Mini—Synth Sound Effects Synthesizer

Construction

and

Operation

Waveform Processing

Waveform Processing
WP-20 Mini-Synth Sound Effects Synthesizer

INTRODUCTION

The WP-20 Sound Effects Synthesizer does just what it's name implies. It creates sounds synthetically by means of electronics. It comes very close to imitating many real sounds and can also create sounds that do not occur in real life. It performs this magic through the use of an oscillator, bandpass filter, envelope generator, low frequency oscillator, amplifier and a white noise source.

The versatility of the WP-20 comes from the fact that several of it's circuits are 'Voltage Controlled'. The frequency of the oscillator, for example, may be varied manually by turning one of the oscillator control knobs on the front panel. Turning the knob varies a voltage in the oscillator circuit, thereby changing it's frequency.

The frequency of the oscillator can also be changed by applying a changing voltage directly to the circuit. The higher the voltage, the higher the resulting frequency of the oscillator. A lower voltage will produce a lower frequency. This voltage is called 'Control Voltage' or 'Control Signal'. A Control Signal of constantly changing voltage, such as a sine wave will raise and lower or 'Modulate' the frequency of the oscillator. If the Control Voltage Signal frequency was slow enough, the resulting sound would be similar to a rising and falling police siren.

Control voltage signals can also be used to control the Bandpass Filter and the Output Amplifier. One source of control voltage is a special oscillator called a 'Low Frequency Oscillator' or LFO. The LFO can produce square waves, triangle waves (somewhat similar to sine waves) and ramp waves at a frequency range of about 1Hz to 1KHZ.

Another source of control voltage is the 'Envelope Generator' (also called Attack/Decay Generator or A.D. Generator) . Two knobs on this module control attack and decay. The attack control determines how long it will take for a voltage to reach it's maximum point. The decay control determines how long it will take for that voltage to fade away. The resulting signal is called an 'Envelope'. This envelope may be triggered manually with the trigger pushbutton or set to repeat automatically with the repeat switch.

If we used the A.D. Generator to control the Voltage Controlled Amplifier and the Low Frequency Oscillator to modulate the Voltage Controlled Oscillator, the result could sound like a police Siren as it approaches us from a distance, passes us and moves away.

One other important circuit in the WP-20 is the White Noise Generator. White noise is a randon distribution of all frequencies mixed together. Saying 'SHHHH' through your teeth will produce a

sound similar to white noise. White noise is the basic ingredient in imitating wind or surf sound. It can also be added to sounds made by other circuits. One such sound might be the wind as it whistles through a screen door.

The number of sounds that can be made with the WP-20 are almost limitless. Don't be afraid to experiment with different control settings. Sometimes, flipping one switch or turning a knob just slightly will produce a totally new sound. Once you have a sound just right, mark the control settings on a patch sheet so that the sound may be repeated in the future. Don't overlook the possibilities of using a tape recorder to record or modify a sound. If your recorder has 'Sound-On-Sound' you can add different sounds together. Try recording a sound at one speed and playing it back faster or slower.

E X P E R I M E N T . . . H A V E F U N

WP-20 CONSTRUCTION DETAILS

It will be assumed at this point that you have gathered all of the parts necessary to complete construction.

The first phase of construction will involve inserting and soldering parts onto the Printed Circuit Board (PCB). Before any soldering is done, it is recommended that the copper traces on the board be cleaned with an abrasive type household cleanser and thoroughly rinsed and dried. This will insure that the solder will adhere to the copper.

Start at the top left of the parts list with the resistors. Notice that the first resistor has a value of 330 ohms and that it's part number is R20. Locate a 330 ohm resistor and insert it at the point marked as R20 in white letters on the PCB. Solder it in place and trim off the excess leads with diagonal cutters. proceed down the parts list in the same manner. Some values will be used at several different locations. For example, three 4.7K resistors are used at R21, R23, and R43.

IMPORTANT! Two resistors (R41 and R43), one capacitor (C18) and one diode (D3) are not to be mounted to the PC8.. These will be mounted directly on the lugs of controls as shown on the wiring pictorial.

After all resistors have been inserted and soldered to the board, insert and solder the disc capacitors, diodes, IC sockets, transistors and electrolytic capacitors in that order. Be careful to observe proper polarity for diodes and electrolytic caps. Also be sure to properly orient transistors and IC sockets according to the letters and marks on the PCB.

The next step of construction will involve laying out and drilling the holes in the case for all controls and switches. Use the full size front panel layout as a suggested guide. If slide-type switches are used, rectangular holes can be made by drilling a pilot hole of about 1/4 inch, then filing the hole out to the proper dimensions. A template can be made by dissassembling a switch, flattening it and attaching it over the spot where the hole is to be made. (Toggle switches are much easier to mount but are more expensive.)

Two brackets must be made or purchased. One is the holder for the batteries and may be connected to the case at this time. The other is the PCB holder and may be mounted to the PCB now (it will be attached to the case later). See the case diagrams for details.

After all holes are drilled and filed, mount pots, switches and phone jack. Using the wiring diagram as a guide, interconnect all pots and switches with hookup wire. Solder carefully since some terminals have more than one wire connected to them. At this time, connect R41, R43, D3 and C18 according to the diagram.

Connections now must be made between the controls and the PC board. The holes lettered A-Z on the pots and switches diagram match with points A-Z on the PC board. Connect point "A" on the board to point "A" on the panel, "B" to "B", etc. Use adequate lengths of wire to make positioning the board possible.

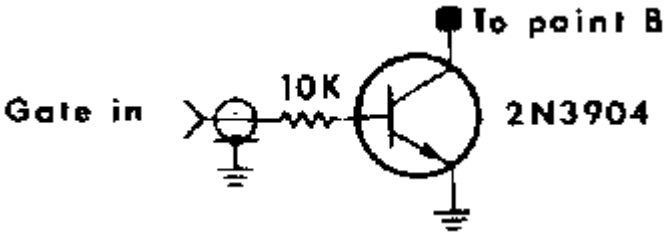
Connect the two 9-volt battery clips according to the wiring diagram. Point "X" (the red lead of B2) connects to point "X" on the PC board.

Insert the IC's in their sockets. The case notch or dot on the IC should match the mark on the PCB. Attach the PC board bracket to the case

Construction of your WP-20 is now complete.

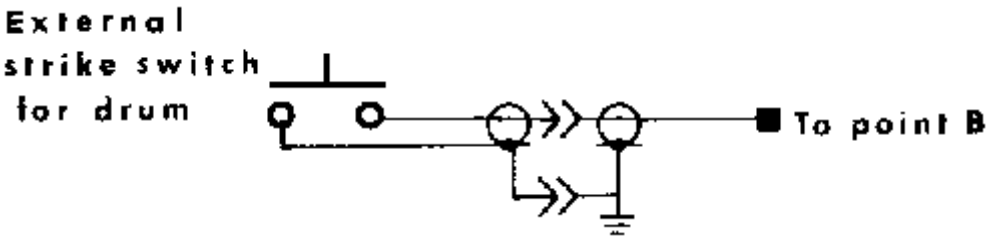
SEQUENCER AND DRUM MODIFICATIONS

The circuit below will allow the WP-20 to be controlled by a sequencer. First, mount two jacks in a convenient place near the Trigger Switch (S3 on figure 2), The gate output of the sequencer will be used to trigger the A.D. Generator in the WP-20 through a



2N3904 transistor. The Trigger Switch is a convenient place to mount the transistor. Solder the collector to the terminal of S3 identified as Point B. Solder the emitter to the other terminal. Connect a 10K resistor from the base of the transistor directly to the 'hot'

terminal of one of the newly installed jacks. Provision must also be made to control the VCO in the WP-20 with the sequencer control voltage. Wire a 100K resistor from the 'hot' terminal of the other jack to pin 1 of IC3 as shown above. The sequencer mod is now complete.



