UNIVERSITY OF WISCONSIN

SPACE SCIENCE AND ENGINEERING CENTER

MADISON, WISCONSIN

T W E R L E

TRANSMITTER AND STABLE OSCILLATOR

MANUFACTURING MANUAL

APRIL 1973

SPACE
SCIENCE AND
ENGINEERING
CENTER

1225 West Dayton Street
Madison, Wisconsin 53706

THE UNIVERSITY OF WISCONSIN

T W E R L E

Transmitter and Stable Oscillator

Manufacturing Manual

April 1973

TWERLE TRANSMITTER

GENERAL

The TWERLE transmitter is of the sampled phase-locked loop type. The block diagram is given in Figure 1. The stable 50.15 MHz signal from the crystal oscillator triggers narrow pulses at the sampler, which are then multiplied by a portion of the RF output signal, extracted from the output path by a 20 dB directional coupler. The error signal from the sampler is amplified and filtered before it is applied to a varactor diode which controls the power oscillator frequency around 401.2 MHz. The phase modulation is inserted in the RF section of the feedback path. The modulator utilizes a quadrature hybrid coupler.

Physically, the power oscillator, the directional coupler and the modulator are etched on one microstrip board 7 1/2" by 2 1/4", and the sampler, the loop amplifier, the modulator driver and switching circuit are built on a printed circuit board of similar size. The two boards are attached back-to-back. They are packaged in a rectangular foam box. The crystal oscillator and its oven control circuitry are housed in a separate spherical package.

POWER OSCILLATOR

The power oscillator is a microstrip design, grounded collector circuit. The oscillation frequency is determined by a microstrip 1/4 λ line, with a tap for the emitter. Output is extracted from the base, thru a matching network for 50 Ohm load. Voltage control of the frequency is obtained by a varactor in series with a small decoupling capacitor connected in parallel to the emitter tap. Adjustment of the free running frequency is available, over approximately ± 20 MHz range, by means of a 1.3 pF variable capacitor at the end of the 1/4 λ line.

A typical free running frequency stability vs. temperature is better than ± 0.6 MHz @400 MHz over the temperature range -50°C to +20°C. It was measured while simulating real transmitting conditions; i.e., the transmitter was on once a minute for a period slightly longer than 1 second, and the frequency counter 1 second gate was opened immediately after applying the supply voltages.

