s it is possible to improve the performance of a rhythm section by increasing the number of rhythms (figs. 44 and 45) or the number of instruments (figs. 46 and 47).

Fig. 44 – Increase in number of rhythms, using two M 252s

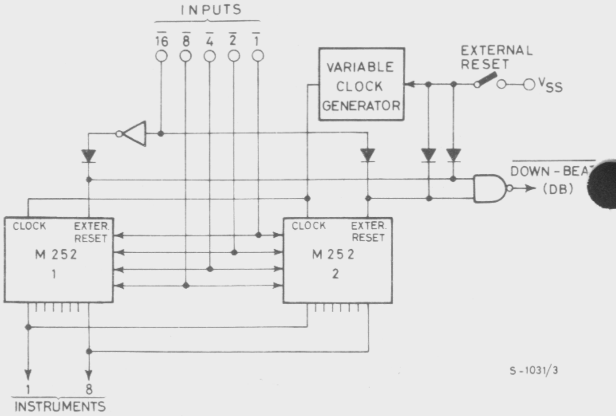


Fig. 45 – Increase in number of rhythms, using two M 253s

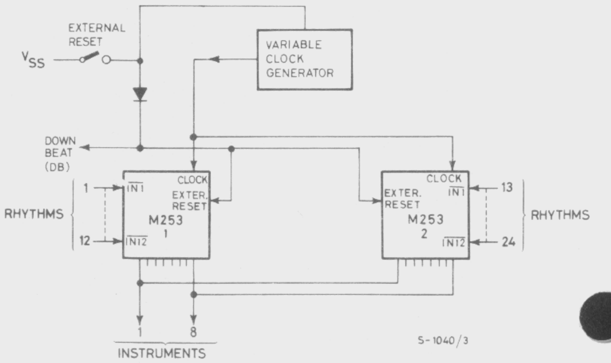


Fig. 46 – Increase in number of instruments, using two M 252s

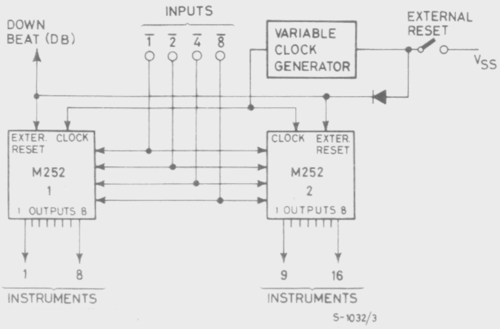
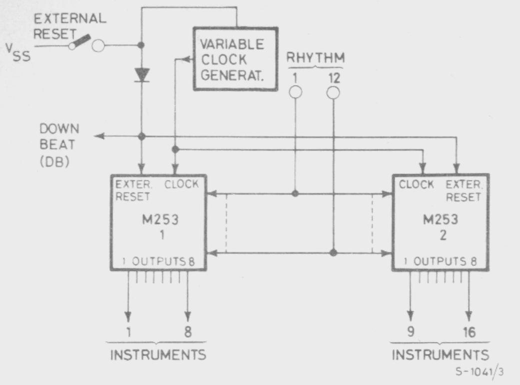


Fig. 47 – Increase [illegible]ber of instruments, using two M 2[illegible]



It [illegible]lso possible to increase the number of elementary times, as shown in figs. 48 and 49, thereby allowing more intricate rhythms to be produced. As can be seen from the figures, the inputs and outputs are paralleled, the number of rhythms and instruments remaining unchanged.

The number of elementary times however, has been doubled, by causing first one IC to count through its cycle and then the other, in a continuous sequence.

Fig. 48 – Increase in number of elementary times, using two M 252s

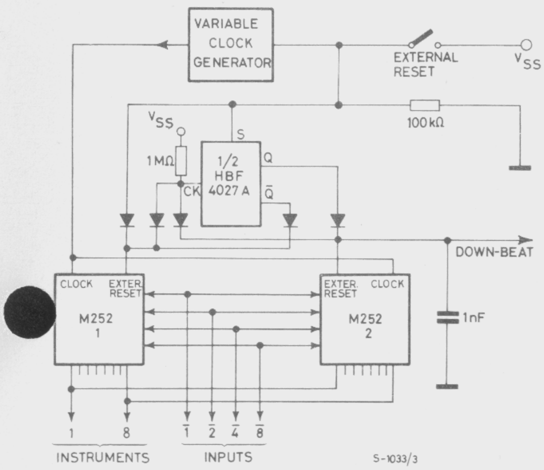
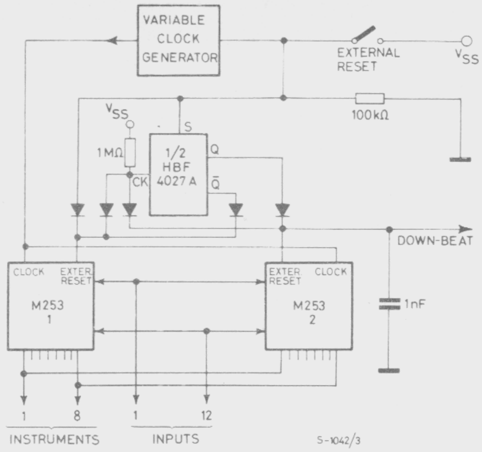


Fig. 49 – Increase in num[illegible]lementary times, using two M 25[illegible]



The capacitor at the reset pin of the second IC ensures that, when the external reset is applied, the system always restarts with IC 1.

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