The WP-20 may be wired to function as a drum synthesizer. Mount a jack in the side of the case near Trigger Switch (S3). The 'hot' lead of the jack should be connected to the 'Point B' side of S3 Wire the ground terminal of the jack to the other side of S3 Connect a SPST switch through shielded cable and a plug to the jack. This external switch should be mounted so that it can be easily struck with your hand or a drum stick.

WP-20 PARTS LIST

RESISTORS (All are 1/4 watt, 5%)

330 ohm	R20
2.2K	R3
4.7K	R21, R23, R43
10K	R2, R9, R10, R14, R19, R28, R35, R48
20K	R12, R27, R32
30K	R41
39K	R24
47K	R15, R33, R49
l00K	R4, R5, R8, R11, R13, R16, R17, R18
	R25, R26, R29, R34
390K	R7, R22
1 meg	R1, R6, R30, R31

POTENTIOMETERS (All are 200K linear taper) R36, R37, R38, R39, R40, R42, R44, R45, R46, R47

DISC CAPACITORS

.005uf	C2, C17
.01uf	C6
.02uf	C3, C13, C14, C19
.1uf	C4, C7, C10, C11
.22uf	C12
470pf	C15

ELECTROLYTIC CAPACITORS (10 volts or more)

1uf	C5, C8, C20
10uf	C9, C16
47uf	C1
4.7uf	C18

INTEGRATED CIRCUITS

LM3900 Quad Norton Amp	IC2, IC3
CD4001 Quad Nor Gate	IC4
LM555 Timer	IC1

DIODES

1N914	D1, D2, D3

TRANSISTORS

2N3904 (NPN)	Q1, Q2, Q3, Q4

NOTE:
Q1 should be selected for the best noise generation. After selection, cut off collector lead of Q1. It will not be needed.

SWITCHES

SPST	S1, S2, S4, S5, S9
SPDT	S6, S7, S8, S10, S11, S12, S13, S14, S15
SPST Pushbutton, momemtary, norm. Open	S3

JACK

1/4 inch phone jack (mono)	J1

BATTERIES

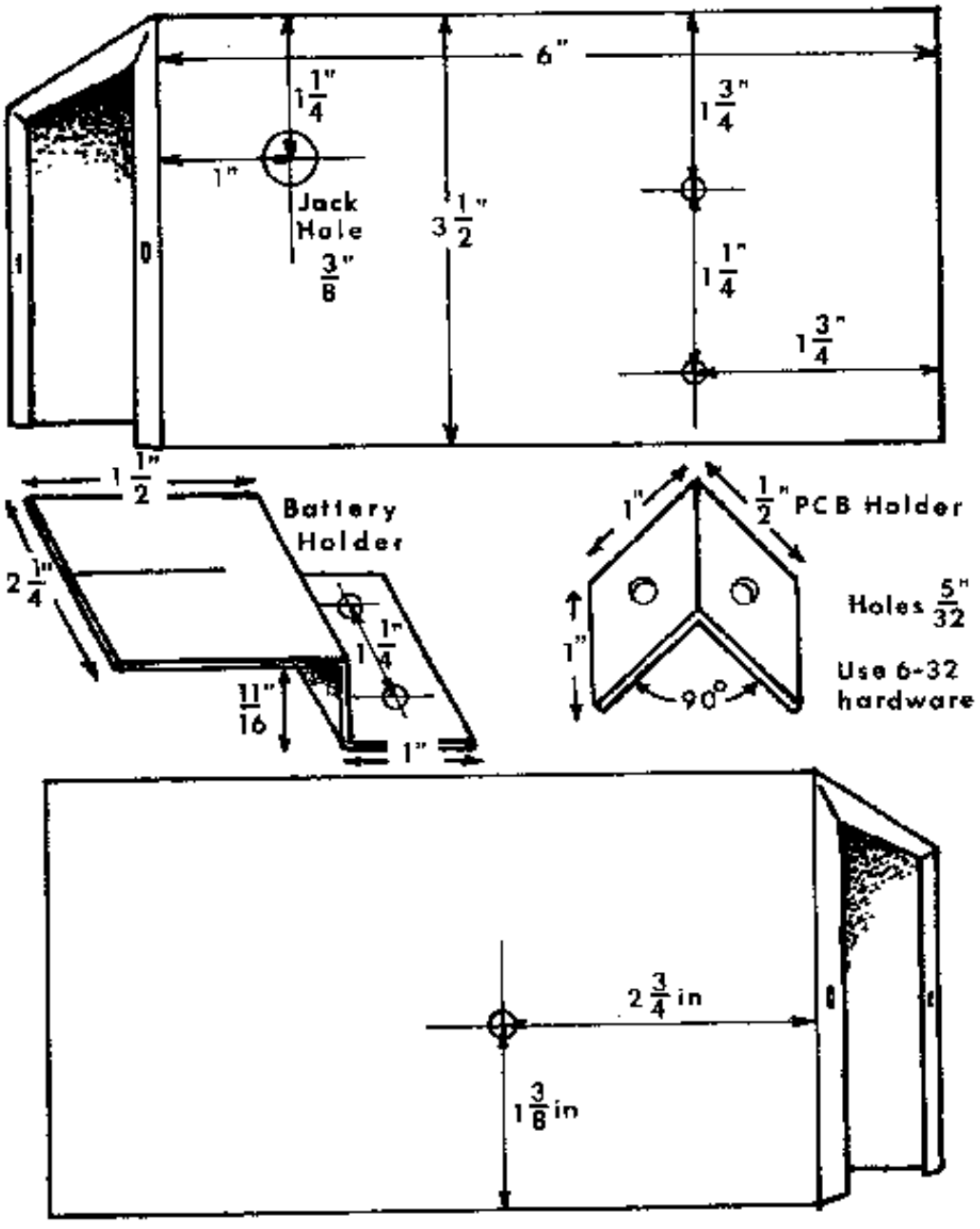
9V (Alkaline preferred)	B1, B2

RECOMMENDED ENCLOSURE

LMB Titefit #TF783 (6" X 8" X 3 1/2") (or equiv.)

MISCELLANEOUS

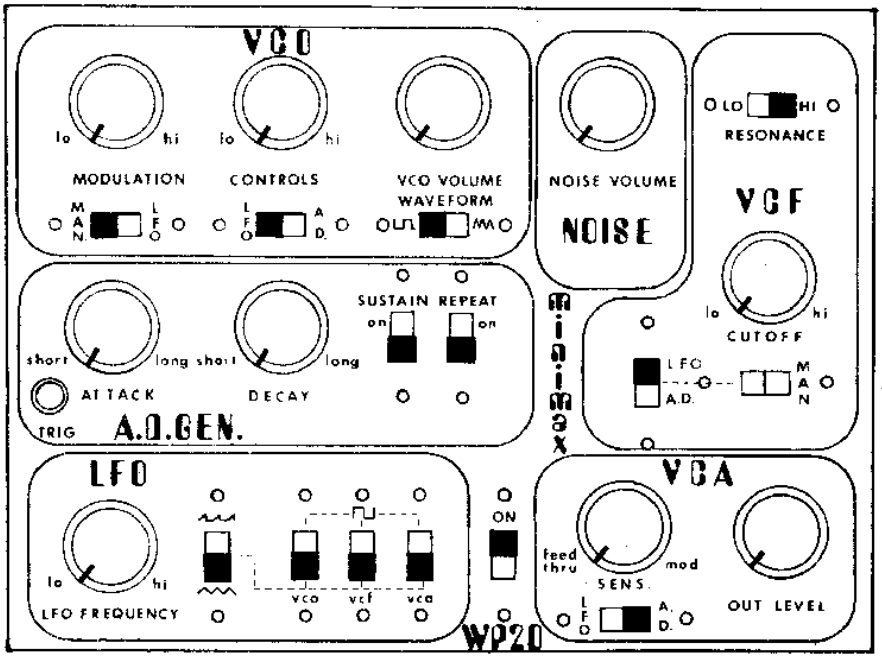
Hardware, Hookup wire, Knobs, 9V battery clips, IC sockets.