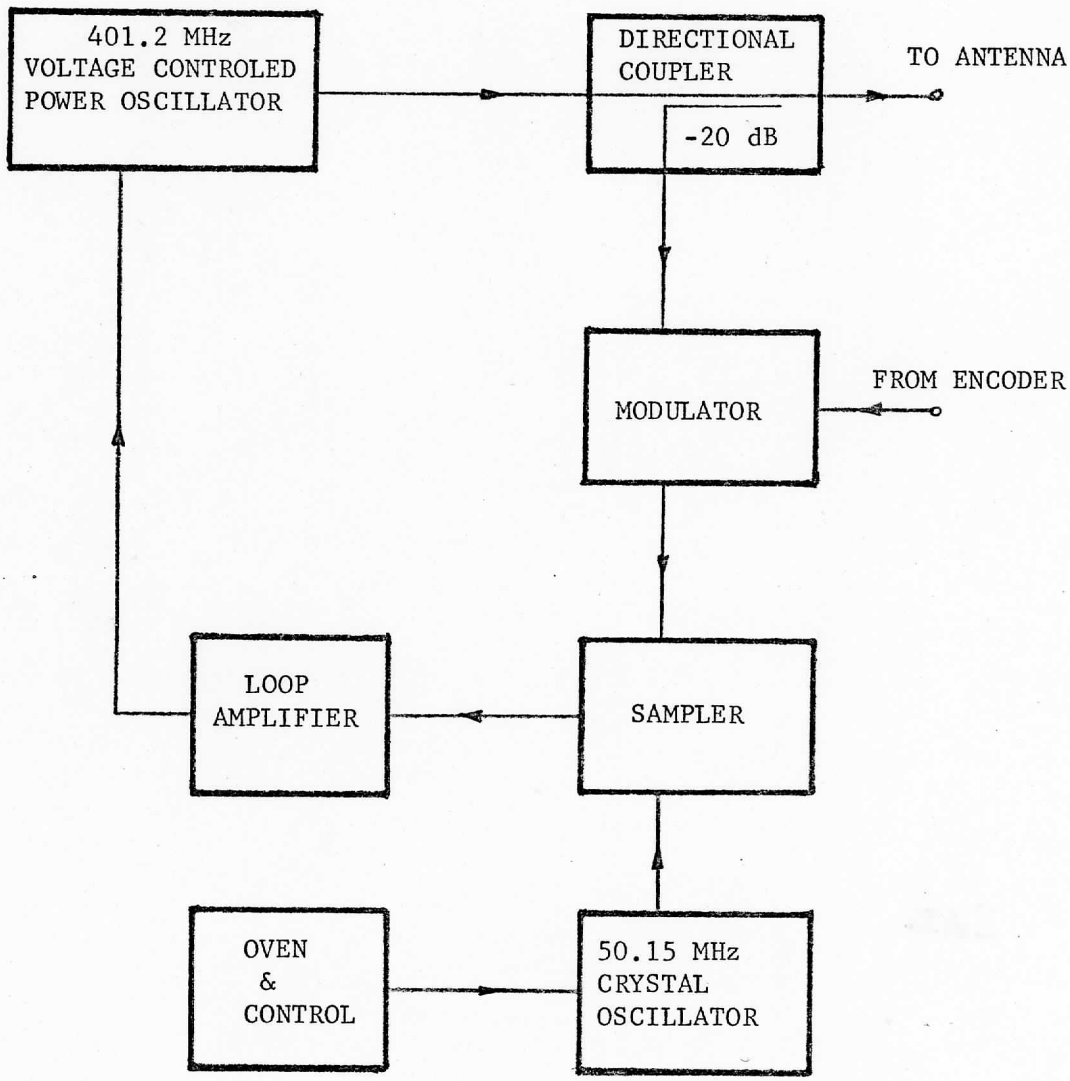


FIG. 1 TWERLE TRANSMITTER BLOCK DIAGRAM

The power oscillator utilizes an RCA 40941 transistor and is adjusted for delivering 0.7 Watts RF output with an efficiency of at least 50%.

To guarantee proper oscillations down to -40°C a sensistor is included in the biasing circuitry.

DIRECTIONAL COUPLER

The directional coupler is etched together with the power oscillator on the same microstrip board. It is located on the microstrip 50 Ohm line between the oscillator output and the antenna connector. The insertion loss is less than 0.2 dB. A fraction of the forward wave, at a level of -20 dB, appears on the 3rd port of the coupler and is fed to the modulator which is also placed on the same microstrip board.

MODULATOR

The modulator is based on a quadrature hybrid coupler. Among the four ports of this coupler there are two ports with 90° phase shift between them. When these two ports are terminated by an open circuit, the phase of the output port is 360 degrees off the phase at that port when the two are terminated by a short circuit. Any smaller phase difference, such as the required 120 degrees, can be obtained by an appropriate reactive termination at these two ports. The termination for our application includes a fixed coil in series with a varicap. The +60, 0, and -60 degrees phase shifts are obtained by applying typically 9V, 13V, and 21V across the varicap.

A modulation driver is used to translate the encoder modulation voltage levels, to the levels required by the modulator. The +60° and -60° levels are adjusted by two potentiometers.

SAMPLER

The sampler receives two input frequencies: 50.15 MHz from the crystal oscillator, and 401.2 MHz from the power oscillator. It yields a low frequency output which is related to the phase error between the two. The sampler consists of two parts. The first part generates narrow pulses at the 50.15 MHz rate utilizing a step recovery varactor diode. The pulses width is smaller than half the period of the 401.2 MHz signal, i.e., less than 1.2 nanosecond. In the second part, those narrow pulses multiply the 401.2 MHz signal. The multiplier consists of a diode bridge, an HP hot carrier quad, preceded by a self made RF transformer, utilizing a ferrite bead.

LOOP AMPLIFIER

The loop amplifier is a 3-stage dc amplifier. The first stage is a differential amplifier which is followed by a common emitter; the output stage is a complimentary emitter follower. A feedback path, which includes the loop filter, exists between the output and the inverse input. The amplifier output swing is ± 11 volt. Open loop gain is 16,000; dc closed loop gain is set at 145. A bias potentiometer, in parallel to the inverse input, serves to nullify all offsets generated in the sampler and the loop amplifier itself.

CRYSTAL OSCILLATOR AND BUFFER

The crystal oscillator is a pierce oscillator operating at 50 MHz.

The oscillator is followed by a cascode FET buffer which brings the output level to 4.5 mW at 50 Ohm.

The oscillation frequency will be slightly above the crystal series resonance frequency. This Δf is a result of loading the crystal with the series combination of the base to ground capacitor C31 and the effective capacity of the collector tuned circuit.

The collector tuned circuit is required in order to prevent the crystal from oscillating at other than the desired fifth overtone.

The buffer is not included in the active oven. To prevent its input impedance change vs. temperature from pulling the oscillator frequency, a high r crystal is used. $\left[r = \frac{c_0}{c_1} = \frac{f_s}{2\left(f_p - f_s\right)} \right]$ (typical value r = 7000).

With this high r oscillator frequency adjustment is very limited. Still some frequency change could be implemented by tweaking the coil of the collector tuned circuit. In general this would be accompanied by a change in amplitude.

The oven is set to +25°C which is approximately 50 degrees above the expected passive oven temperature. The crystal's AT cut (0') has a relatively broad inflection point at that temperature, which simplifies the accuracy requirements from the bridge and the thermistor.

The frequency stability is:

	Short term (RMS)	Better than	0.5 Hz @ 400 MHz/sec.
vs.	Temperature	Better than	1 Hz @ 400 MHz/°C

