April 8, 1975

FREQUENCY SHIFTER BOARD #1 PRELIMINARY CIRCUIT DESCRIPTION

Board #1 contains two sections that are nearly identical. Each section is an 'all pass' phase shifter. The total amount of phase shift increases with frequency; the phase difference between the outputs of the ~~of the~~ two sections is $90 \pm 1^{\circ}$ within the frequency region 30-16kHz.

The input jack provids a signal of nominal level +2dBm, and and maximum level +12 dBm. Decoupling is provided by C1 and C7, initial bias level by resistive dividers R1-R2 and R27-R28, clamping of input spikes by diodes CR1-CR4, and suppression of VHF oscillation by C15-C18. The initial bias level is about -8 volts, and remains at that level through the chain of stages within a section. Op amps A1 and A2 are merely unity gain followers.

To check the circuit, first short out the input. The output D.C. levels should be between -6 and -9 volts and the total noise within the frequency band 20-20kHz should be less than -80 dBm. Next, apply a 1kHz signal of level ± +12 dBm. The output waveforms should be undistorted and the output levels should be within 1dB of the input. Finally set the frequency sequentially at the values 40Hz, 170Hz, 725 Hz, 3kHz, and 13kHz. Starting with the last ~~pair of~~ stage~~s~~, set the variable resistor~~s~~ for 90^{0} phas e shift at the frequency corresponding to that pair of stages. ~~Try to position the trimmer rotors so that, within a pair, one rotor is as much left of center as the other is right of center~~. Go through all five test frequencies, then repeat. Two passes should be plenty. For the time being, use a scope with no visible phase shift between XX and

Y inputs, and adjust for 90° phase shift by displaying the two board outputs on X and Y axes and adjusting for perfectly round circle.

TEST PROCEDURE
FOR
BODE FREQUENCY SHIFTER
Model 1630

BOARD 1

REFERENCE DRAWINGS:

FIG. 1 - TEST SETUP FOR CARD 1, DOME FILTER OF BODE FREQUENCY SHIFTER
SCHEMATIC DIAGRAM OF CARD 1 (DWG 08-039)
COMPONENTS ASSEMBLY DRAWING OF CARD 1 (DWG 93-137)

TEST EQUIPMENT:

POWER SUPPLY ± 15 VOLTS DC
AUDIO LEVEL METER
DC VOLTMETER
OSCILLOSCOPE WITH X AND Y INPUT
AUDIO SIGNAL GENERATOR 20-20,000 Hz
TEST ADAPTER FOR CARD 1 PER FIG. 1

PRELIMINARY STEPS:

1. CONNECT TEST EQUIPMENT WITH TEST ADAPTER FOR CARD 1, AS SHOWN IN FIG. 1.

2. SET SUPPLY VOLTAGES OF POWER SUPPLY TO WITHIN .25 VOLTS. OF +15 AND -15 VOLTS DC.

3. TURN OFF POWER SUPPLY.

4. PLUG TEST ADAPTER INTO CARD 1, AND TURN ON POWER SUPPLY.

TEST STEPS AND ADJUSTMENTS:

1. SHORT OUT THE INPUT BY SETTING SWITCH SW4 IN GND POSITION.

2. READ OUTPUT DC LEVELS WITH SWITCH SW3 IN POSITIONS X AND Y. THESE LEVELS SHOULD BE WITHIN $\pm$1.5 VOLTS OF 7.5 VOLTS BIAS. OPTIONAL TEST WITH SWITCH SW3 IN POSITION Z1. FOR PROBING THE DC LEVELS AT THE EMITTERS OF ALL NPN TRANSISTORS THROUGHOUT THE TWO PHASE SHIFTER CHAINS. THESE DC LEVELS SHOULD ALSO BE AROUND 7.5 VOLTS.

3. CHECK NOISE (SWITCH SW4 STILL GROUNDED) WITH SWITCH SW2 IN POSITIONS X AND Y. THE TOTAL NOISE LEVEL WITHIN THE FREQUENCY BAND OF 20 TO 20,000 Hz SHOULD BE LESS THAN -80 dBm.

4. APPLY A 1 kHz SIGNAL OF LEVEL + 12 dBm TO THE INPUT OF CARD 1. THE OUTPUT WAVEFORMS SHOULD BE UNDISTORTED (SW1 IN POSITIONS B OR C) AND THE OUTPUT LEVELS SHOULD BE WITHIN 1 dB OF THE INPUT (SW2 IN POSITIONS X AND Y VS. Z).

5. SET THE FREQUENCY SEQUENTIALLY AT 40 Hz., 170 Hz., 725 Hz., 3080 Hz, and 13090 Hz. SET SWITCH SW1 IN POSITION A. STARTING WITH THE LAST PAIR OF STAGES, SET THE VARIABLE RESISTOR FOR 90^{o}PHASE SHIFT AT THE FREQUENCY CORRESPONDING TO THAT PAIR OF STAGES.

GO

THROUGH ALL FIVE TEST FREQUENCIES, THEN REPEAT. TWO PASSES SHOULD BE PLENTY. FOR THE TIME, USE A SCOPE (WITH SWITCH SW1 IN POSITION A) WITH NO VISIBLE PHASE SHIFT BETWEEN X AND Y INPUTS, AND ADJUST FOR 90° PHASE SHIFT BY DISPLAYING THE TWO BOARD OUTPUTS ON X AND Y AXES AND ADJUSTING FOR PERFECTLY ROUND CIRCLE.

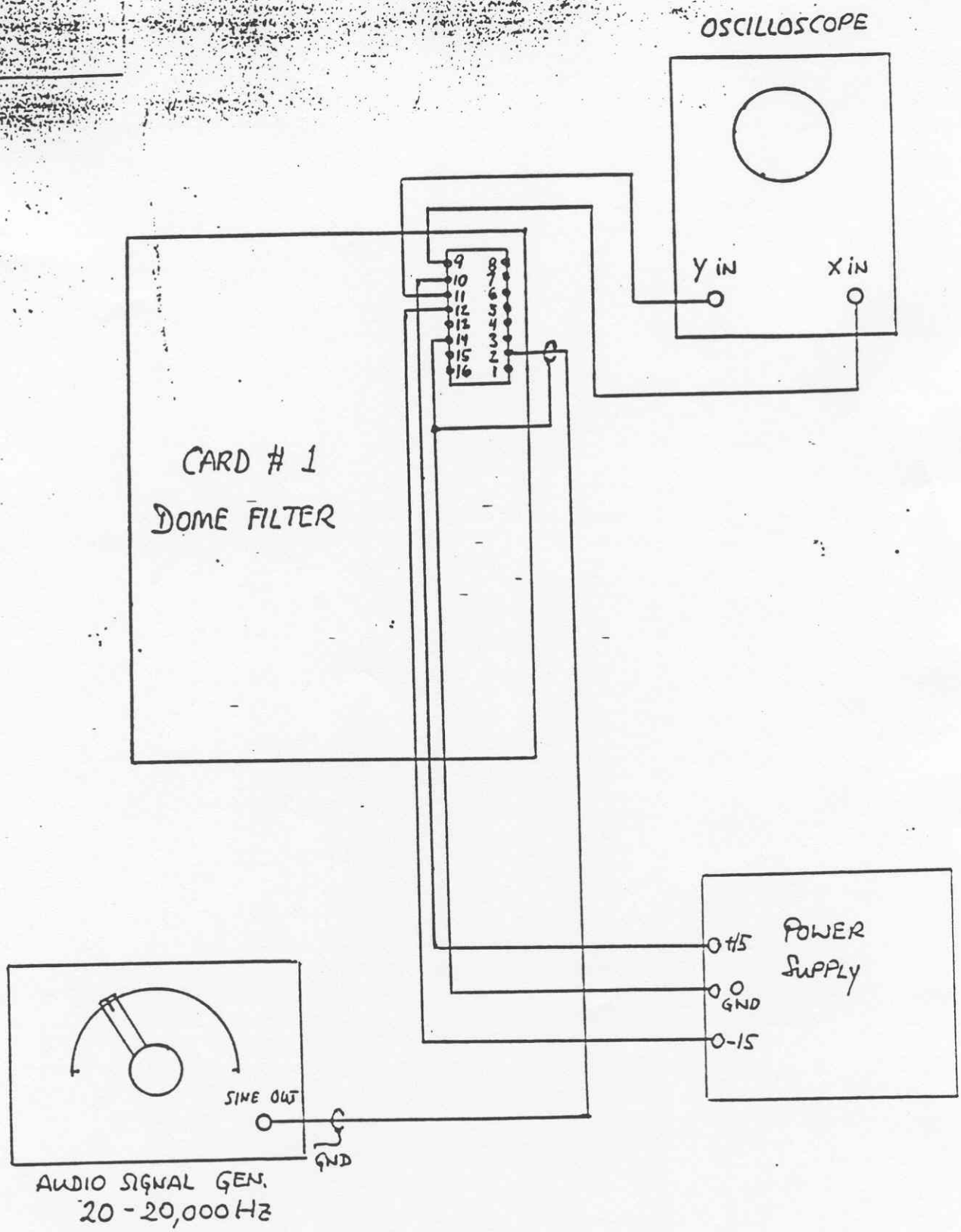
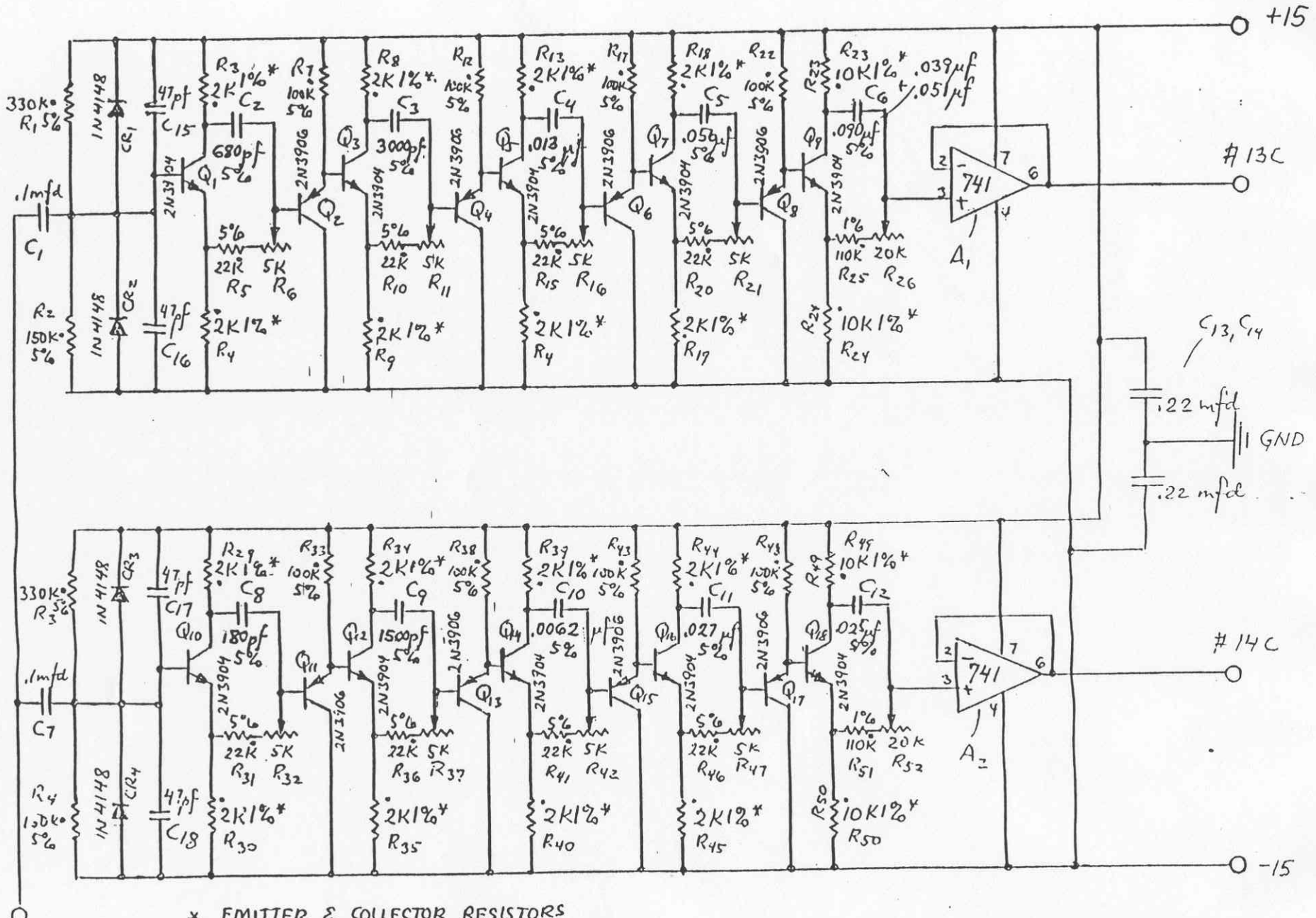