6"
1 1/4"
1"
Jack Hole 3/8"
3 1/2"
1 3/4"
1 1/4"
1 3/4"
1 1/2"
Battery Holder
2 1/4"
1 1/4"
11/16"
1"
1"
1/2" PCB Holder
1"
Holes 5/32"
Use 6-32 hardware
90°
2 3/4 in
1 3/8 in

OPERATION

NOTE If any of the following tests fail to work properly, refer to 'TROUBLESHOOTING' section.

1) Connect the WP-20 to the AUX. input of an amplifier with shielded audio cable.
2) Set controls as shown on set-up patch sheet.



3) Advance Oscillator Volume, Filter Cut Off and Output level controls to midrange.
4) Turn the left hand Modulation control slowly up and down. A tone of changing frequency should be heard.
5) Vary the left hand Modulation control and the VCF cut-off frequency. Notice the differences in pitch and timbre.
6) Advance the right hand Modulation control. The oscillator is now being modulated by the LFO.
7) Advance the LFO frequency control and experiment with the LFO switch settings.
8) Turn the right hand Modulation knob off (to the left). Move the switch below the Frequency cut off knob to the AD/LFO position. The filter is now being controlled by the LFO. Vary the LFO knob, the left hand Modulation knob and the Filter knob to make different sounds
(9) Set both the Attack and Decay knobs to the 9 o'clock position. Move the Filter select switches to the AD position. Press the Trigger button firmly and release. The filter is now being controlled by the AD generator. Change the Attack/Decay settings. Move the Sustain and Repeat switches.
(10) Turn the VCO volume off. Turn the Noise volume fully on. Set the Filter select switch back to Manual. Vary the cut off frequency knob. The sound of wind should be heard.

TROUBLESHOOTING

(1) Are both the WP-20 and the amplifier turned on Are the batteries in the WP-20 fresh?

(2) Is the WP-20 correctly connected to the AUX. input of your amplifier?
(3) Check for proper parts placement on the PC Board. Check for proper wiring between controls and board. Check for bad solder connections and shorts between copper traces on the PC Board.
(4) Replace IC3 with one that is known to be good.
(5) Replace Q4 with one that is known to be good.

SPECIFIC PROBLEMS

No sound from oscillator
See 4 and 5 above.

No noise
Is Q1 oriented correctly? Change Q1.

LFO not working
Change IC4.

Filter not working
Change Q3.
Change IC2.

VCA not working
Change Q2
Change IC2.

AD Generator not working
Change IC1.
Change D1 and D2

WP-20 MODULE DESCRIPTIONS

VCO (See figure 1)

R42 acts as a voltage level control and is fed from S14 which selects either the 9 volt supply or the LFO output. R40 performs a similar function but with voltage selected from either the A.D. generator or LFO. These voltages are mixed via R17 and R18 and fed into the noninverting input of buffer amp IC3A.

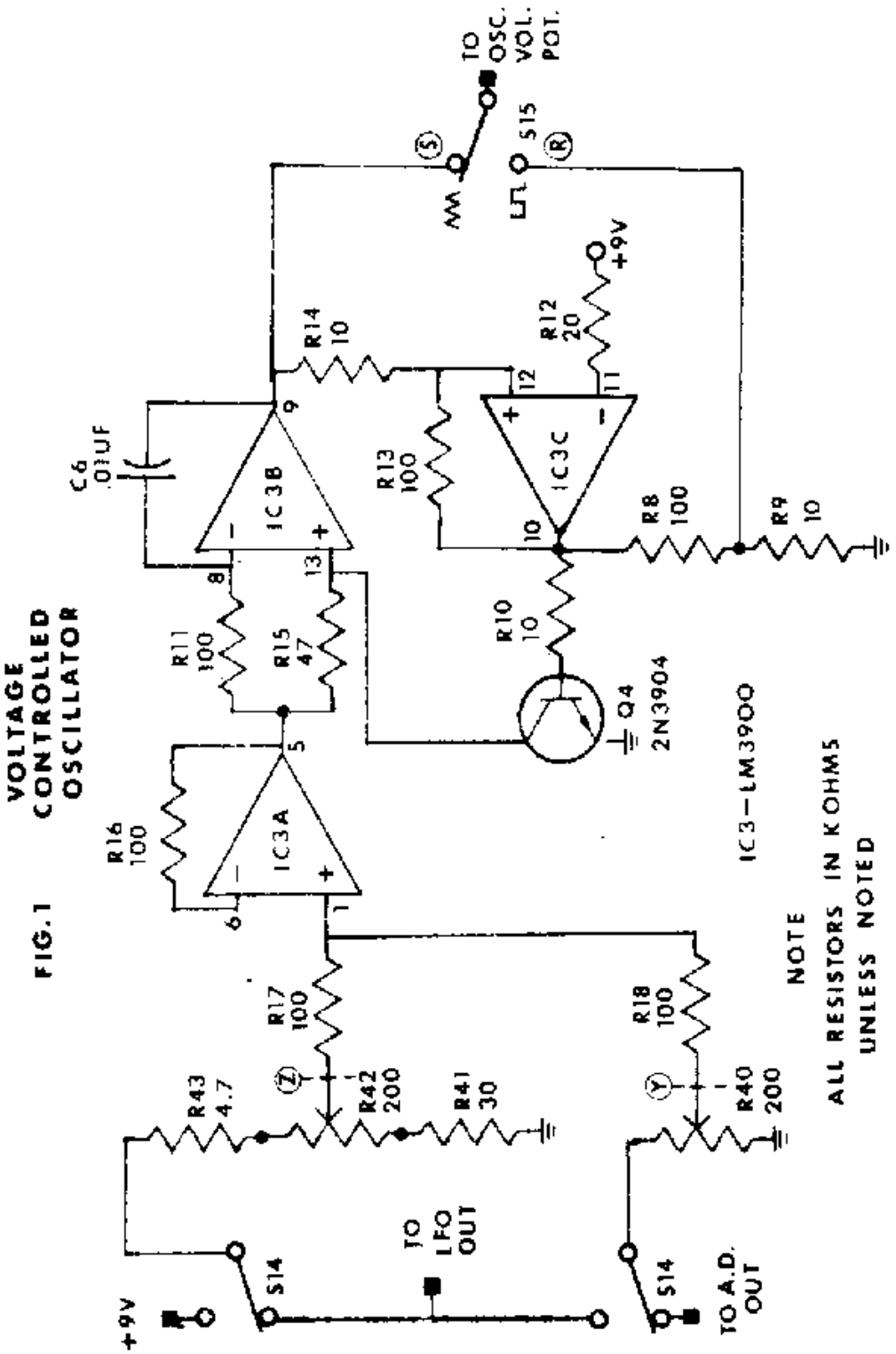
IC3B, IC3C and associated components comprise the actual oscillator. IC3B is used to integrate the DC input control voltage and IC3C is connected as a Schmitt Trigger. The output of the Schmitt Trigger controls clamping transistor Q4.