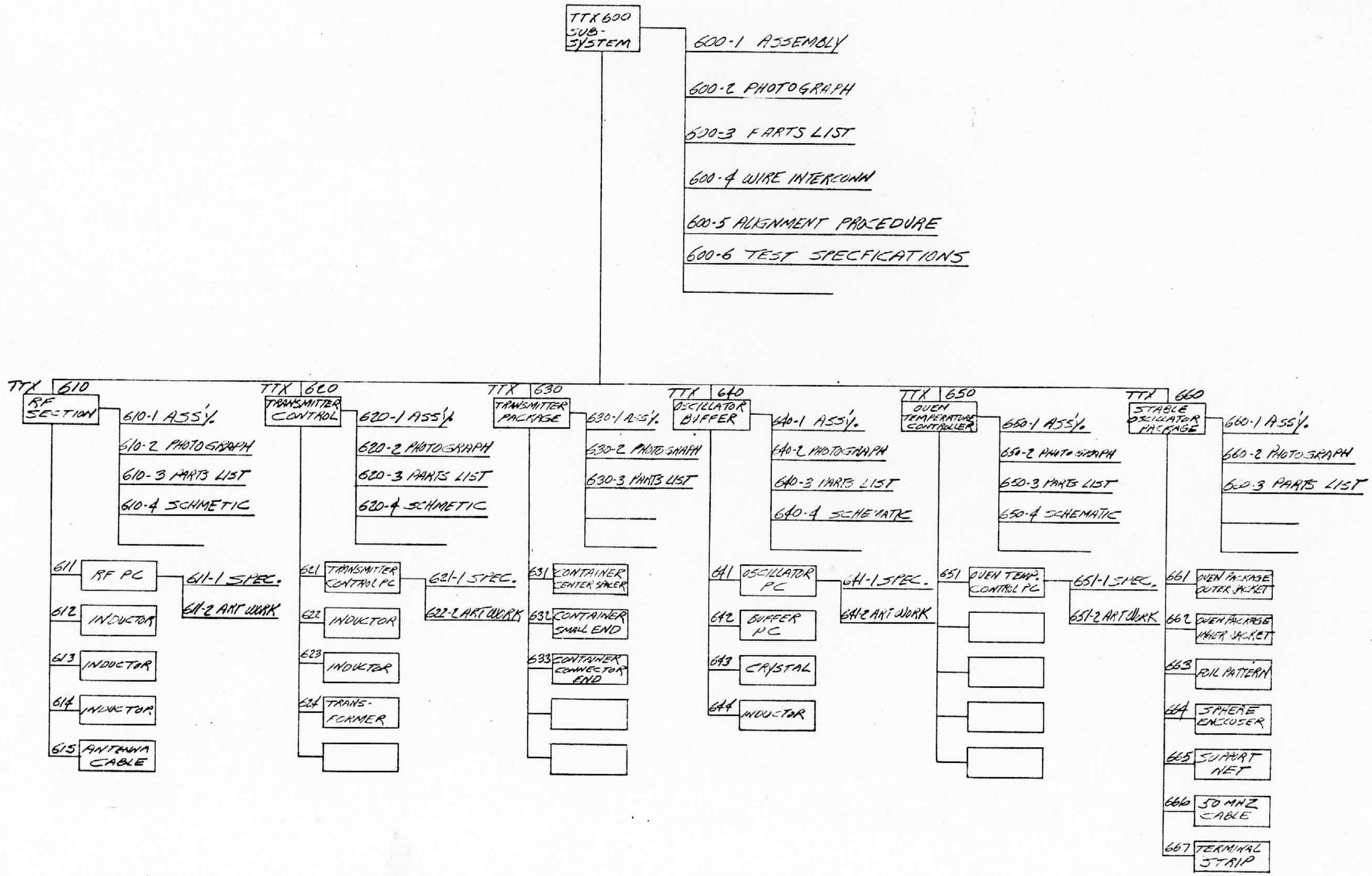
OVEN AND OVEN CONTROL

The crystal oscillator is housed in a miniature Dewar flask of the type used for the hypsometer in the standard radiosonde. The flask, a buffer amplifier, and the oven control circuitry, are all placed within a shielded rectangular foam box, with all terminals passing "feed thru" capacitors. The entire package is kept inside an 8" foam sphere; its upper hemisphere covered with aluminized mylar (mylar outside), and the lower hemisphere covered with aluminum foil painted with white lead paint.

The inside (daytime) temperature of the sphere is expected to stay within -45°C to -25°C for the entire balloon life (i.e. all latitudes), with a temperature rate of change smaller than 2.5°C/15 min.

The oven control circuit is a proportional switching controller set to balance at +25°C. The heater is two 500 Ohm resistors in series. The maximum heater power is 0.5 Watts. The flask heat losses are 15 mW/°C, and the oscillator circuitry power, dissipated inside the oven, is 26 mW, implying minimum temperature differential of 17°C. The oven control and the buffer are outside the flask; their power dissipation is 78 and 106 mW respectively.