Fig. 1. TEST SETUP FOR CARD # 1, DOME FILTER OF BODE FREQUENCY SHIFTER

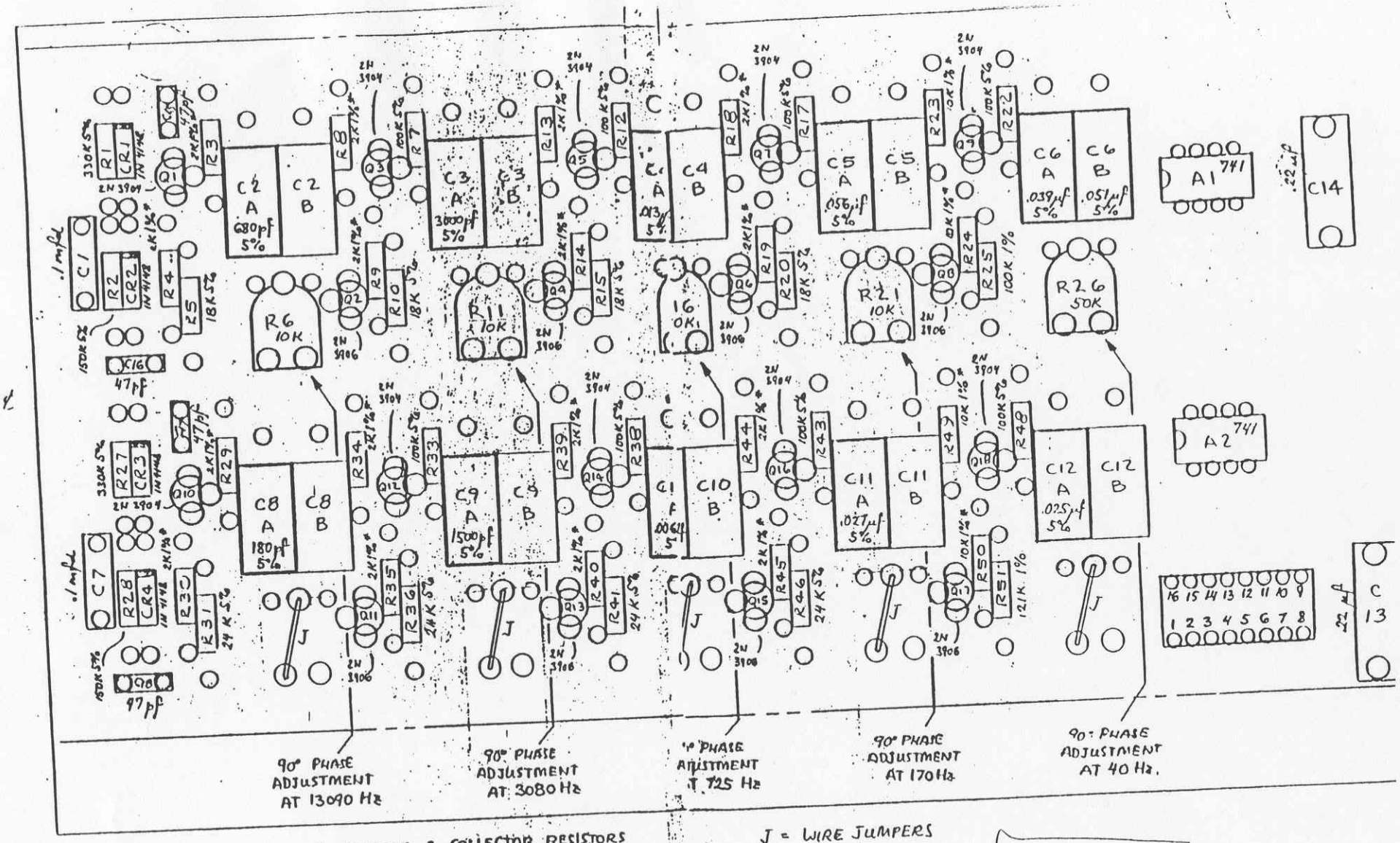
H. Bode
7-15-74



* EMITTER & COLLECTOR RESISTORS MATCHED IN PAIRS FOR .1% TRACKING

5/14/74

CARD # 1


90° PHASE ADJUSTMENT AT 13090 Hz
90° PHASE ADJUSTMENT AT 3080 Hz
90° PHASE ADJUSTMENT AT 725 Hz
90° PHASE ADJUSTMENT AT 170 Hz
90° PHASE ADJUSTMENT AT 40 Hz.
* EMITTER & COLLECTOR RESISTORS MATCHED IN PAIRS FOR 1% TRACKING.
J = WIRE JUMPERS
CARD # 1
91-137

April 8, 1974

FREQUENCY SHIFTER BOARD #2 PRELIMINARY CIRCUIT DESCRIPTION

Board #2 contains +10 and -10 volt regulators, control voltage adder, exponential converter, squelch circuit, and variable frequency oscillator.

The +10 volt regulator is a conventional 723 circuit with fixxed voltage divider R1-R2 and no current limiting. Its function, as well as the voltage regulator on Board #3, is to isolate the two oscillators as much as possible so they do not lock. The circuitry consisting of A2, Q1 and associated components comprises a tracking regulator. The circuitry keeps the voltage at the junction of R3 and R4 very near ground. Since R3 is equal to R4 and one end of R3 is connected to the +10 supply, the end of R4 connected to the emitter of Q1 sets itself to -10 volts.

A6 and surrounding resistors comprise a control voltage adder. The free end of R23 goes to the wiper arm of the main AMOUNT OF SHIFT panel control, and therefore varies between -10 and +10 volts. The free ends of R25, R26, and R27 go to the three control input jacks. The added output is applied through R5 to the exponential converter circuit.

The exponential converter circuit is similar to that of the Mini. A3 and assicated circuitry produce a voltage at the wiper arm of R10 that increases by approximately 18.7 millivolts whenever the AMOUNT OF SHIFT panel control wiper arm changes two volts, or whenever any of the control inputs changes one volt.

As can be seen from the schematic, the voltage at the wiper arm of R10 is applied to one base of a transistor pair. The other transistor of this pair is kept running at a constant current of slightly under 30 microamperes. When the current through this transistor is not such that the voltage across R14 is +10 volts, then A5 produces an error signal. The error signal is fed through R21 and R20 to a third transistor (pins 12, 13, and 14 of the CA 3046). This third transistor supplies the total operating current to the transistor pair. Thus, even though the left hand transistor of the pair may change drastically in operating current, the current through the right hand transistor remains relatively constant. For every 18.7 millivolts increase at the base of the left-hand transistor, the collector current will double. This collector current is provided by A4 through R12. A4 acts to keep the collector of the left-hand transistor at ground voltage, just as A5 acts to keep the collector of the right-hand transistor at ground voltage. As the current through the collector of the left-hand transistor increases, the output of A4 increases proportionally. Thus, an 18.7 millivolt increase at the base of the left-hand transistor results in the doubling of the voltage at the output of A4. This voltage goes through precision resistor R17 to the RANGE panel switch. In this circuit, C2 suppresses RF, C3 and C4 suppress oscillation, and R6 has a positive temperature coefficient to correct for temperature-dependent behaviour of the transistor pair.

To adjust the exponential converter, proceed as follows: Set the AMOUNT OF SHIFT panel control to midposition (zero volts to R23) Set R57, R10, R13, and R16 to midposition. Measure the output of A4. It should be about 140 millivolts. Adjust R57 so that the output of A4 is something convenient, say 150 millivolts or so. Next apply a +2.000 volt step to R25, 26, OR 27. Adjust R10 so the output of A4 exactly quadruples. Now remove the +2.000 volt step and apply a -5.000 volt step. Adjust R16 so that the output of A4 is 5 ± 1 millivolts. Finally, remove the -5.000 volt step and apply a +5.000 volt step. Adjust R13 so that the output of A4 changes by a factor of 32 as the +5.000 volt step is alternately applied and removed. Final adjustment of these controls will have to be done once the board is in the actual module.

A9 is simply an inverting buffer on the RANGE switch. It is called into effect whenever the RANGE switch is on one of the LINEAR positions. Note that the low frequency compensation adjustment R16 in the exponential converter in effect compensates for the offset in A9, as well as the offset in A4. This is because either A4 or A9 feeds control voltage to the variable oscillator.

The audio input, in addition to going to the all-pass phase shifter on Board #1, also goes to A7. Diodes Cr2 and CR3 clamp the input of A7 and prevent it from being zapped by audio signals greater than ± 5 volts. CR3,4,5,6 form a full wave bridge. For signal levels at the input of A7 greater than a few millivolts, a full wave rectified signal appears at the bridge output. The full-wave rectified signal is amplified by A8 and charges up C7

through R38 and CR7. As the audio signal increases, the D.C. voltage at point A (junction of CR7 and C7) rapidly goes to about -7.5 volts, then saturates. This voltage is applied to the base of Q4 which then turns on and supplies operating current for A13. The magnitude of this operating current is determined by the drop across R36. This same drop across R36 also turns on Q3, thus lighting up the squelch LED on the front panel.

The variable frequency oscillator consists of current source A10, follower A11, and Schmitt trigger A12. A10 charges capacitor C9. The direction of the current is determined by the polarity of the voltage at pin 3, while the magnitude of the current is determined by the voltage across R47-R48. C9 charges, and A11 follows its voltage, until the voltage at pin 2 of A12 crosses the voltage at pin 3 and A12 flips the sign of its output. The output of A12 thus switches between +10 and -10. The setting of R52 determines the voltage to which C9 has to charge, and therefore determines the oscillator's frequency range. To set R52, ground both the free end of R44 and the junction of R48 and R49. Then set R52 so the frequency is 20.00 kHz. A voltage change of 2.50 volts at the junction of R48 and R49 will change the frequency by 5 kHz. A voltage change of 10 volts at the free end of R44 will change the oscillatorfrequency about 400 Hz. C8 bypasses any RF or stray signal from the fixed oscillator on Board #3.