When Q4 is not conducting, current flows through R15 into the noninverting input of IC3B. This causes the output voltage to ramp up until the trip voltage for IC3C is reached. The output of IC3C now goes high turning on transistor Q4 which clamps the noninverting input of IC3B to ground. The output of IC3B now ramps down until the lower trip point of IC3C is reached. This turns Q4 off and the cycle is ready to repeat. The frequency of this waveform depends on the output voltage of IC3A. The higher this voltage, the higher the resulting current flow is through R11 and R15 causing the cycles to occur faster.

The combined action of these components produces a triangle waveform at the output of IC3B and a squarewave of the same frequency at the output of IC3C. Voltage divider R8 and R9 reduce the amplitude of the squarewave to match that of the triangle wave.

VCO Schematic

All resistors in K-ohms unless noted



ENVELOPE GENERATOR (See figure 2)
(Also referred to as Attack/Decay Generator or A.D. Generator)

The envelope generator is comprised of IC1, IC2A and associated components. IC1 (a 555 timer) is used in a modified monostable mode.

When S3 is depressed, the trigger input of IC1 (pin 2) is momentarily brought low. This causes pin 3 to go high and simultaneously turns off the internal clamping transistor which allows C2 to charge. Current flows through forward biased D1, through R36 (Attack Control) and charges C16. This voltage is fed to high impedance buffer amp IC2A whose output is fed through R2 to IC1 (pins 6 and 7). When this voltage charges to 2/3 of the power supply voltage, pin 3 goes low (it's current sinking state). Now, D2 which is forward biased, discharges C16 through R37 (Decay Control). This completes one Attack/Decay cycle. When S2 (Sustain Switch) is closed, pin 3 will stay high as long as S3 (Trigger Switch) is depressed.

For the repeat function to operate, S2 must be open and S5 (Repeat Switch) closed. This causes the Attack/Decay Generator to retrigqer itself via R32 at the end of each decay cycle. The A.D. output is taken from the output of IC2A.

AD Generator Schematic

All resistors in K-ohms unless noted

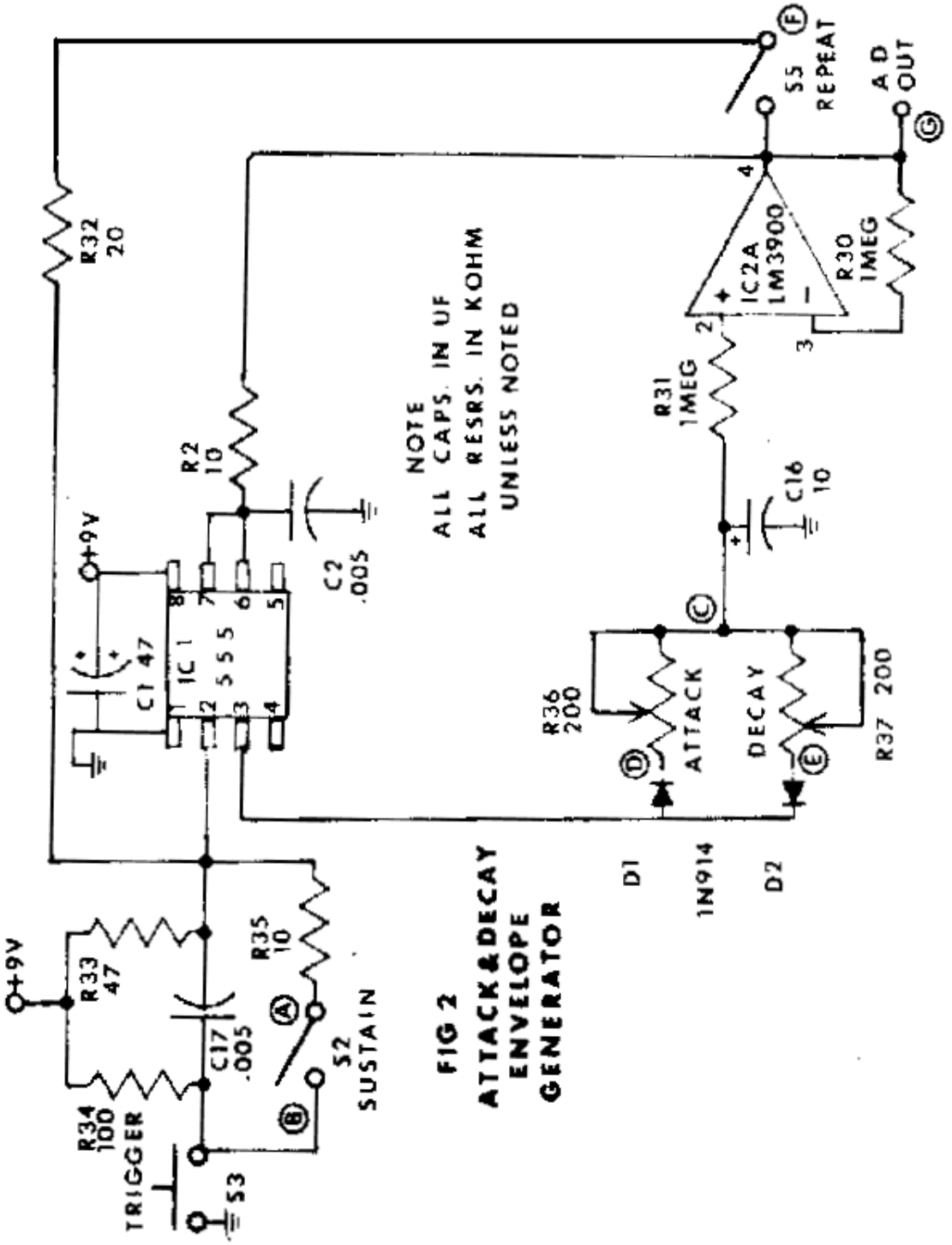


FIG 2
ATTACK&DECAY ENVELOPE GENERATOR

Low Frequency Oscillator (LFO) (See figure 3)

The Low Frequency Oscillator is comprised of IC4A, IC4B, IC4C (all CMOS NOR gates) and associated components. It produces a squarewave of about 50% duty cycle at the output of IC4C. R21 and C9 integrate the squarewave into a triangle wave. When S9 is closed, D3 quickly discharges C9 (if IC4C is low) resulting in a ramptype waveform. Switches S10, S11 and S12 distribute either the squarewave or the triangle/rampwave to the VCA, VCF and VCO modulation select switches.