REVISIONS			
LTR.	DESCRIPTION	DATE	APPROVED



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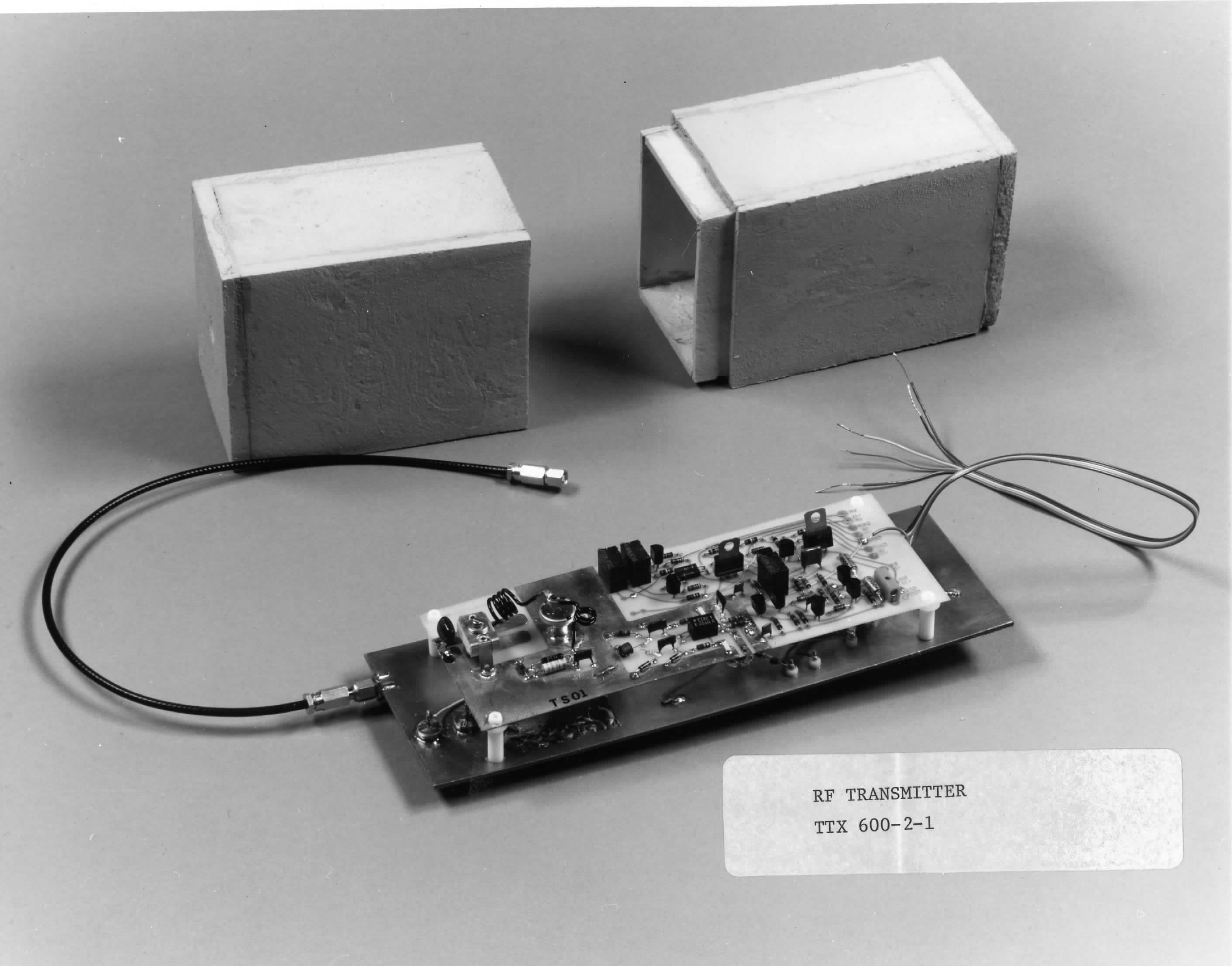
TITLE: TWERLE TRANSMITTER DRAWING TREE			
SCALE NONE	DRAFTSMAN [illegible] DATE	CHECKER DATE	ENGINEER DATE
NEXT HIGHER ASSEMBLY	PRODUCT ASSURANCE DATE	PROJECT APPROVAL DATE	
PROJECT NO. [illegible]	SIZE	SHEET 1 OF 1	DRAWING NO. TTX-600