The triangular output of A11 is fed to Buffer A13 through resistive divider R55-56. The level at the input of A13 is on the order of 100 mv. peak. This level is enough to slightly overdrive A13 and give a quasi-sine wave at the output

TEST PROCEDURE
FOR
BODE FREQUENCY SHIFTER
Model 1630

BOARD 2

REFERENCE DRAWINGS:

FIG. 2 - TEST SETUP FOR CARD 2, VARIABLE OSCILLATOR (INCLUDING +10 AND -10 VOLT REGULATORS, CONTROL VOLTAGE ADDER, EXPONENTIAL CONVERTER AND SQUELCH CIRCUIT) OF BODE FREQUENCY SHIFTER
SCHEMATIC DIAGRAM OF CARD 2 (DWG 08-040)
COMPONENTS ASSEMBLY DRAWING OF CARD 2 (93-139)

TEST EQUIPMENT:

POWER SUPPLY +15 AND -15 VOLTS DC
VARIABLE CONTROL VOLTAGE SOURCE
DC VOLTMETER
FREQUENCY COUNTER
OSCILLOSCOPE
AUDIO SIGNAL GENERATOR 20-20,000 Hz
TEST ADAPTER FOR CARD 2 INCLUDING TEST CIRCUIT AS SHOWN IN FIG. 2

PRELIMINARY STEPS:

1. CONNECT TEST EQUIPMENT WITH TEST CIRCUIT AND TEST ADAPTER FOR CARD 2, AS SHOWN IN FIG. 2.

2. SET SUPPLY VOLTAGES OF POWER SUPPLY TO WITHIN .25 VOLTS OF +15 AND -15 VOLTS DC.

3. TURN OFF POWER SUPPLY.

4. PLUG TEST ADAPTER INTO CARD 2, AND TURN ON POWER SUPPLY (AFTER CHECKING FOR CORRECT ORIENTATION OF PLUGS).

TEST STEPS AND ADJUSTMENTS:

1. ADJUSTMENT OF EXPONENTIAL CONVERTER

A. SET THE AMOUNT OF SHIFT PANEL CONTROL TO MID-POSITION (ZERO VOLTS TO R23 OR AT TERMINAL 8A). SET R57, R10, R13 AND R16 TO MID-POSITION. MEASURE OUTPUT OF A4 (TERMINAL 6B). IT SHOULD BE ABOUT 140 MILLIVOLTS.

B. ADJUST R57 SO THAT THE OUTPUT OF A4 (TERMINAL 6B) IS SOMETHING CONVENIENT, SAY 150-MILLIVOLTS OR SO.

+2.000 C. APPLY A +2000 VOLT STEP TO R25, R26, OR R27 (TERMINALS 4A, 5A, or 6A). ADJUST R10 SO THAT OUTPUT OF A4 (6B) EXACTLY QUADRUPLES. .600

-2.000 -5.000 D. REMOVE THE +2000 VOLT STEP AND APPLY A -5000 VOLT STEP. ADJUST R16 SO THAT THE OUTPUT OF A4 (6B) IS 5±1mv. .005

-5.000 +5.000 E. REMOVE THE -5000 VOLT STEP AND APPLY A +5000 VOLT STEP. ADJUST R13 SO THAT THE OUTPUT OF A4 (6B) CHANGES +5.000 BY A FACTOR OF 32 AS THE +5000 VOLT STEP IS ALTERNATELY APPLIED AND REMOVED. 4.800

FINAL ADJUSTMENT OF THESE CONTROLS WILL HAVE TO BE DONE ONCE THE BOARD IS IN THE FINAL MODULAR ASSEMBLY.

2. ADJUSTMENT OF OSCILLATOR FREQUENCY

A. THE SETTING OF R52 DETERMINES THE FREQUENCY RANGE

OF THE OSCILLATOR. TO SET R52, GROUND BOTH THE FREE END OF R44 (BY TURNING THE ZERO ADJUST CONTROL TO GROUND POSITION) AND THE JUNCTION OF R48 AND R49 (BY SETTING SWITCH SW1 IN POSITION C). THEN SET R52 SO THE FREQUENCY IS 20,000 kHz. O (zeeo)

B. A VOLTAGE CHANGE OF 2.50 VOLTS AT THE JUNCTION OF R48 AND R49 (SWITCH SW1 IN POSITION A WITH CONTROL VOLTAGE OF 2.50 VOLTS APPLIED TO CORRESPONDING INPUT) WILL CHANGE THE FREQUENCY BY 5 kHz. SKIP

C. A VOLTAGE CHANGE OF 10 VOLTS AT THE FREE END OF R44 (SETTING OF ZERO ADJUST POTENTIOMETER IN +10 VOLT POSITION) WILL CHANGE THE OSCILLATOR FREQUENCY ABOUT 400 Hz.

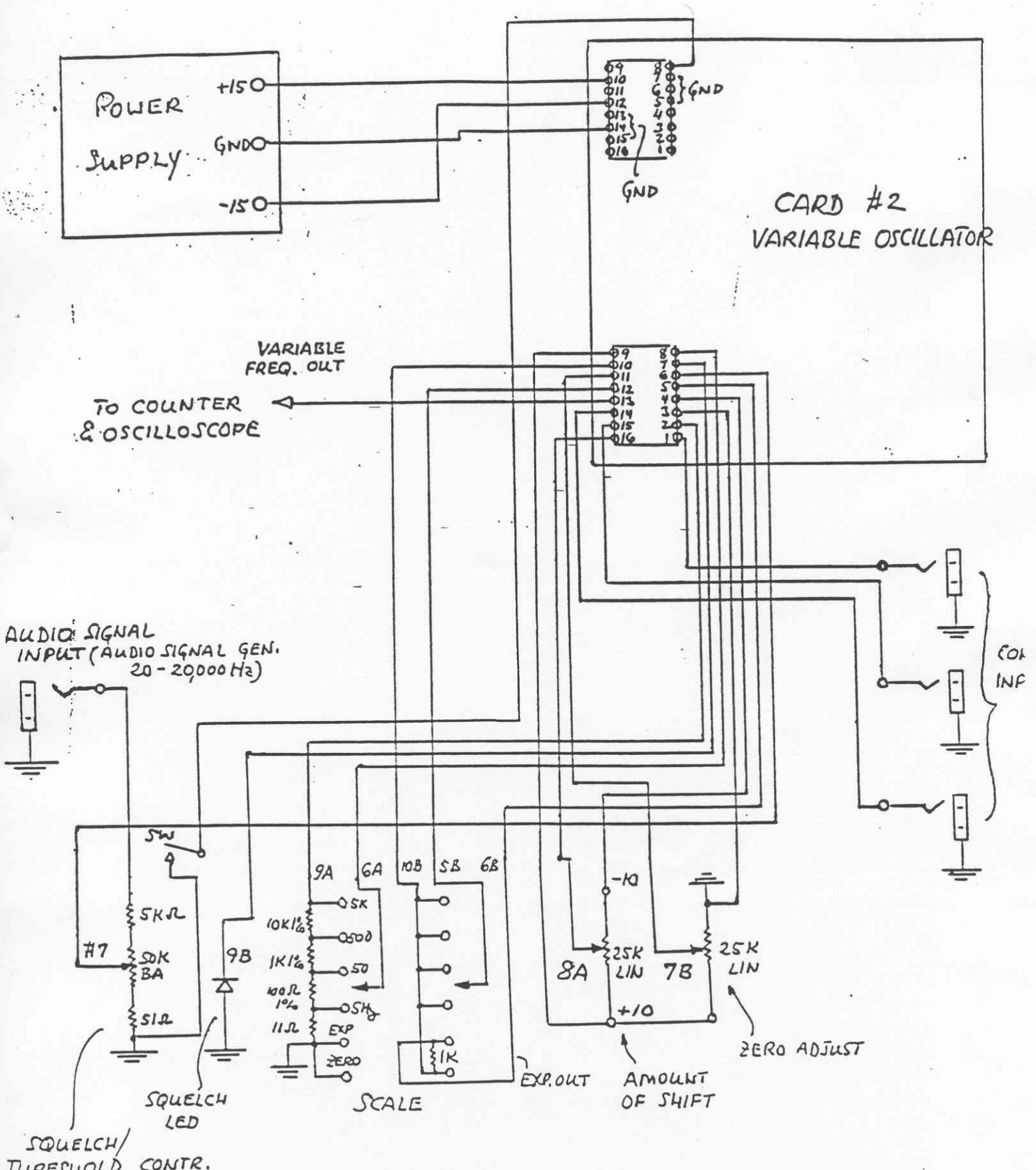
D. THE LEVEL OF A TRIANGULAR WAVEFORM AT THE INPUT OF A13 IS IN THE ORDER OF 100 mv PEAK. SKIP

E. A CLIPPED ("QUASI-SINE") WAVE WILL BE OBSERVED AT THE OUTPUT OF A13 (TERMINAL 9C), WHEN A13 IS TURNED ON THROUGH A BIAS VOLTAGE OF ABOUT -7.5 VOLTS, WHICH IS SUPPLIED THROUGH THE SQUELCH CIRCUIT, WHEN AN AUDIO SIGNAL IS SUPPLIED TO INPUT #7.

3. PERFORMANCE OF THE SQUELCH CIRCUIT

THE AUDIO INPUT IN ADDITION TO GOING TO THE ALL-PASS PHASE SHIFTERS ON BOARD 1, ALSO GOES TO A7 (TERMINAL 7).

DIODES CR2 AND CR3 CLAMP THE INPUT OF A7 AND PREVENT IT FROM BEING ZAPPED BY AUDIO SIGNALS GREATER THAN ± 5 VOLTS. CR3,4,5, and CR6 FORM A FULL WAVE BRIDGE. FOR SIGNAL LEVELS AT THE INPUT OF A7 GREATER THAN A FEW MILLIVOLTS, A FULL WAVE RECTIFIED SIGNAL APPEARS AT THE BRIDGE OUTPUT. THE FULL-WAVE RECTIFIED SIGNAL IS AMPLIFIED BY A8 AND CHARGES UP C7 THROUGH R38 AND CR7. AS THE AUDIO SIGNAL INCREASES, THE DC VOLTAGE AT THE JUNCTION OF CR7 AND C7 RAPIDLY GOES TO ABOUT -7.5 VOLTS, THEN SATURATES. THIS VOLTAGE IS APPLIED TO THE BASE OF Q4, WHICH THEN TURNS ON AND SUPPLIES OPERATING CURRENT FOR A13. THE MAGNITUDE OF THIS OPERATING CURRENT IS DETERMINED BY THE DROP ACROSS R36. THIS SAME DROP ACROSS R36 ALSO TURNS ON Q3, THUS LIGHTING UP THE SQUELCH LED ON THE FRONT PANEL.



TEST SETUP FOR CARD # 2, VARIABLE OSCILLATOR OF BODE FREQUENCY SHIFTER.

Fig. 2.