LFO Schematic

All capacitors in uF unless noted
All resistors in K-ohms unless noted

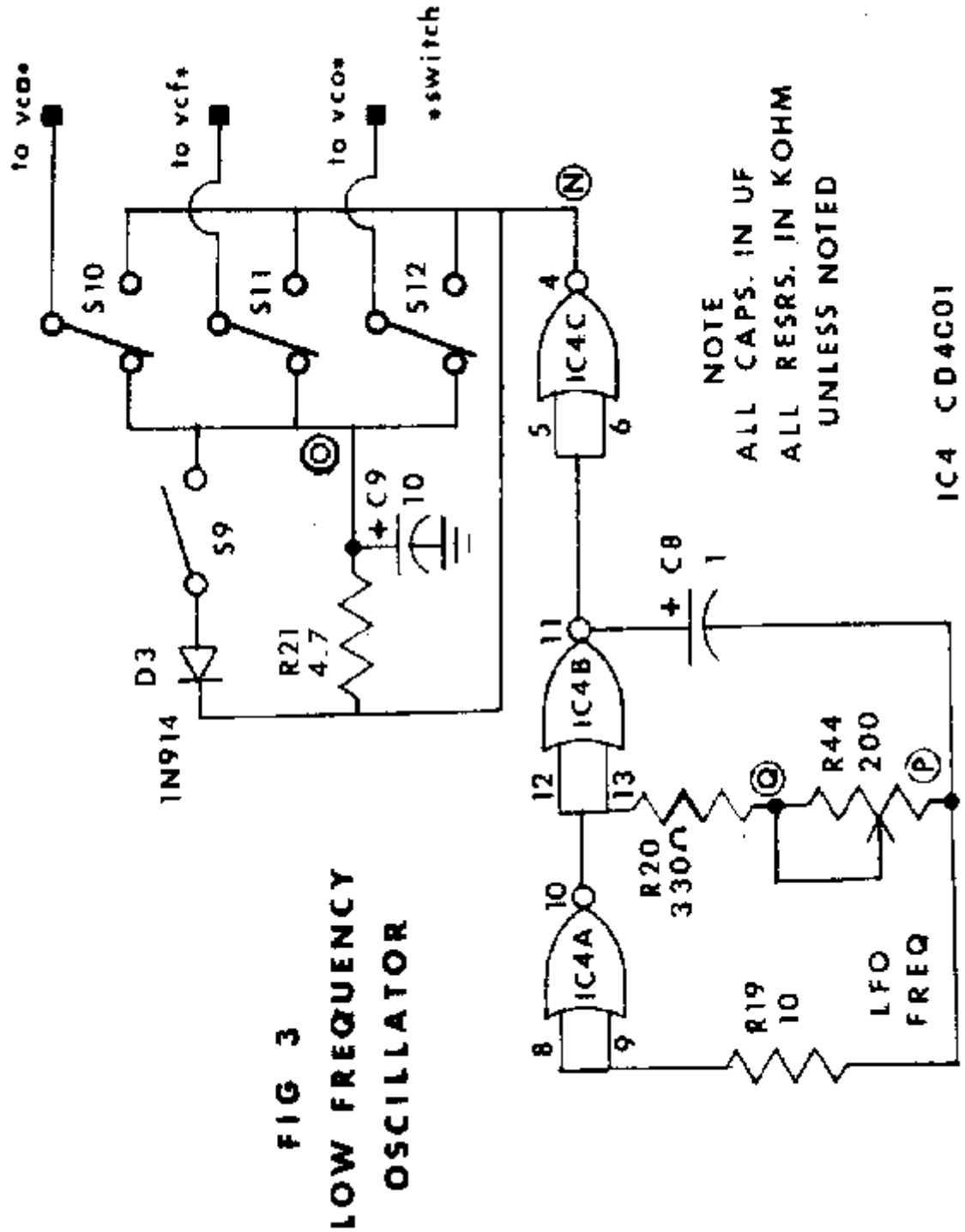


FIG 3
LOW FREQUENCY
OSCILLATOR

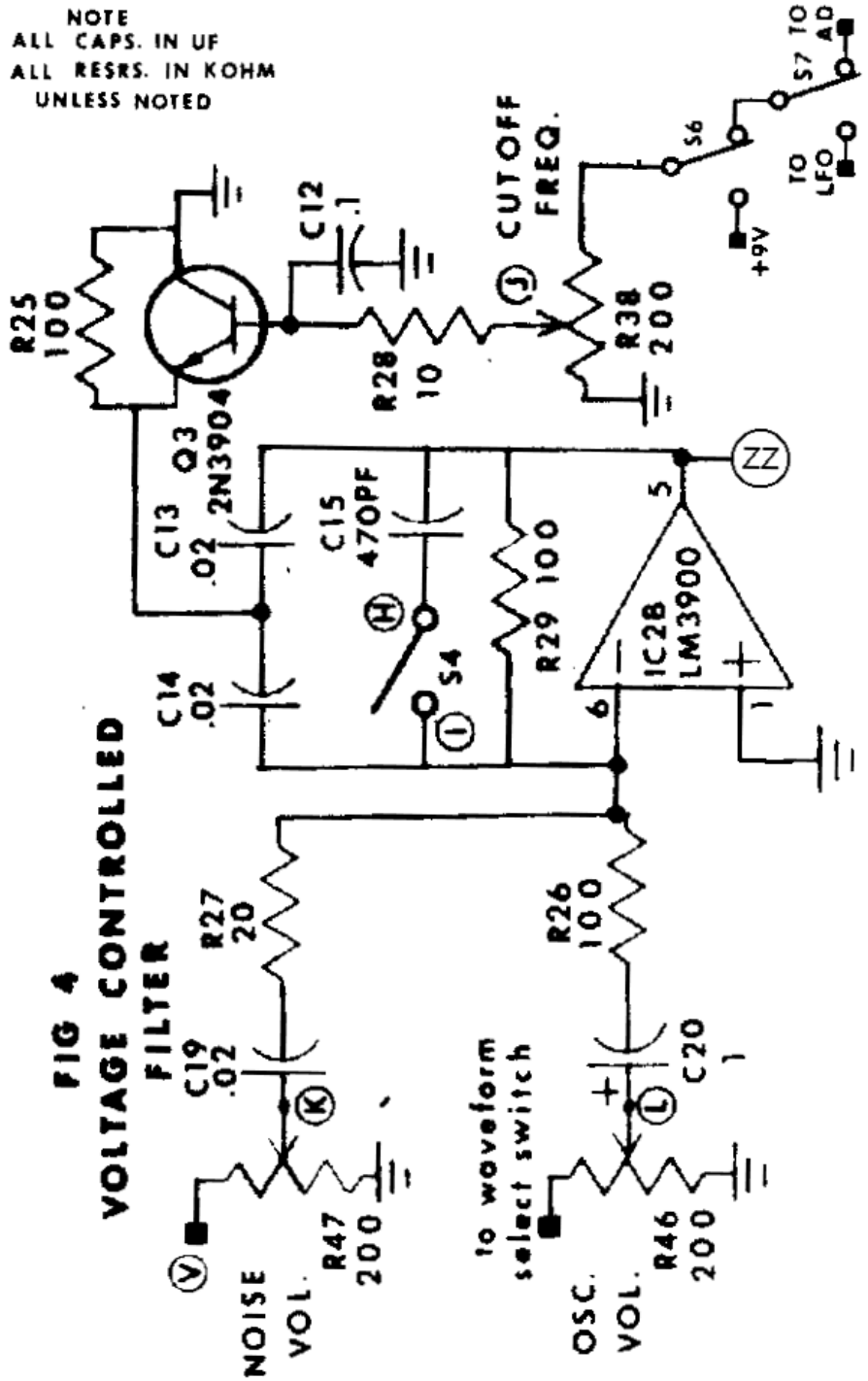
VOLTAGE CONTROLLED FILTER (VCF) (See figure 4)

IC2B and associated components from the mixing and filtering section of the WP-20. The noise signal is dropped across R47 (Noise Volume Control), picked off at the wiper and fed to the inverting input of IC2B via C19 and R27. Similarly, the VCO output is dropped across R46 (VCO Volume Pot), picked off at the wiper and is also fed to the inverting input of IC2B via C20 and R26.