TS01
RF TRANSMITTER
TTX 600-2-1

STABLE OSCILLATOR

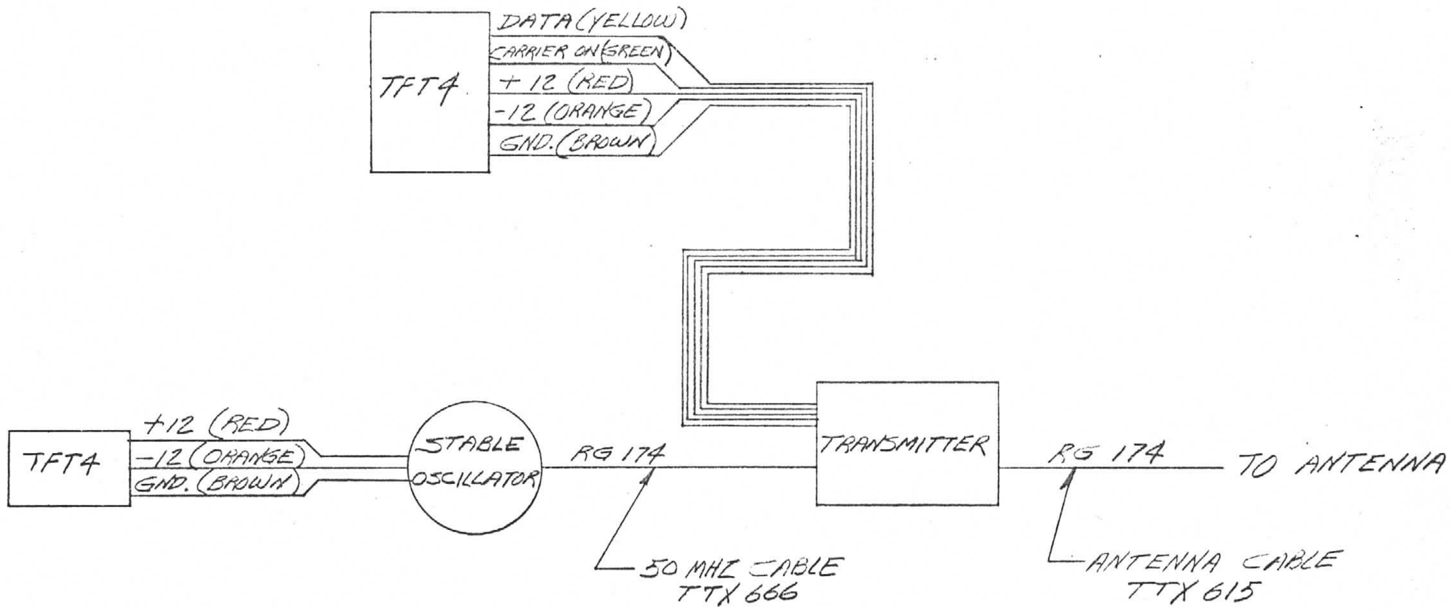
TTX 600-2-2

T W E R L E Transmitter TTX600 Date 28 March 1972 Page 1 of 1

REFERENCE		DESCRIPTION	SOURCE	QUAN. ASSY.	
...g. No	SCHEM.				
TX610		RF Section		1	
TX620		Transmitter Control		1	
TX630		Transmitter Package		1	
TX640		Oscillator-Buffer		1	
X650		Oven Temperature Controller		1	
X660		Stable Oscillator Package		1	

#TTX600-3

REVISIONS			
SYM.	DESCRIPTION	DATE	APPROVED



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TITLE: TRANSMITTER INTERCONNECT WIRING DIAGRAM			
SCALE: NONE	DRAFTSMAN	DATE CHECKER	DATE ENGINEER DATE
APPROVAL	DATE	DESIGN ACTIVITY APPROVAL	DATE ADDITIONAL APPROVAL DATE
PROJECT NO. 6300	SIZE B	SHEET 1 OF 1	DRAWING NO. TTX 600-4

REVISIONS			
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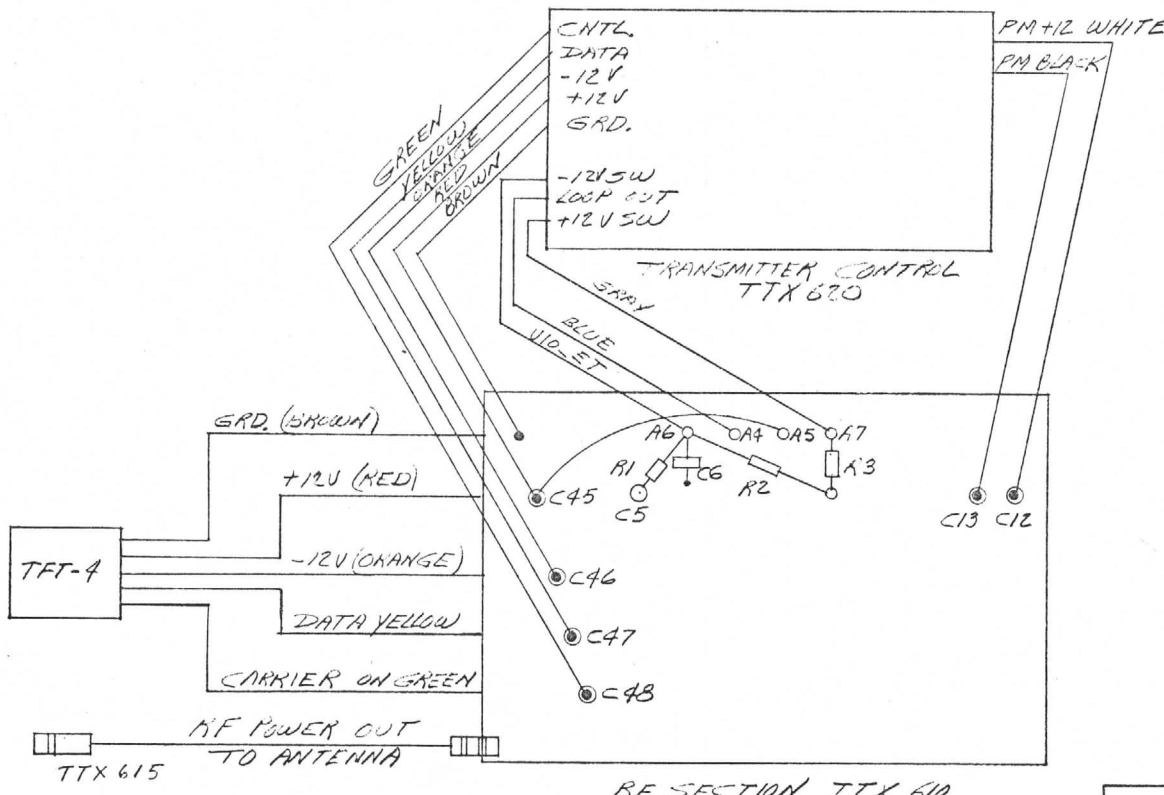

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TITLE: TRANSMITTER SECTION INTER CONNECTION DIAGRAM			
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APPROVAL	DATE	DESIGN ACTIVITY APPROVAL · DATE	ADDITIONAL APPROVAL · DATE
PROJECT NO. 6300	SIZE B	SHEET 1 OF 1	DRAWING NO. TTX 600-4-1