H. Bode
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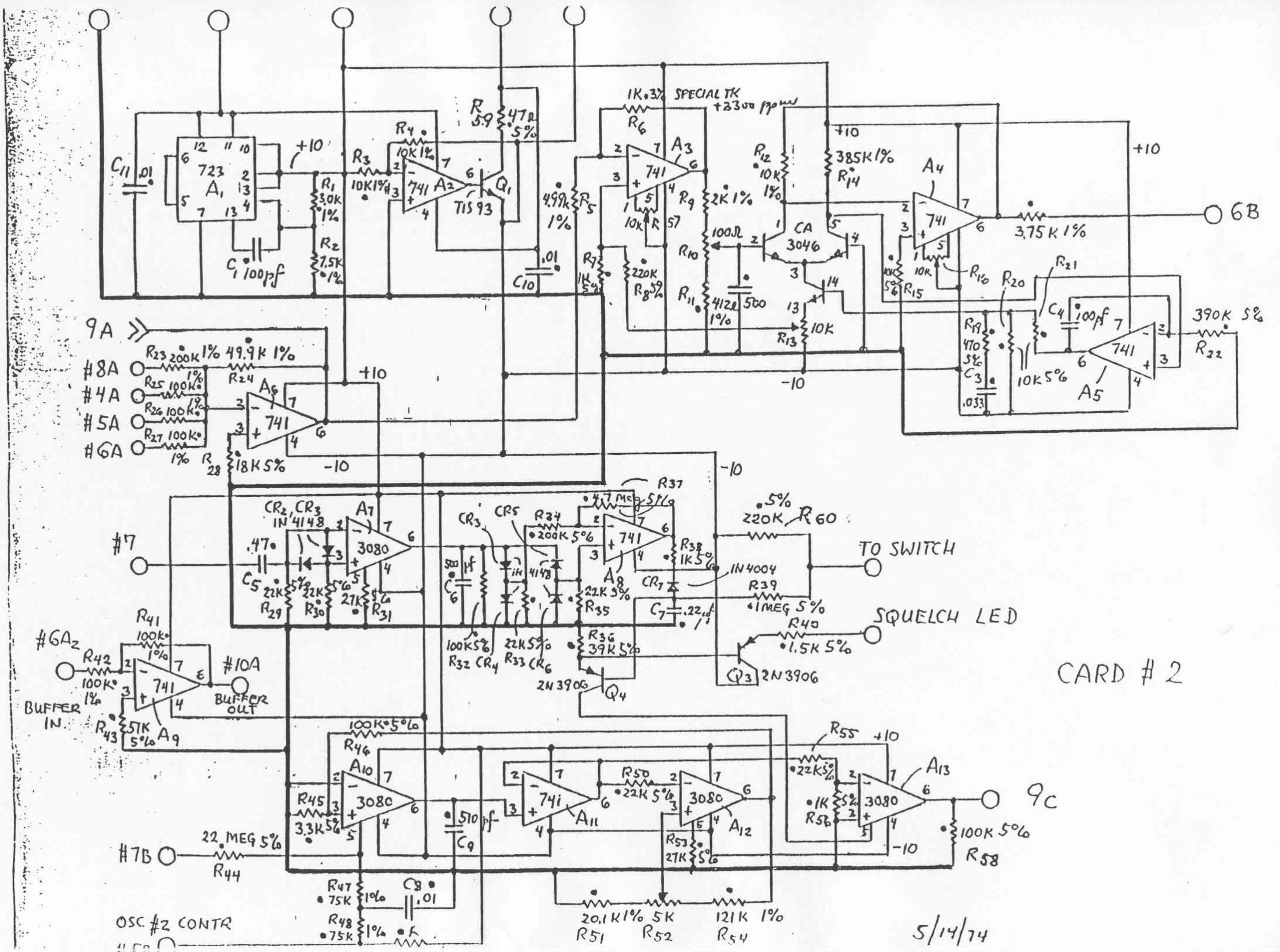
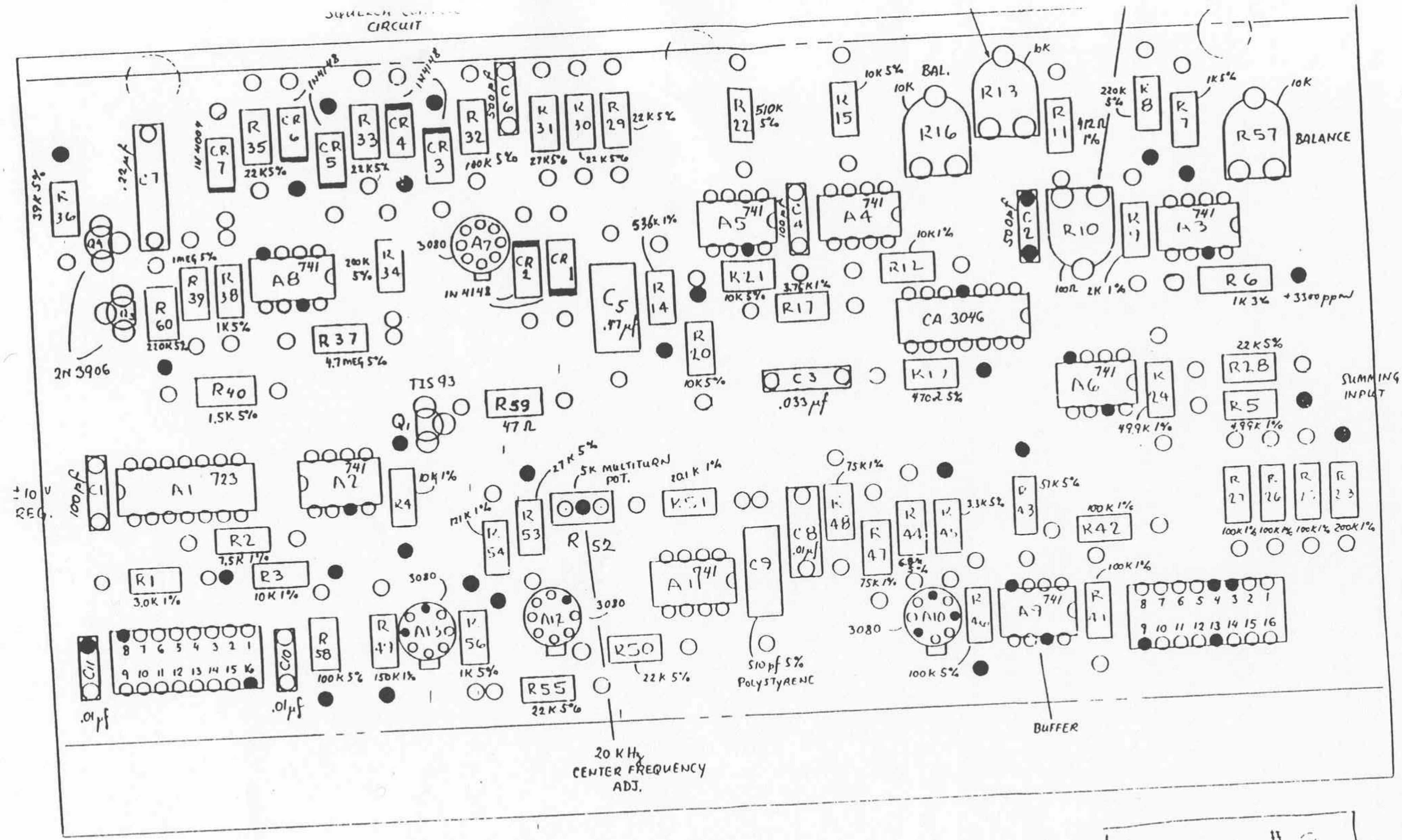


CARD # 2
5/14/74
6B
9A
#8A
#4A
#5A
#6A
#7
TO SWITCH
SQUELCH LED
#6A2
BUFFER IN
#10A
BUFFER OUT
#7B
9C
OSC #2 CONTR
723
A1
741
A2
TIS 93
Q1
A3
SPECIAL TK +2300 ppm
CA 3046
A4
A5
A6
3080
A7
A8
A9
A10
A11
A12
A13
2N 3906
Q3
Q4
1N 4004
1N 4148
C11 .01
C1 100pf
C10 .01
C4 100pf
C3 .033
C5 .47
C6 500pf
C7 .22uf
C8 .01
C9 510pf
R1 3.0K 1%
R2 7.5K 1%
R3 10K 1%
R4 10K 1%
R 5.9
47Ω 5%
R5 4.99K 1%
R6 1K .3%
R7 1K 5%
R8 220K 5%
R9 2K 1%
R10 100Ω
R11 412Ω 1%
R12 10K 1%
R13 10K
R14 385K 1%
R15 10K 5%
R16 10K
R19 470 5%
R20
R21 10K 5%
R22 390K 5%
3.75K 1%
R23 200K 1%
R24 49.9K 1%
R25 100K 1%
R26 100K 1%
R27 100K 1%
R28 18K 5%
R29 22K 5%
R30 22K 5%
R31 27K 5%
R32 100K 5%
R33 22K 5%
R34 200K 5%
R35 22K 5%
R36 39K 5%
R37 4.7 MEG 5%
R38 1K 5%
R39 1MEG 5%
R40 1.5K 5%
R60 220K 5%
R41 100K 1%
R42 100K 1%
R43 51K 5%
R44 22 MEG 5%
R45 3.3K 5%
R46 100K 5%
R47 75K 1%
R48 75K 1%
R50 22K 5%
R51 20.1K 1%
R52 5K
R53 27K 5%
R54 121K 1%
R55 22K 5%
R56 1K 5%
R58 100K 5%
+10
-10


CIRCUIT
SUMMING INPUT
BALANCE
BAL.
BUFFER
20 KHz
CENTER FREQUENCY
ADJ.
5K MULTITURN
POT.
±10 V
REG.
2N 3906
TIS 93
CA 3046
510pf 5%
POLYSTYRENE

CARD #2

91-139

April 8, 1974

FREQUENCY SHIFTER BOARD #3 PRELIMINARY CIRCUIT DESCRIPTION

Board #3 contains plus/minus 10V regulators, 20.00 kHz fixed oscillator, 90° phase shifter for the oscillator, two multipliers and associated followers and low pass filters. This card accepts the output from the variable frequency oscillator and produces two beat frequency signals 90° apart.

A1, A2, and Q1 and associated circuitry produce plus/minus 10 volts for driving the fixed oscillator. The regulators are exactly the same as those on Board #2.

A3, A4, A5, and associated circuitry comprise the 20.000 kHz fixed oscillator. It is exactly the same as the variable oscillator circuit on Board #2, the only difference being the simplified current supply for A3. The idea in having the two oscillators as alike as possible is that the variations with temperature and time would thereby be minimized.

The triangular signal for the fixed oscillator is applied to A6 at such a level that it overdrives it slightly. The current coming out of A6 is a rounded triangular,-nearly a sine shape. C3 and L1 resonate at 20kHz. The voltage waveform across C3-L1 is a very pure sine wave. This waveform is applied to phase shift network C6-R19-20, and R21-C7. Each leg of the network shifts the phase 45°. The phase difference between the inputs of the two buffers A7 and A8 is thus 90°. Buffers A7 and A8 each have a gain of 5. Their outputs should have a level of 1.8 Vp-p and a pure sine waveform.