C13, C14, R25 and Q3 located in the feedbackloop of IC2B perform the voltage-variable filtering function. Control voltage dropped across R38 is picked off at the wiper and current is fed through R28 to the base of Q3. As current through R28 increases the emitter to collector resistance decreases. This causes the pole frequency of the filter circuit to go up passing higher harmonics of the signal being fed in to the output. Damped oscillation inherent in the filter circuit also adds color to the sound of the waveform of the signal being fed in. When S14 is closed, C15 (470PF) is connected from the input of IC2B to it's output. This adds more damping to the circuit, reducing it's resonance.

VCF Schematic

All capacitors in uF unless noted
All resistors in K-ohms unless noted

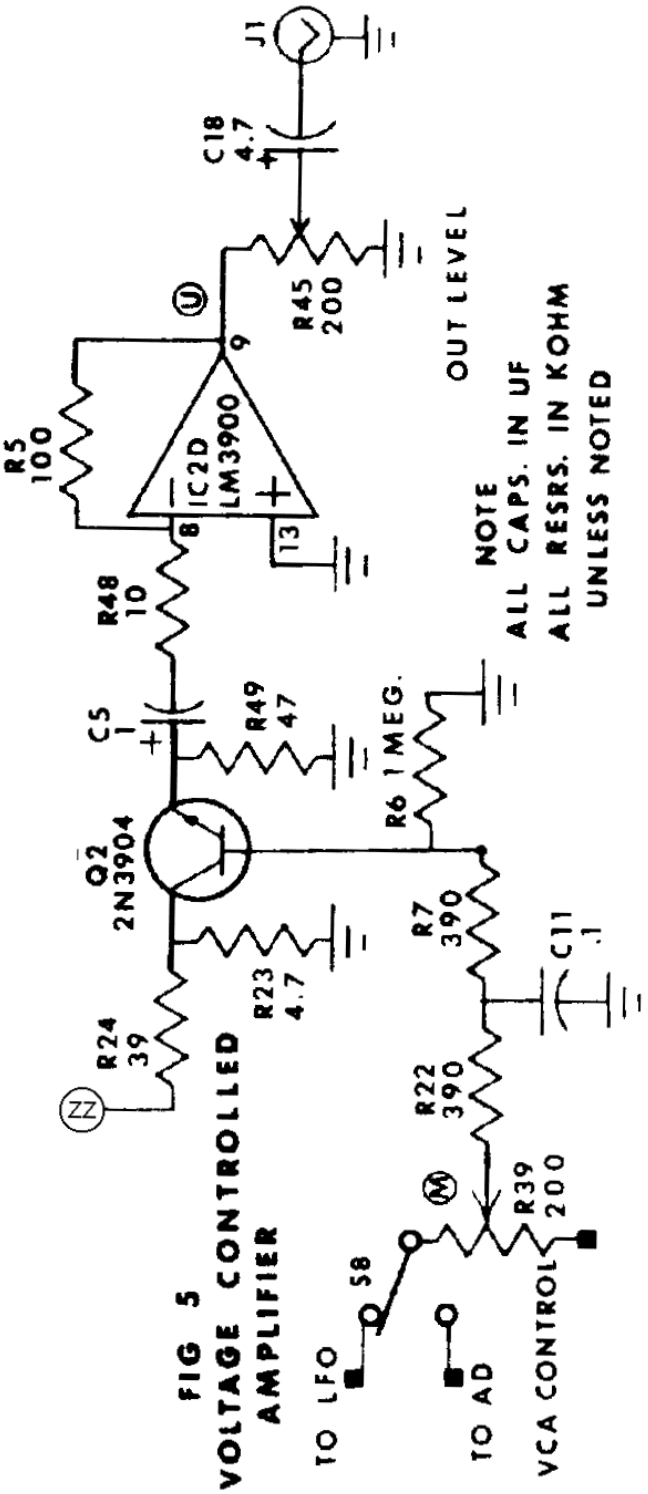


VOLTAGE CONTROLLED AMPLIFIER (VCA) (See figure 5)

The input signal to the Voltage Controlled Amplifier is fed into R24 and dropped on R23. This signal is really riding on the DC output bias of IC2B. It can pass from Q2's collector to emitter, through C5 and R48 into buffer amp IC2D if a current is being fed to Q2's base through R22 and R7. S8 selects either the LFO or A.D. outputs to modulate the amplitude of the signal being fed into IC2D when R39 is turned fully clockwise (marked 'Modulation' on front panel) Turning R39 fully counter-clockwise (toward 9 volts) , turns Q2 steadily on. The output of IC2D is dropped across R45 (Output Level Pot), picked off at the wiper and fed through C18 to the output jack.

VCA Schematic

All capacitors in uF unless noted
All resistors in K-ohms unless noted



NOISE SOURCE (See figure 6)

The noise source is a simple reverse bias junction technique. 18 volts is applied to the emitter of Q1 through R1. The base of Q1 is grounded. An avalanche effect is produced since 18 volts exceeds the emitter to base breakdown voltage of Q1. The resulting white noise signal is buffered by IC2C which has a gain of about 20. This output is fed to the Filter/Mixer circuit. (More noise gain can be achieved if necessary by changing R4 to 1meg)

POWER SUPPLY (See figure 7)

Two 9 volt batteries (preferably alkaline) in series provide 18 volts to the noise source transistor. There is no need to switch it off because current draw is only a few microamps. 9 volts from B1 switched through S1 provides power to the rest of the circuit. Average current draw of the entire circuit is about 25mA. As B1 wears down the A.D. Repeat function may not operate. When this happens, just interchange B1 and B2.

Capacitors C1, C4, C7 and Cl0 bypass to ground any spikes from IC's in the circuit which perform switching functions.

We aren't here anymore but this was our old logo (pretty fancy huh?)