REVISIONS			
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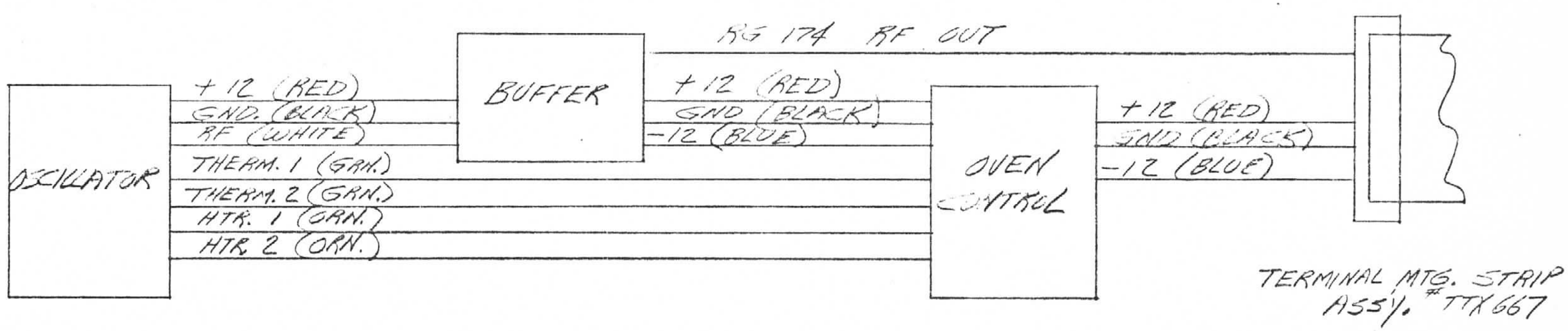

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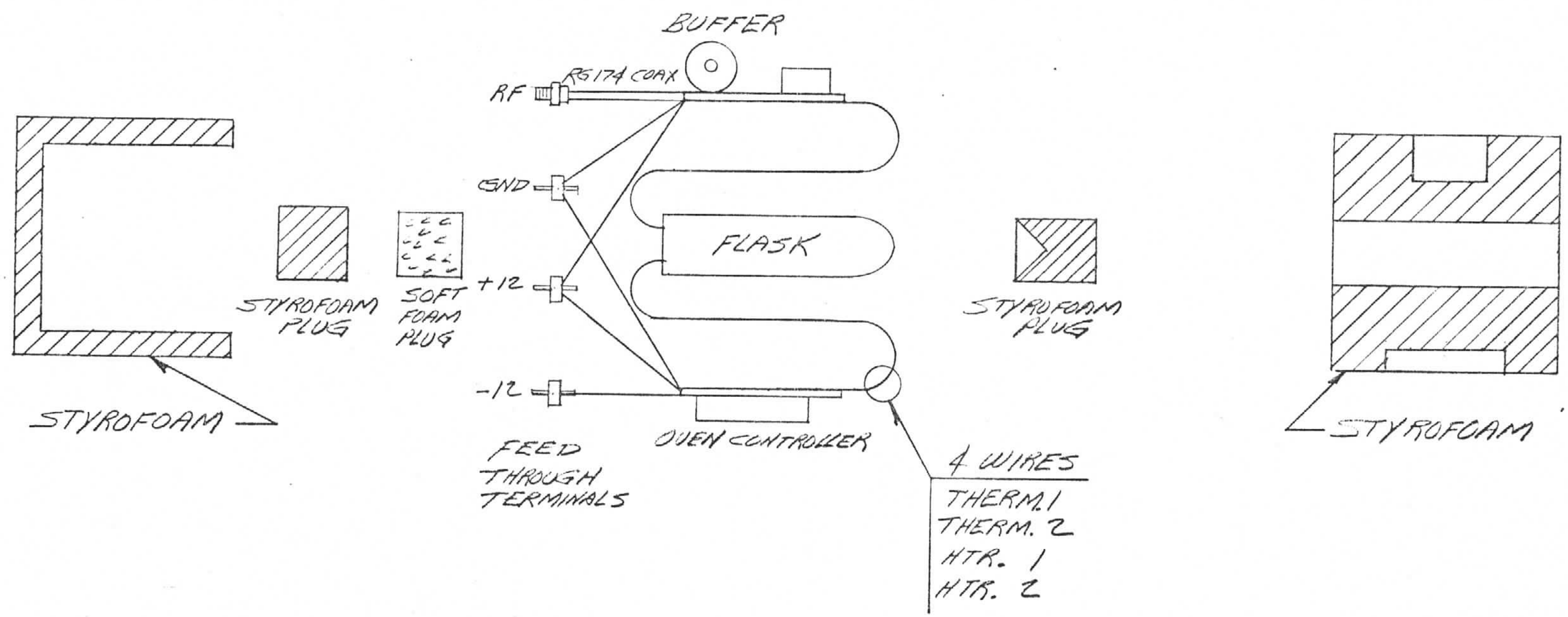
TITLE: STABLE OSCILLATOR INTERCONNECT WIRING DIAGRAM

SCALE NONE	DRAFTSMAN	DATE	CHECKER	DATE	ENGINEER	DATE
APPROVAL		DATE	DESIGN ACTIVITY APPROVAL	DATE	ADDITIONAL APPROVAL	DATE
PROJECT NO 6300	SIZE B	SHEET 1 OF 1	DRAWING NO. TTX 600-4-2			



REVISIONS

SYM.	DESCRIPTION	DATE	APPROVED

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TITLE: OSCILLATOR, BUFFER, OVEN CONTROLLER WIRING + ASSEMBLY DRAWING

SCALE NONE	DRAFTSMAN DATE	CHECKER DATE	ENGINEER DATE
APPROVAL DATE	DESIGN ACTIVITY APPROVAL DATE	ADDITIONAL APPROVAL DATE	
PROJECT NO. 6300	SIZE B	SHEET 1 OF 1	DRAWING NO. TTX 600-4-3