A9 and A10 are two multipliers, which are conventional in all respects. See the Motorola (1496) or the Fairchild (796) data sheets for detailed description of this circuit. Refer now to the top section (A9). The variable oscillator signal is applied at low level (about 10-20 millivolts) between pins 7 and 8 (ground). The fixed oscillator signal is applied at high level between pins 1 (-7.5 volts D.C.) and 4. Capacitor C24 is a bypass capacitor to stop the whole device from flying at 100 mHz, which it does easily. R33 is a bias resistor which determines the operating current for the whole device. R34 is a gain-determining resistor. The output signal (containing sum and difference frequencies) appears as a differential current at pins 6 and 9. A11 is a difference amplifier. Its output contains the sum (about 40 kHz) and the difference (0-5 kHz) ~~xxxxxx~~ frequencies. A12 and associated components are a low pass filter with a cutoff frequency of about 10 kHz. This signal goes to a second filter and the final multipliers on Board #4. The lower section (A10) is identical to the top section (A9). The output of low pass filter A14 is nearly identical to that of A12, except for the 90^{o} phase shift.

R22 adjust the D.C. component that is added in with the variable oscillator signal, and thus is used to balance out the leakthough of the fixed oscillator. Similarly, R63 adjusts the D.C. component that is added in with the fixed oscillator signal, and thus is used to balance out the leakthrough of the variable oscillator. R36 adjusts the D.C. offset between pins 6 and 9 of A9, and thus is used to zero the D.C. output of A12. adjustments R43, R47, and R57 perform the same functions for the lower multiplier section.

TEST PROCEDURE
FOR
BODE FREQUENCY SHIFTER
Model 1630

BOARD 3

REFERENCE DRAWINGS:

FIG. 3 - TEST SETUP FOR CARD 3, FIXED OSCILLATOR (INCLUDING +10 AND -10 VOLT REGULATORS, 90° PHASE SHIFTER FOR THE OSCILLATOR, TWO MULTIPLIERS AND ASSOCIATED FOLLOWERS AND LOWPASS FILTERS) OF BODE FREQUENCY SHIFTER.
SCHEMATIC DIAGRAM OF CARD 3 (DWG. 08-041)
COMPONENTS ASSEMBLY DRAWING OF CARD 3 (DWG. 93-140)

TEST EQUIPMENT:

POWER SUPPLY +15 AND -15 VOLTS DC
AUDIO SIGNAL GENERATOR 15-25 kHz
OSCILLOSCOPE
DC VOLTMETER
TEST ADAPTER FOR CARD 3 INCLUDING TEST CIRCUIT AS SHOWN IN FIG. 3

PRELIMINARY STEPS:

1. CONNECT TEST EQUIPMENT WITH TEST CIRCUIT AND TEST ADAPTER FOR CARD 3, AS SHOWN IN FIG. 3.

2. SET SUPPLY VOLTAGES OF POWER SUPPLY TO WITHIN .25 VOLTS OF +15 AND -15 VOLTS DC.

3. TURN OFF POWER SUPPLY.

4. PLUG TEST ADAPTER INTO CARD 3, AND TURN ON POWER SUPPLY

(AFTER CHECKING FOR CORRECT ORIENTATION OF PLUGS).

TEST STEPS AND ADJUSTMENTS:

1. BALANCING OUT LEAK-THROUGH OF FIXED AND VARIABLE OSCILLATORS.

A. SET SW1 IN POSITION B TO OBSERVE FIRST BFO OUTPUT ON OSCILLOSCOPE.

B. SET AUDIO SIGNAL GENERATOR TO 21 kHz AND A SINE WAVE OUTPUT OF _ VOLTS.

C. ADJUST R22 TO BALANCE OUT THE LEAK-THROUGH OF THE FIXED OSCILLATOR.

D. ADJUST R63 TO BALANCE OUT THE LEAKTHROUGH OF THE VARIABLE OSCILLATOR.

E. SET SW1 IN POSITION A TO MEASURE DC OFFSET AT DC VOLTMETER.

F. ADJUST R36 ~~WITH~~ until THE DC OUTPUT OF A12 (FIRST BFO OUTPUT) IS AT ZERO VOLTS.

G. LEAVE SW1 IN POSITION A TO MAKE THE FOLLOWING OSCILLOSCOPE OBSERVATIONS OF THE SECOND BFO OUTPUT.

H. ADJUST R43 TO BALANCE OUT THE LEAK-THOUGH OF THE FIXED OSCILLATOR.

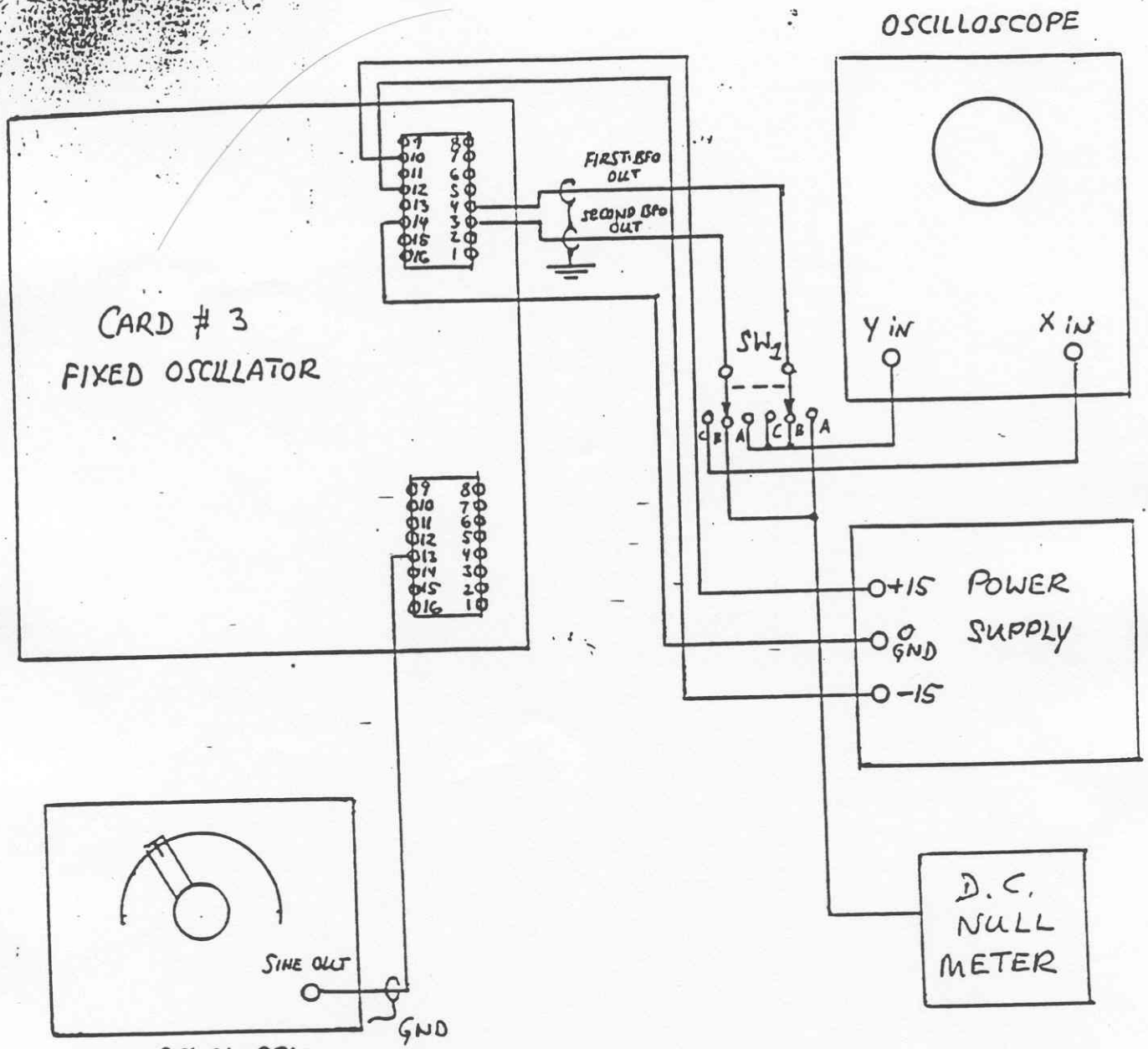
I. ADJUST R47 TO BALANCE OUT THE LEAK-THROUGH OF THE VARIABLE OSCILLATOR.

J. SET SW1 IN POSITION B TO MEASURE THE DC OFFSET OF THE SECOND BFO.

K. ADJUST R57 UNTIL THE DC OUTPUT OF A14 (SECOND BFO OUTPUT) IS AT ZERO VOLTS.

2. ADJUSTMENT FOR 90° PHASE SHIFT

SET SWITCH SW1 IN POSITION C AND ADJUST R20 (ALSO ADJUSTING Y VS X GAIN ON THE OSCILLOSCOPE) TO ACHIEVE A CIRCULAR PATTERN. IT SHOULD BE NOTED THAT THE CIRCLE WILL BE MODULATED BY A SMALL REMAINING PORTION OF THE VARIABLE AND FIXED OSCILLATOR FREQUENCIES.



SW_1 IN POSITION A: SCOPE OBSERVATION OF SECOND BFO. D.C. NULL ADJUSTMENT FOR FIRST BFO.

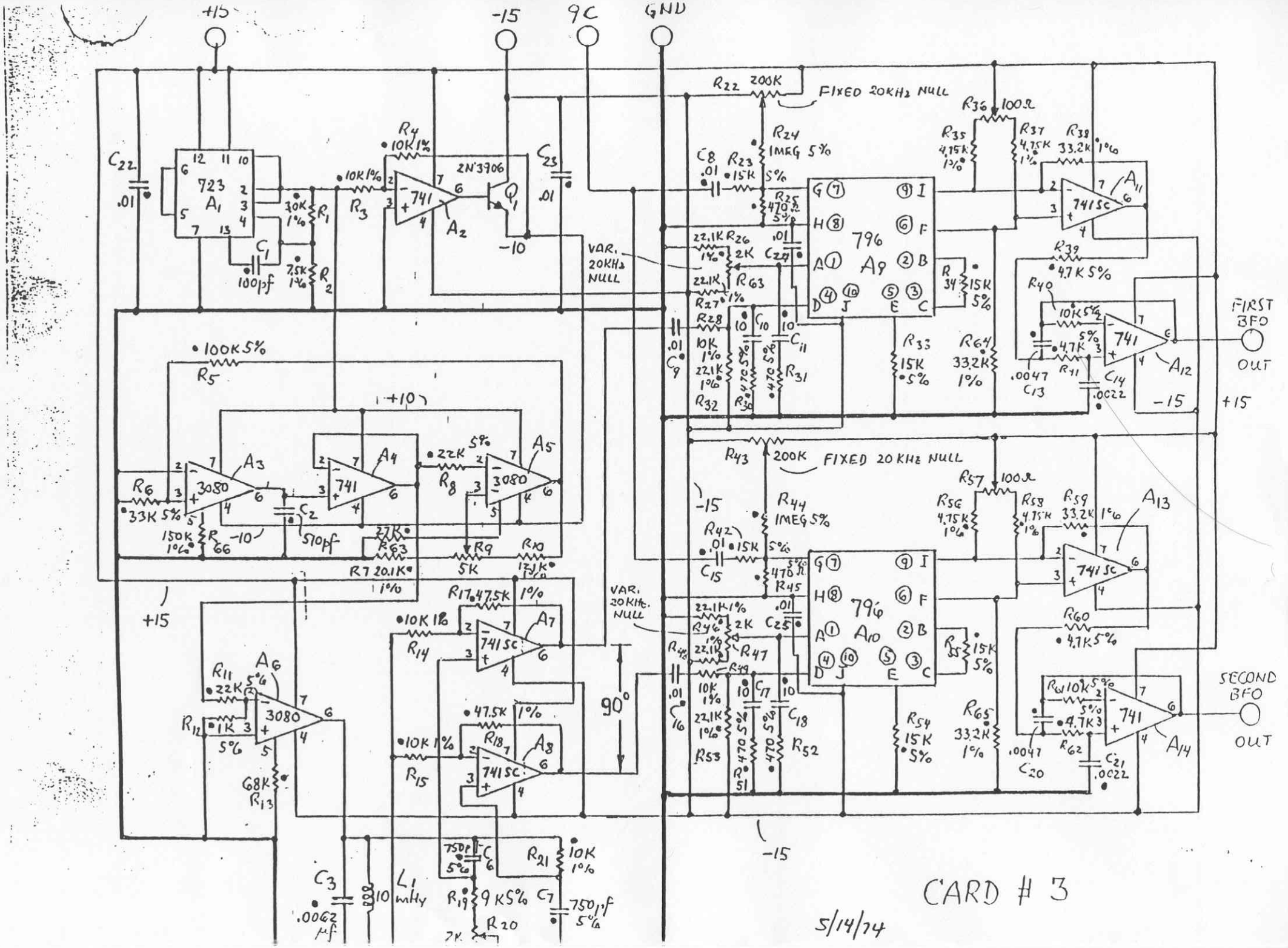
SW_1 IN POSITION B: SCOPE OBSERVATION OF FIRST BFO. D.C. NULL ADJUSTMENT FOR SECOND BFO.