Noise Generator Schematic

All capacitors in uF unless noted
All resistors in K-ohms unless noted

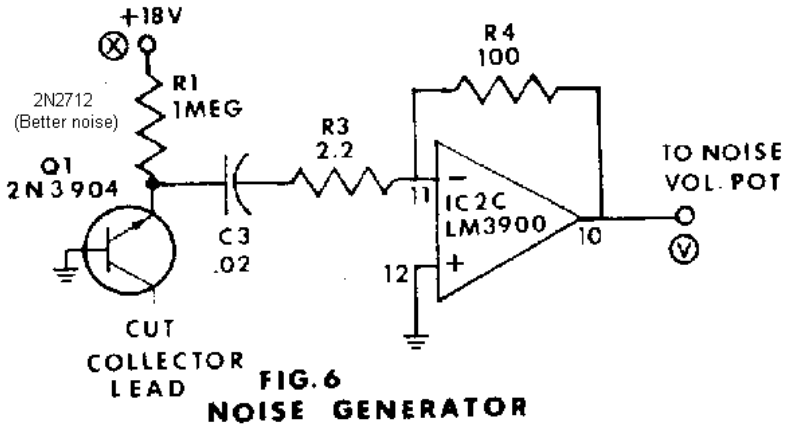


FIG. 6
NOISE GENERATOR

Power Supply Schematic

All capacitors in uF unless noted
All resistors in K-ohms unless noted

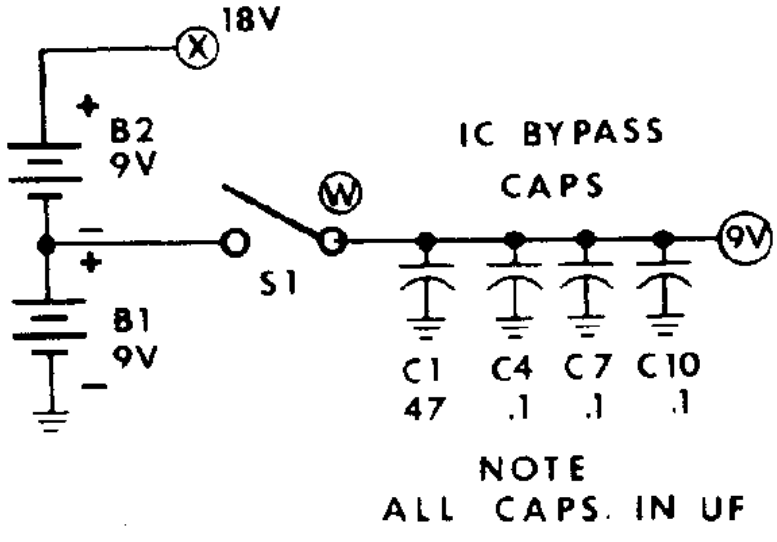
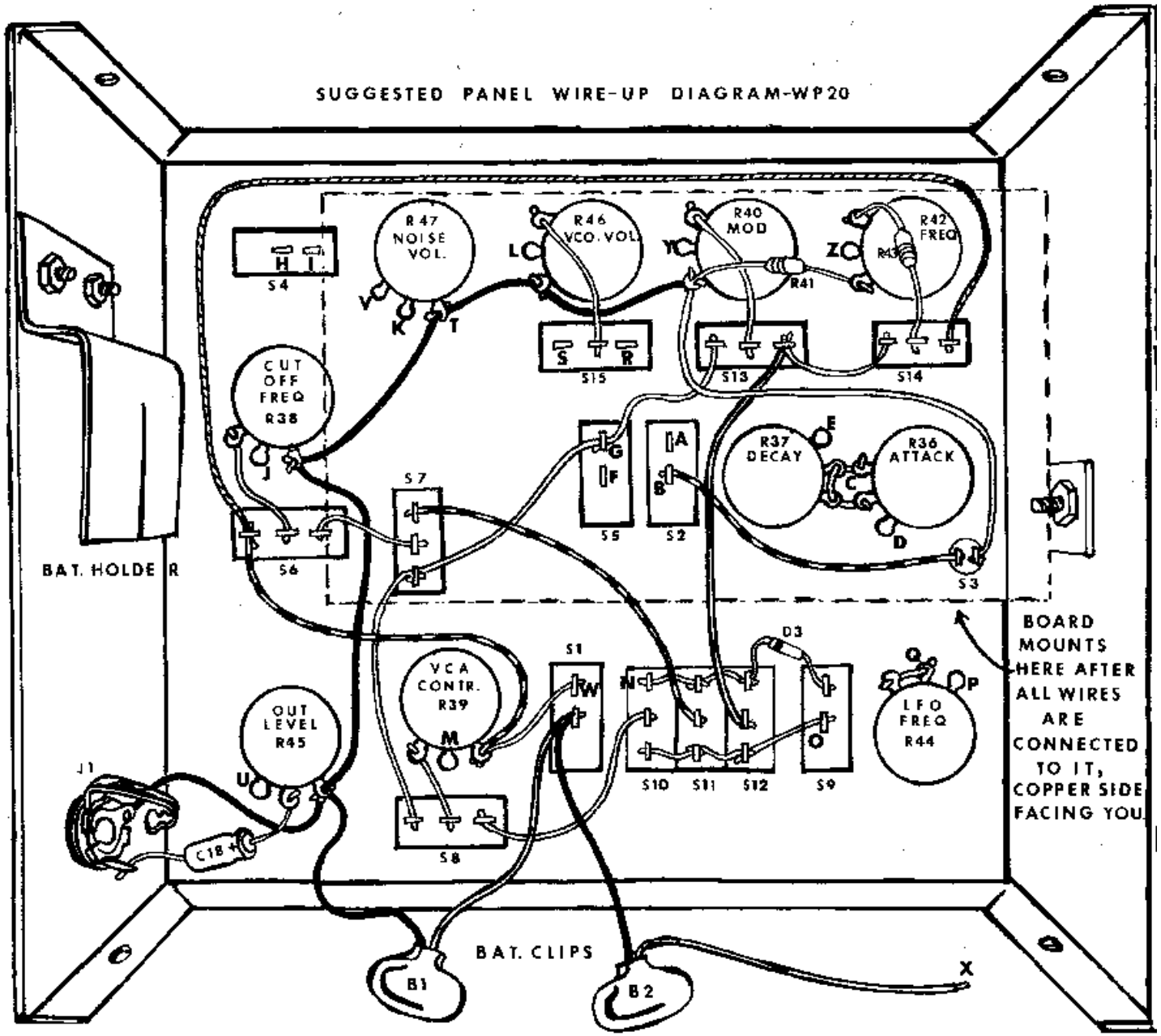
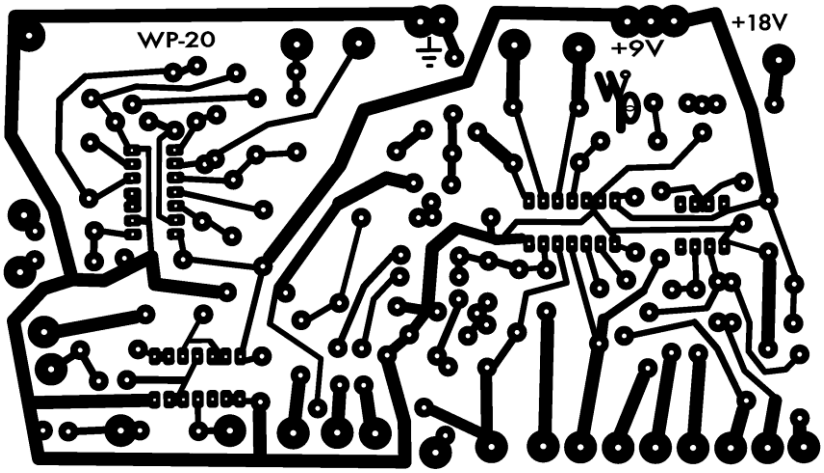
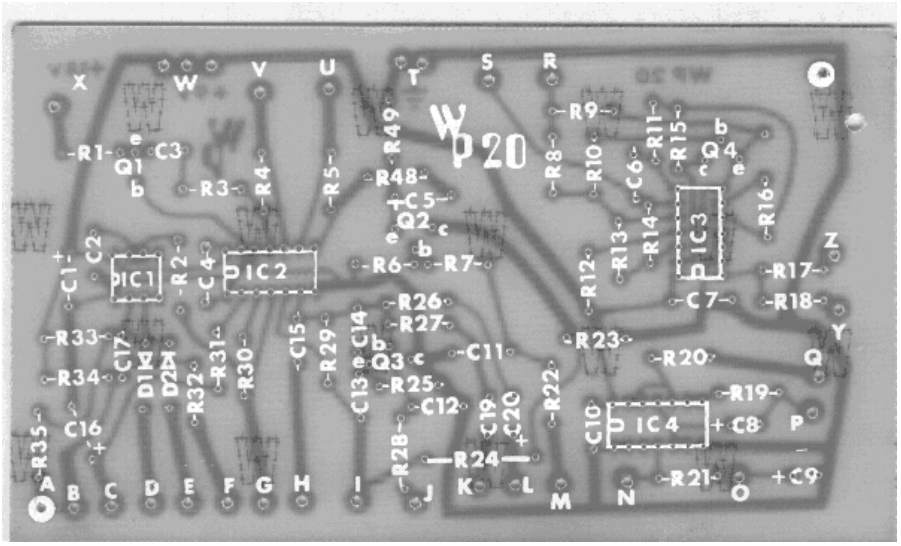


FIG 7 POWER SUPPLY


SUGGESTED PANEL WIRE-UP DIAGRAM-WP20
R47 NOISE VOL.
R46 VCO. VOL
R40 MOD
R42 FREQ
R43
R41
S4
S15
S13
S14
CUT OFF FREQ R38
S7
S6
S5
S2
R37 DECAY
R36 ATTACK
S3
BAT. HOLDER
VCA CONTR. R39
S1
D3
OUT LEVEL R45
LFO FREQ R44
S10
S11
S12
S9
S8
J1
C18
BAT. CLIPS
B1
B2
BOARD MOUNTS HERE AFTER ALL WIRES ARE CONNECTED TO IT, COPPER SIDE FACING YOU.