TWERLE TRANSMITTER--ALIGNMENT PROCEDURE

TRANSMITTER ELECTRIC SPECIFICATIONS

(not including stable oscillator package)

1. Inputs
   a. RF: 50.15 MHz 1.5V ptp ± 0.1V, 50 Ohms
   b. DC: ± 12V ± 0.1V
   c. MOD: 0, +6, +12V ± 1V
2. RF Power Output: 0.7W @ 401.2 MHz, SWR <1.1
3. DC Power Input: I_{+12V} <65 mA, I_{-12V} <65 mA (Pdc <1.6W)
4. Minimum Locking Range: 396 to 406 MHz @ SWR <1.1

*5. Locking Time: <10 msec

6. Modulation
   a. Input levels 0V, +6V, +12V, ± 1V
   b. Output levels (respectively) +60° ± 6°, 0°, -60° ± 6°
   *c. Phase transition time <100 μsec

*To be measured only at encoder-transmitter integration phase

RECOMMENDED INSTRUMENTS FOR THE TWERLE TRANSMITTER TEST SYSTEM

(Figure 2)

Signal Generator	HP 608E
Oscilloscope	TEK 7904 Mainframe
	TEK 7A19 Amp + P6051 Probe
	TEK 7A12 Amp
	TEK 7B92 Time Base
Wattmeter	BIRD Mod. 43 (N connector) with 275-1 Wattmeter Element

30 dB	Attenuator	Microlab/FXR	AA-30N
20 dB	"	"	AA-20N
0-15 dB	"	"	AJ-210N
Double Stub Tuner		"	S2-05N

Slotted Line	GR-874-LBB with 874-D20L Adjustable stub (and various GR to N and BNC adapters)
Directional Coupler	HP 774D
Spectrum Analyzer	TEK 1L20 and Scope
(Counter)	HP 5245L with HP 5253P converter plug-in

Notes:

1. Buffers, Xtal Oscillator and Ref XMTR are all TWERLE type.
2. A counter can replace the spectrum analyzer at a cost of slightly slower alignment procedure.
3. N connectors are recommended throughout the system; hence, several "subminiature" to N adapters will be needed.

ALIGNMENT PROCEDURE

POWER

1. Inspect boards, check for correct values and polarities.
2. Connect the transmitter to the test system (Figure 2).
3. Set signal generator at 50.15 MHz ± 0.1 MHz. Adjust output to be 1.5V ± 0.1V ptp into 50 Ohm load (use scope).
4. Without DC power, connect the S.G. to the transmitter 50 MHz input.
5. Measure with the scope and the 6051 probe (with its two tips adapter) between pin 1 of transformer T_1 and ground.
   Adjust C15 for maximum pulse (negative)
   Peak reading $\geq$ 2V
   1/2 voltage pulse width $\leq$ 1.2 μsec
6. Adjust R24, R40, R41, C8, C9 and C29 to approximate center.
7. Disconnect L6, on the RF board, from the "loop out" terminal and short it to ground temporarily.
8. Turn power supply on.
9. Switch on "Carrier On" for the transmitter under test only.
10. Currents should be below 100 mA each.
11. Adust C8 and C9 (go back and forth between them) to get 0.7 W RF output with minimum dc current. This minimum should not exceed 70 mA (from each supply voltage).

12. Adjust C29 to bring the free-running frequency to 401.2 ± 0.5 MHz. (You can use your reference transmitter to find the 401.2 point on the spectrum analyzer).
13. Repeat steps 11 and 12 until you obtain the specified 0.7W RF at the specified free-running frequency of 401.2 ± 0.5 MHz, with the minimum dc currents. These final minimums should not exceed 65 mA each.
14. Turn power off, connect L6 to its original place and turn power on.

LOCKING

15. Reduce the signal generator output at least 30 dB (maintain 50 Ohms).
16. Adjust R24 to read 0V on TP1. Your probe should have equivalent input impedance of 1 MOhm in parallel with 200 pF, approximately.
17. Increase the S.G. output back to its original level (1.5V ptp), and frequency of 50.15 MHz. Your output frequency should be locked (8 times the S.G. frequency). You can check the locking by slightly varying the S.G. frequency.
18. Switch "carrier on" off and on. Locking should be regained.
19. Vary the S.G. frequency up until loss of lock occurs. Back up until upon switching "carrier on" on, locking is regained. Mark fmax. fmax >407MHz (typical 411 MHz)
20. Lower the S.G. frequency and repeat. fmin <396 MHz (typical 394).

MODULATION

21. Replace the S.G. with the Xtal oscillator output. Check the SWR on the slotted line for each transmitter separately (use "carrier on" switches). If either SWR is worse than 1.01 readjust the tuning stub. (Use the oscilloscope to read the null from the slotted line detector).
22. Switch both carriers "on"
23. Set modulation switch at 0°. Find and mark the null position, Do. (Adjust the 0-15 dB attenuator for minimum null).
24. Switch to "-60°". Bring the slotted line detector to Do -62.5mm (move toward the transmitter under test). Adjust R41 for null at that point. (If you can't achieve null, remove R43. If you still can't achieve null, connect R43 at the alternate position).

25. Switch to "+60°". Move the slotted line detector to Do + 62.5mm (move toward the reference transmitter). Adjust R40 for null at that point.
26. Repeat steps 23, 24 and 25 once more.
27. Switch carrier off to both. Shut down the power to the transmitter under test.
28. Remove the tested transmitter, insert it into its package, and reconnect it to the system.
29. Switch power on and carrier on.
30. Monitor and record DC supply currents and RF power out.
31. Switch the reference transmitter carrier on, monitor and record the null positions for -60°, 0° and +60°.
32. Switch the reference carrier off. Replace the crystal oscillator with the S.G.
33. Monitor and record the minimum and maximum locking frequency (steps 19 and 20).