SW_1 IN POSITION C: SCOPE OBSERVATION OF FIRST & SECOND BFO FOR PHASE ADJUSTMEN (CIRCULAR PATTERN).

TEST SETUP FOR CARD # 3, FIXED OSCILLATOR OF BODE FREQUENCY SHIFTER.

Fig. 3

H. Bode
7-15-74


+15
-15
9C
GND
A1
723
A2
741
Q1
2N3906
A3
3080
A4
741
A5
3080
A6
3080
A7
741SC
A8
741SC
A9
796
A10
796
A11
741SC
A12
741
A13
741SC
A14
741
R1
R2
R3
R4
R5
R6
R7
R8
R9
R10
R11
R12
R13
R14
R15
R17
R18
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R20
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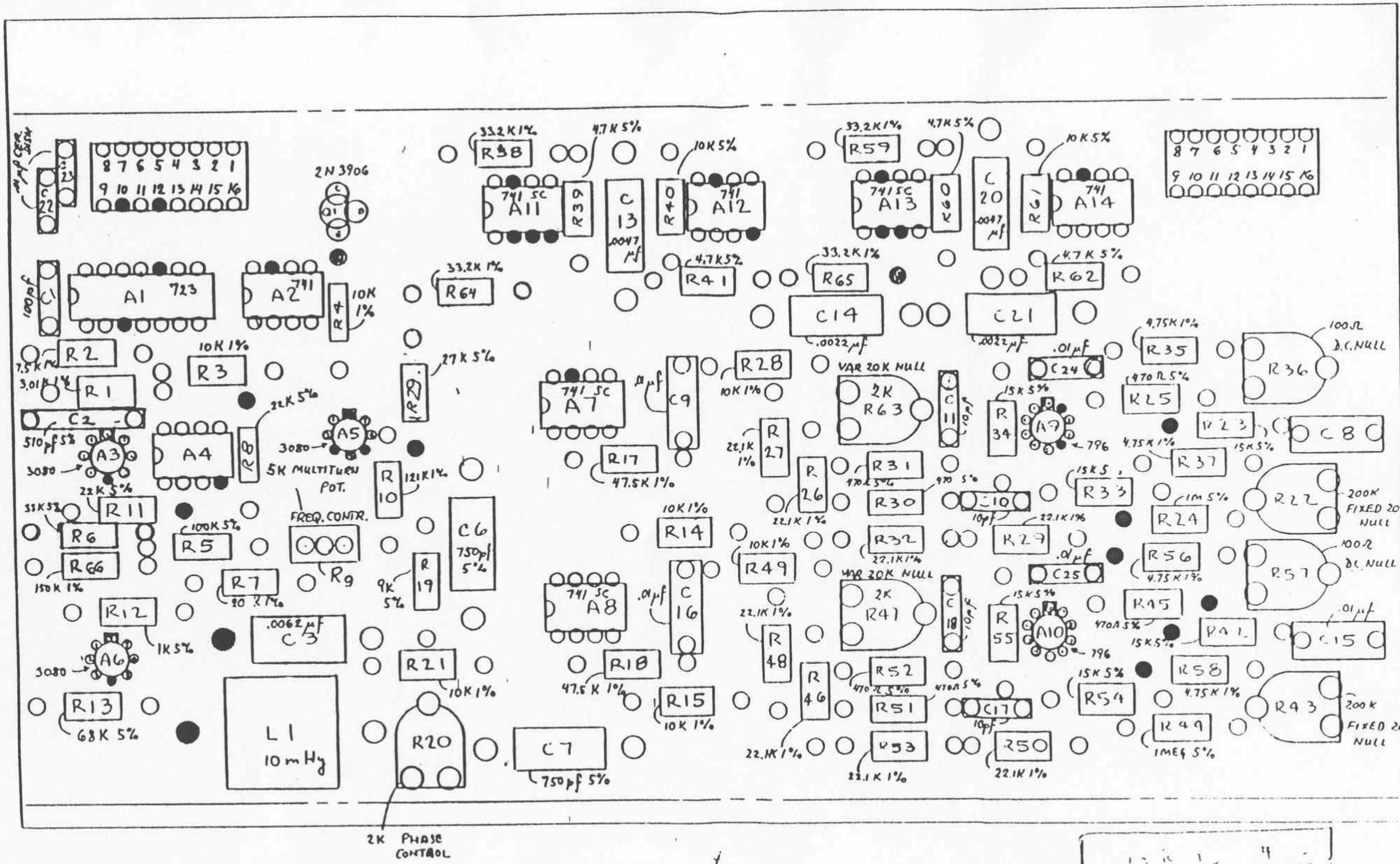
R50
R51
R52
R53
R54
R55
R56
R57
R58
R59
R60
R61
R62
R63
R64
R65
R66
C1
C2
C3
C6
C7
C8
C9
C10
C11
C13
C14
C15
C16
C17
C18
C20
C21
C22
C23
C25
L1
10 mHy
VAR. 20KHz NULL
VAR. 20KHz NULL
FIXED 20KHz NULL
FIXED 20 KHz NULL
90°
FIRST BFO OUT
SECOND BFO OUT
CARD # 3
5/14/74



SCALE 2/1 91-140

April 8, 1974

FREQUENCY SHIFTER BOARD #4 PRELIMINARY CIRCUIT DESCRIPTION

Board #4 contains a low pass filter for each of the difference (beat) signals, two final multipliers, and final amplifiers and adders. The board receives the two beat signals shifted by 90°, the two audio signals shifted (on board #1) by 90°, The A output is the sum of the audio and beat frequencies, while the B output is the difference between the two. The level of the outputs is the same as the audio input level.

Low pass ~~fif~~ filters A1 and A2 have cutoff frequencies of approximately 10kHz. They remove the last bit carrier leakthrough and sum frequency signal from board #3. The waveforms at the outputs of A1 and A2 should be pure sine waves at the beat frequency. The levels should be the same as the outputs of Board #3. Transistor Q1 turns on and off at the beat rate, and drives the 'zero beat' LED on the front panel.

Final multipliers A3 and A4 are conventional in most respects. See the Motorola specs for a detailed description of this circuitry. Refer to the top multiplier. The audio (program) input is applied between pins 6 and 9 (near ground). ~~KXX~~ A3 supplies plus/minus 4 volts between pins 2 and 4 to power balance adjustments R13, 14, and 15. R14 supplies a voltage which is effectively added to the program input, and is therefore used to balance out the beat signal. The beat signal is applied between pins 10 and 13 of A3. R13 supplies a voltage which is effectively added to the carrier (beat) input, and is therefore used to balance out the program signal.

R15 balances out the D. C. component which is fed to the output. The output is a single-ended current which is converted into a voltage by A5. Resistors R10 and R11 are gain determining resistors. Note that they are not the resistance values recommended by Motorola. This is because the final multiplier is optimized for a program level of plus 2 dBm, but has enough headroom to accept a program level of plus 12 dBm without serious distortion. C4-R8 and C5-R9 suppress parasitics, RF, and other celestial debris. R12 biases the entire multiplier (in accordance with the manufacturers recommendations) C6 and C7 provide line bypass. R45-46-47-48 divide the voltage that is applied to the balancing adjustments, thus increasing the resolution of R13 and R14. Preliminary investigation shows that these wirewound trimmers don't have enough resolution if they are connected directly across pins 2 and 4 of A3.

Multiplier A4 is identical inoperation to that of A3.

As mentioned above, A5 is a current-to-voltage converter. R17 determines the gain. C8 is recommended by the multiplier manufacturer. A8 adds the outputs of A5 and A6, thus producing the sum output. R23 balances the two multiplier signals and thus nulls out the difference signal. A7 is simply an inverting amplifier, period. A9 adds the outputs of A6 and A7, thus producing the difference output. R41 nulls out the sum signal.

TEST PROCEDURE
FOR
BODE FREQUENCY SHIFTER
Model 1630

BOARD 4

REFERENCE DRAWINGS:

FIG. 4 TEST SETUP FOR CARD 4, MULTIPLIERS (INCLUDING LOWPASS FILTERS, FINAL AMPLIFIERS AND ADDERS) OF BODE FREQUENCY SHIFTER
SCHEMATIC DIAGRAM OF CARD 4 (DWG. 08-042)
COMPONENTS ASSEMBLY DRAWING OF CARD 4 (DWG. 93-138)

TEST EQUIPMENT:

POWER SUPPLY +15 AND -15 VOLTS DC.
TWO AUDIO SIGNAL GENERATORS 20-20,000 Hz
TWO DOME FILTER BOARDS (Card 1)
OSCILLOSCOPE
DC VOLTMETER
TEST ADAPTER FOR CARD 4 INCLUDING TEST CIRCUIT AS SHOWN IN FIG. 4

PRELIMINARY STEPS:

1. CONNECT TEST EQUIPMENT WITH TEST CIRCUIT AND TEST ADAPTER FOR CARD 4, AS SHOWN IN FIG. 4.

2. SET SUPPLY VOLTAGES OF POWER SUPPLY TO WITHIN .25 VOLTS OF +15 AND -15 VOLTS DC.

3. TURN OFF POWER SUPPLY.

4. PLUG TEST ADAPTER INTO CARD 4, AND TURN ON POWER SUPPLY (AFTER CHECKING FOR CORRECT ORIENTATION OF PLUGS).

TEST STEPS AND ADJUSTMENTS:

1. CHECKING OF BFO WAVEFORMS AND "ZERO BEAT" INDICATOR.

A1

A. THE LOWPASS FILTERS WITH A1 AND A2 HAVE CUTOFF FREQUENCIES OF APPROXIMATELY 10 kHz. THEY REMOVE THE LAST BIT CARRIER LEAK-THROUGH AND SUM FREQUENCY SIGNAL FROM BOARD 3.