WP-20
+9V
+18V


WP 20
X
W
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R1
R2
R3
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R14
R15
R16
R17
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R25
R26
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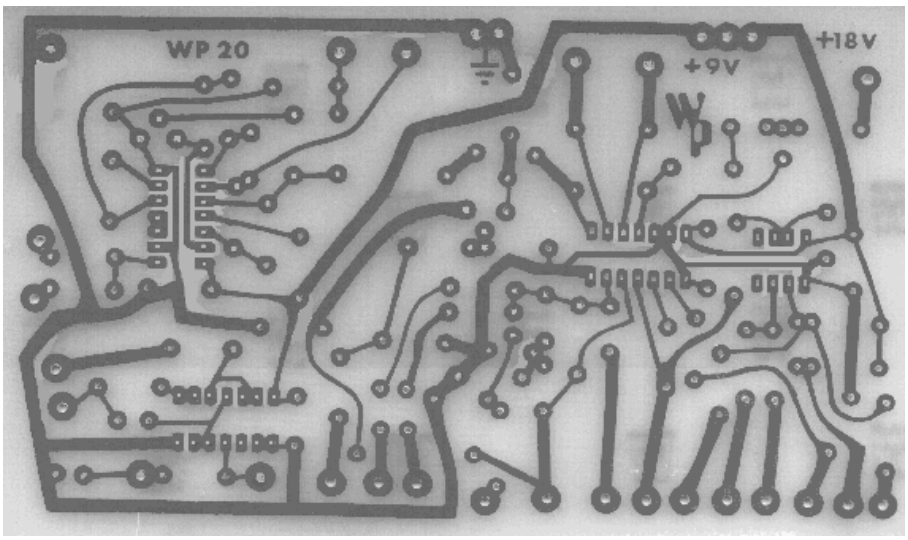
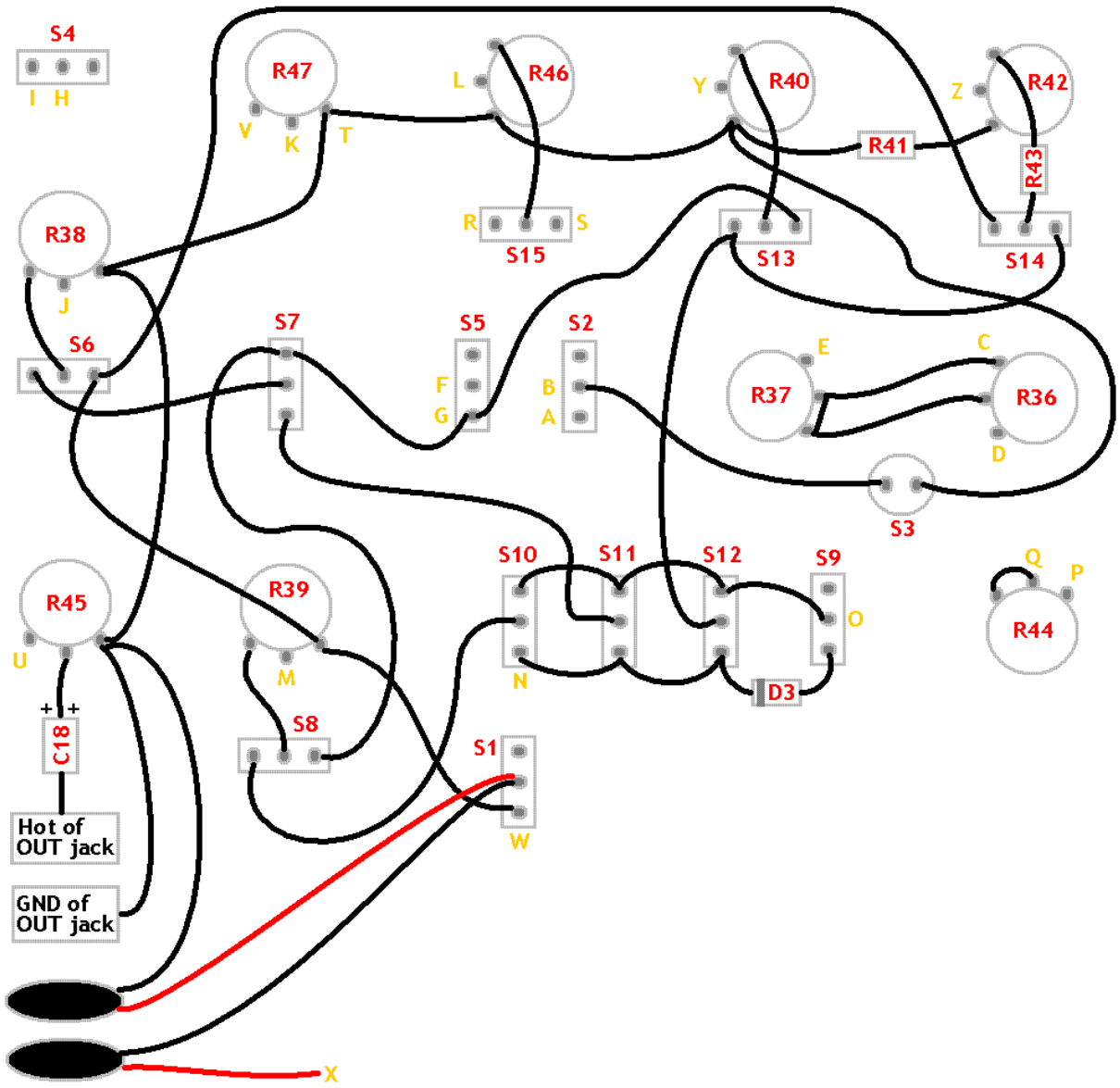
R28
R29
R31
R32
R33
R34
R35
R48
R49
C1
C2
C3
C4
C5
C6
C7
C8
C9
C10
C11
C12
C13
C14
C15
C16
C17
C19
C20
Q1
Q2
Q3
Q4
IC1
IC2
IC3
IC4
D1
D2


WP 20
+9V
+18V


S4
I H
R47
V K T
L R46
Y R40
Z R42
R41
R43
R38
J
R S
S15
S13
S14
S6
S7
S5
F G
S2
B A
E
C
R37
R36
D
S3
S10
S11
S12
S9
O
N
D3
Q P
R44
R45
U
R39
M
S8
S1
W
+ +
C18
Hot of OUT jack
GND of OUT jack
X