SET SWITCH SW1 IN POSITION A AND PROBE WAVEFORMS AT THE OUTPUTS OF A1 AND A2. THEY SHOULD BE PURE SINE WAVES AT THE BEAT FREQUENCY.

THE LEVELS SHOULD BE THE SAME AS AT THE OUTPUTS OF BOARD 3.

B. BRING AUDIO SIGNAL GENERATORS A AND B TO APPROXIMATELY THE SAME FREQUENCY. SINCE TRANSISTOR Q1 TURNS ON AND OFF AT THE BEAT RATE, THE "ZERO BEAT" LED WILL LIGHT UP AT THE SAME RATE.

2. BALANCING OF FINAL MULTIPLIERS AND ADDERS

A. TURN OFF THE AUDIO INPUT SIGNALS AND ADJUST R15, UNTIL THE DC VOLTAGE LEVEL AT THE OUTPUT OF A5 REACHES ZERO.

B. LIKEWISE ADJUST R37, UNTIL THE DC VOLTAGE LEVEL AT THE OUTPUT OF A6 REACHES ZERO.

C. TURN ON AUDIO SIGNAL GENERATOR A AND SELECT A CONVENIENT FREQUENCY, SAY 1 kHz.

D. OBSERVE OUTPUT OF A5 AND ADJUST R13, UNTIL SIGNAL DISAPPEARS.

E. OBSERVE OUTPUT OF A6 AND ADJUST R35, UNTIL SIGNAL DISAPPEARS.

F. TURN OFF AUDIO SIGNAL GENERATOR A AND TURN ON AUDIO SIGNAL GENERATOR B, AGAIN SELECTING THE SAME FREQUENCY.

G. OBSERVE OUTPUT OF A5 AND ADJUST R14, UNTIL SIGNAL DISAPPEARS.

H. OBSERVE OUTPUT OF A6 AND ADJUST R36, UNTIL SIGNAL DISAPPEARS.

I. TURN ON BOTH AUDIO SIGNAL GENERATOR A AND B AND SELECT TWO FREQUENCIES 500 HZ APART - FOR INSTANCE 1000 Hz FOR A AND 1500 Hz FOR B.

J. SET SWITCH SW1 IN THE C POSITION (FOR "A OUT" OBSERVATION ON OSCILLOSCOPE).

K. ADJUST R23, UNTIL THE DIFFERENCE SIGNAL DISAPPEARS.

NOTE: WITH R17 IN CENTER POSITION ADJUST R39 FOR OPTIMUM RESULTS. IN THE FINAL ASSEMBLY, R17 AND R39 WILL NEED TO BE RESET FOR UNITY GAIN OF THE FREQUENCY SHIFTER.

L. SET SWITCH SW1 IN THE B POSITION (FOR "B OUT" OBSERVATION ON OSCILLOSCOPE).

M. ADJUST R41, UNTIL THE SUM SIGNAL DISAPPEARS.

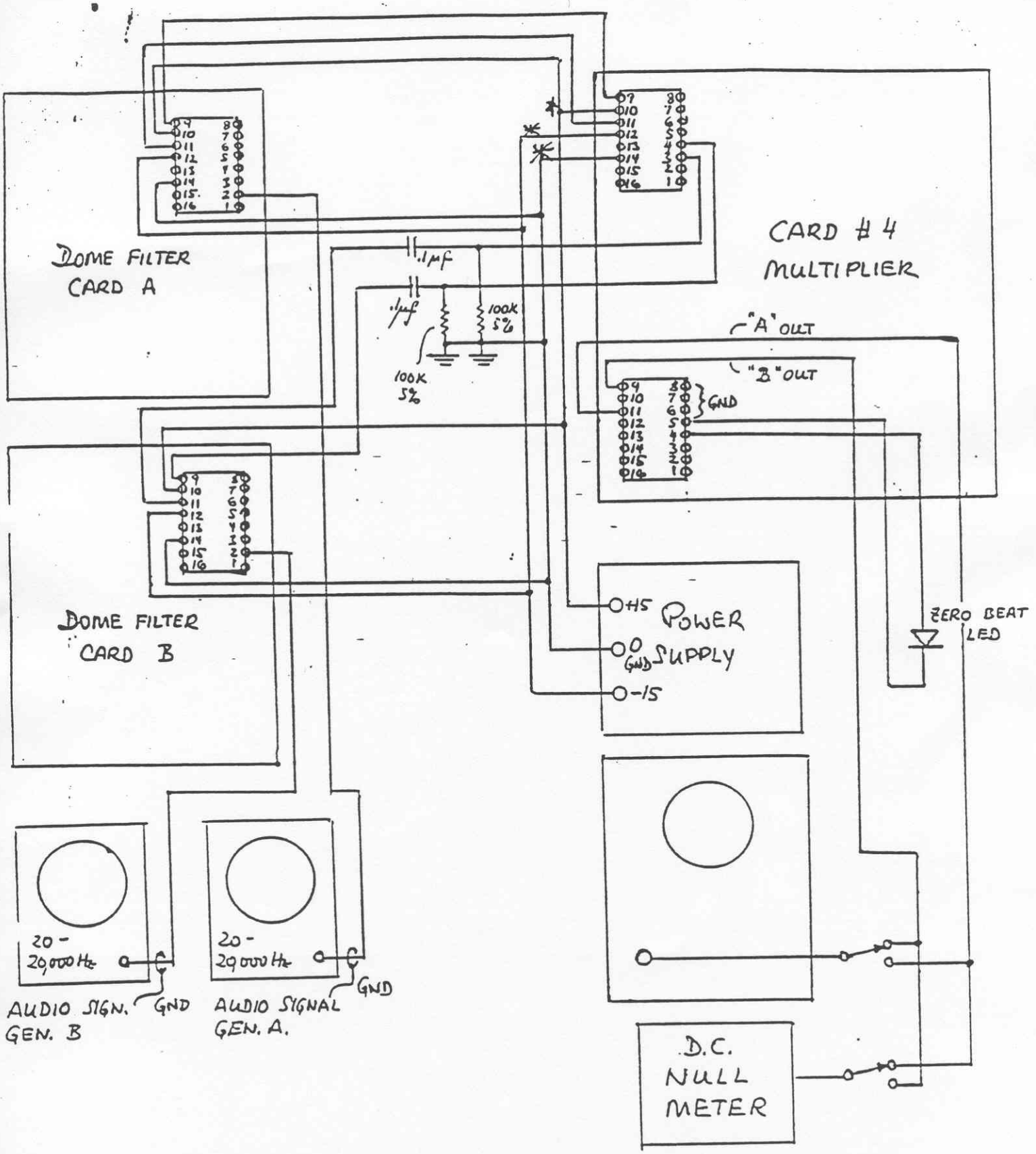
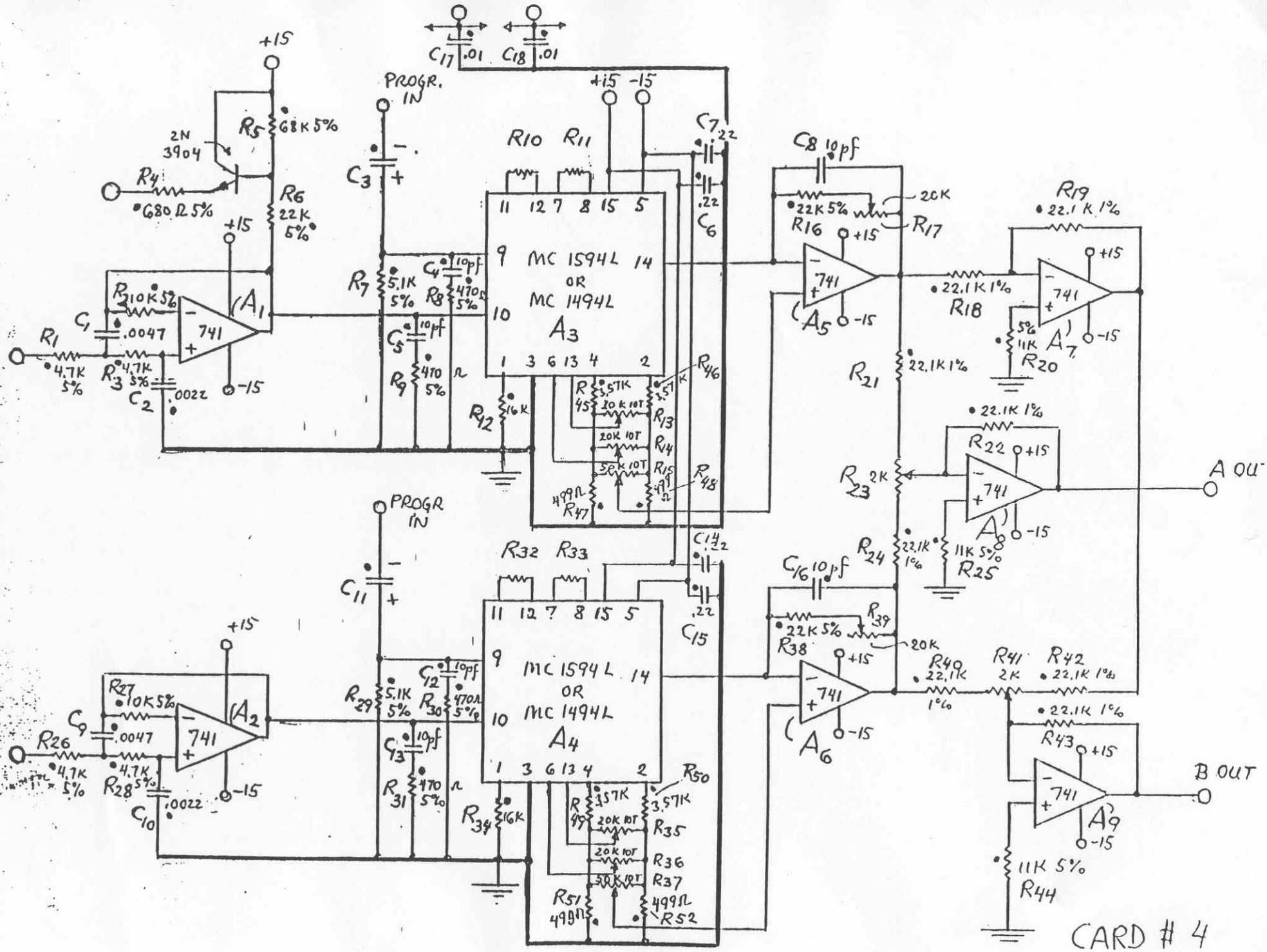
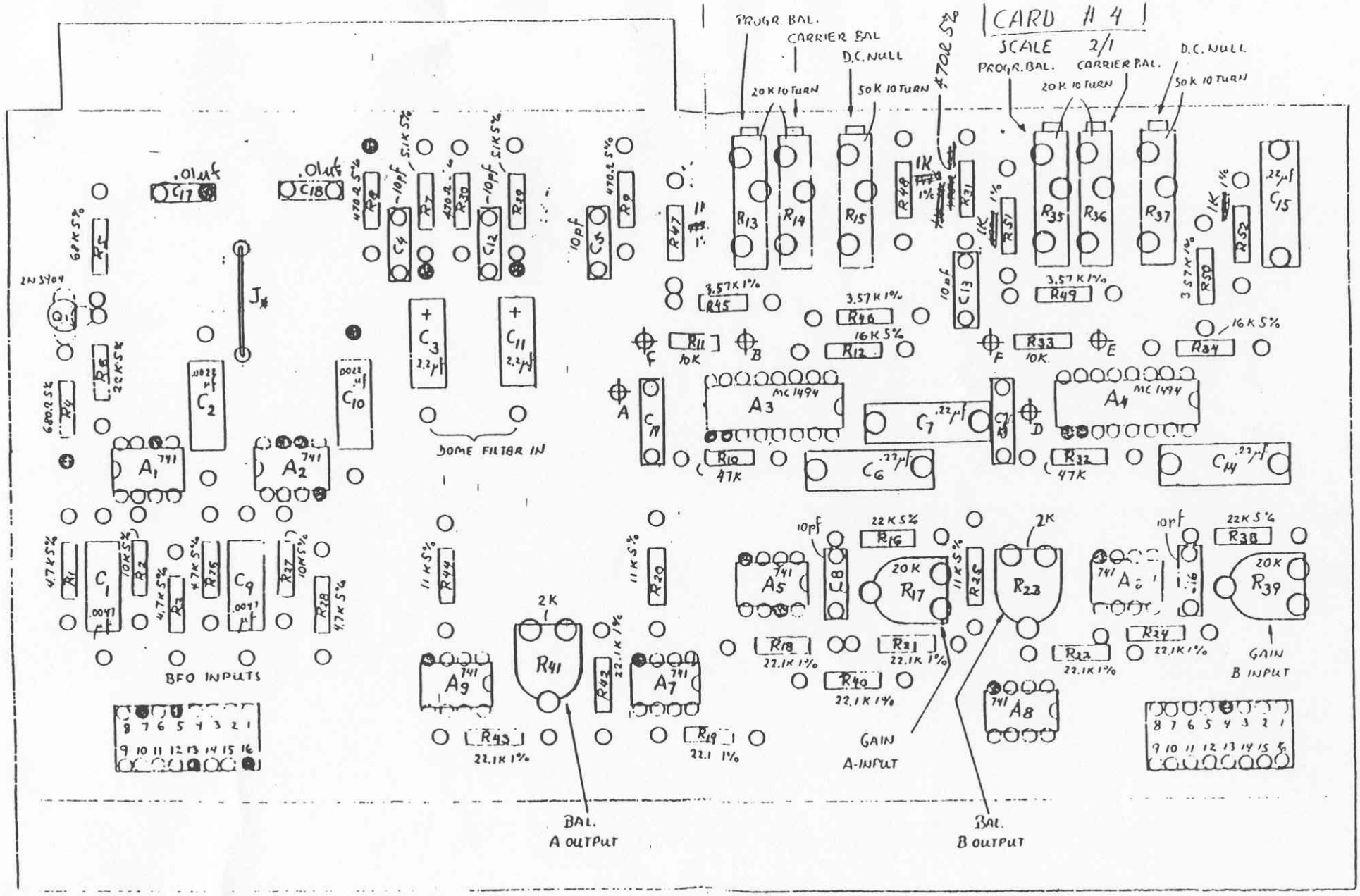


Fig. 4. TEST SETUP FOR CARD # 4, MULTIPLIER OF BODE FREQUENCY SHIFTER

H. Bode
7-15-7


C17 .01
C18 .01
+15
-15
PROGR. IN
2N 3904
R5 68K 5%
R4 680Ω 5%
R6 22K 5%
C3
R10 R11
C7 .22
C8 10pf
22K 5% R16
20K R17
R19 22.1K 1%
R7 5.1K 5%
R8 470Ω 5%
C4 10pf
C5 10pf
R9 470 5%
R12 16K
MC 1594L OR MC 1494L
A3
R46 3.57K
R45 3.57K
20K 10T R13
20K 10T R14
50K 10T R15
499Ω R47
499Ω R48
R1 4.7K 5%
R3 4.7K 5%
C1 .0047
C2 .0022
10K 5%
741
A1
A5
A7
22.1K 1% R18
11K 5% R20
R21 22.1K 1%
R22 22.1K 1%
R23 2K
R24 22.1K 1%
11K 5% R25
A OUT
C16 10pf
R39 22K 5%
20K
R38
R40 22.1K 1%
R41 2K
R42 22.1K 1%
R43 22.1K 1%
11K 5% R44
B OUT
A9
PROGR IN
C11
C14 .22
C15 .22
R32 R33
R29 5.1K 5%
R30 470Ω 5%
C12 10pf
C13 10pf
R31 470 5%
R34 16K
MC 1594L OR MC 1494L
A4
R50 3.57K
R49 3.57K
20K 10T R35
20K 10T R36
50K 10T R37
499Ω R51
499Ω R52
R26 4.7K 5%
R28 4.7K 5%
C9 .0047
C10 .0022
10K 5%
741
A2
A6
CARD # 4

5/11/71

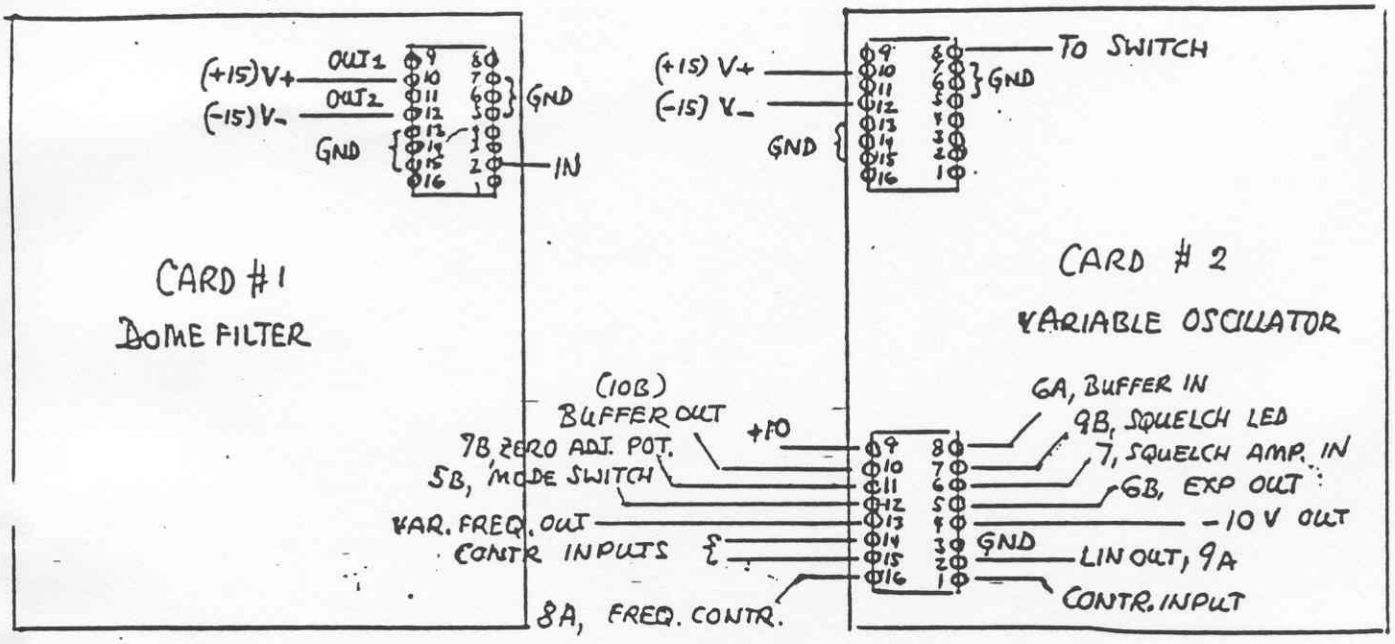


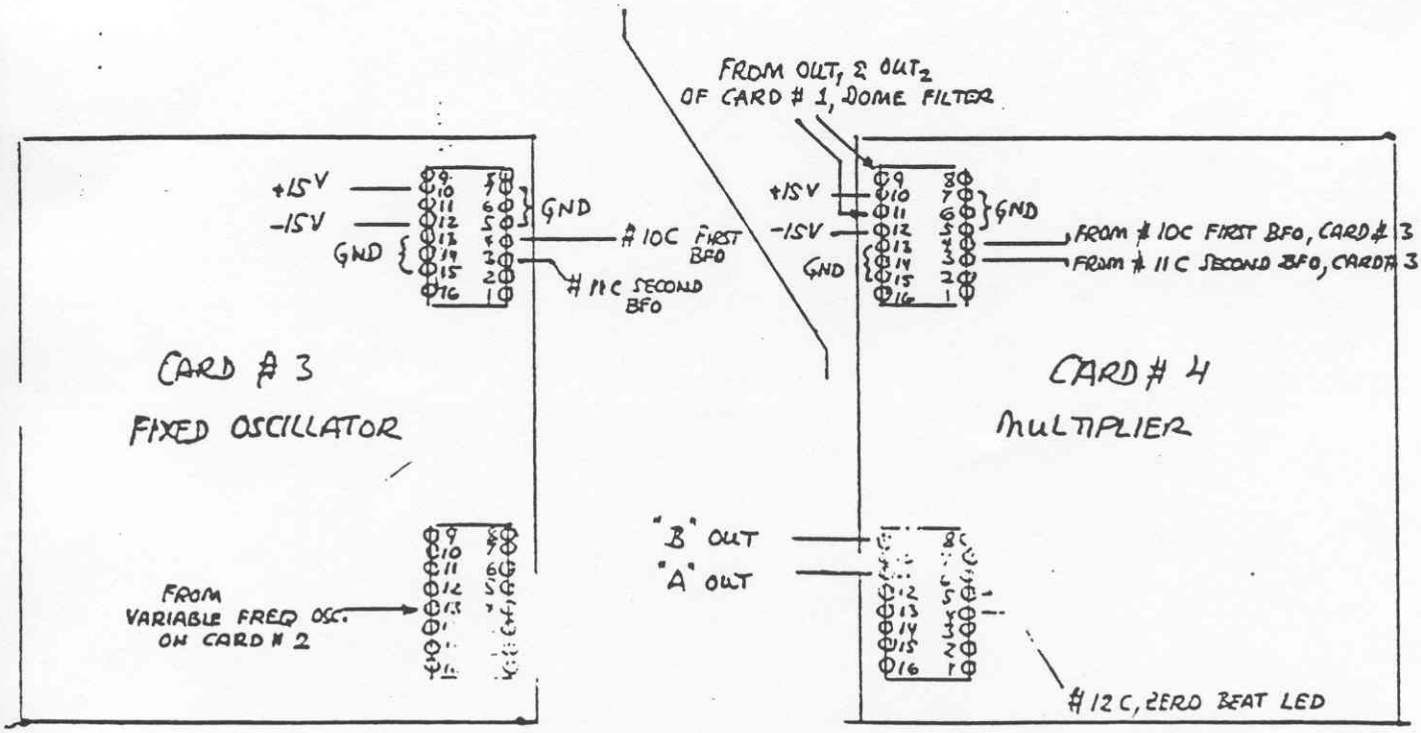
J# SHOULD BE ZERO OHM RESISTOR
TO AVOID SHORT WITH SURFACE TRACE

⊕ TURRET TERMINALS TYP.

91-138 9-24

PIN-OUTS OF P.C. CARDS FOR BODE FREQUENCY SHIFTER





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7-15-74

BODE - FREQUENCY SHIFTER
BASIC INTERCONNECTING WIRING DIAGRAM.