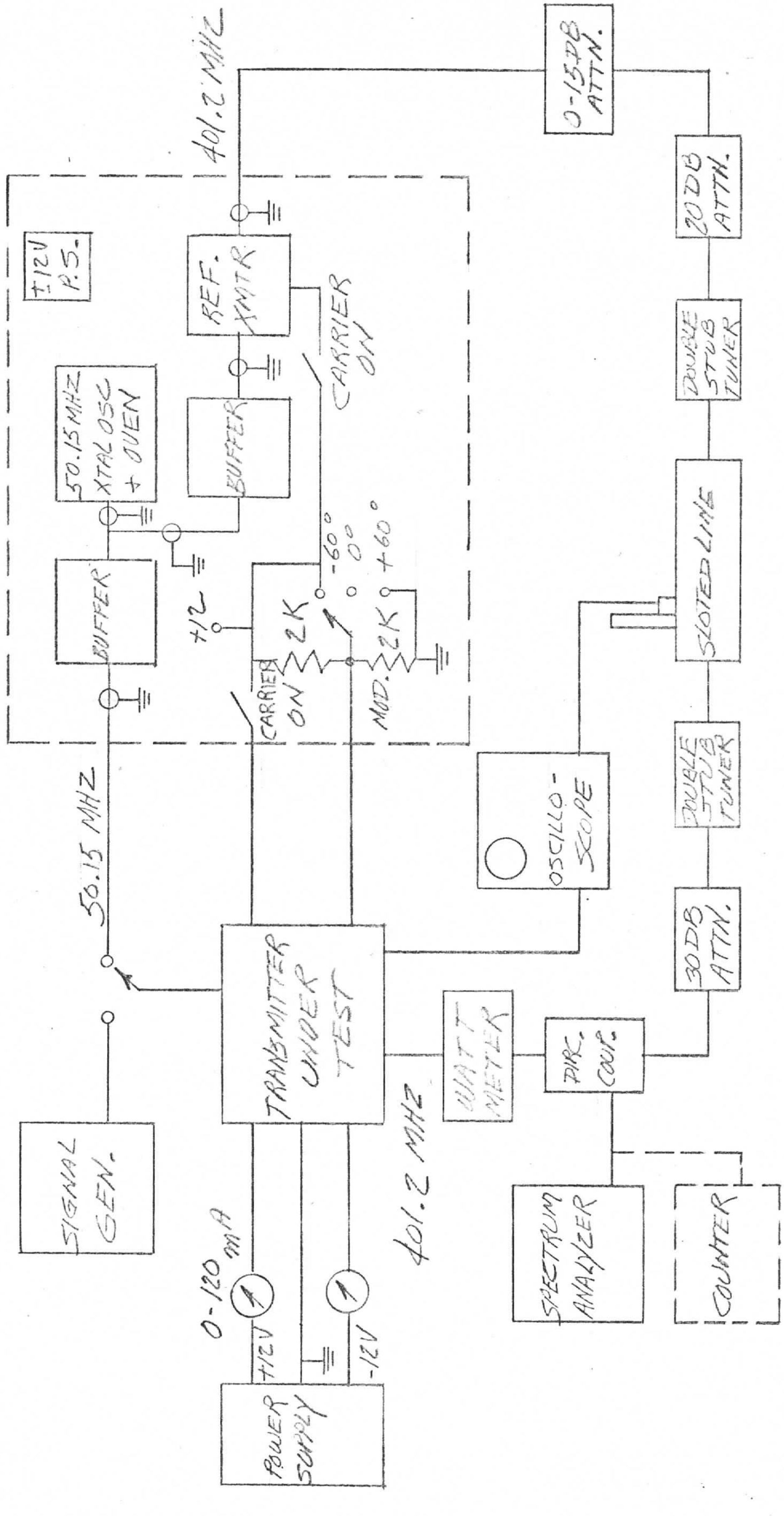


FIGURE 2

TWERLE TRANSMITTER TEST SYSTEM

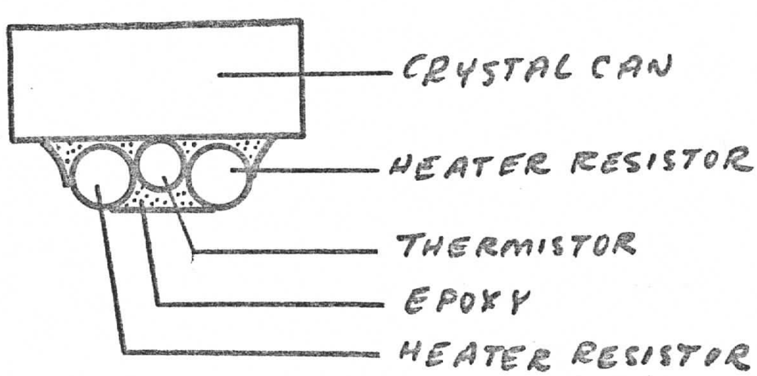
ASSEMBLY AND ALIGNMENT OF STABLE OSCILLATOR

The stable oscillator components fall into two categories, electrical circuitry and thermal packaging. The electrical circuitry consists of three subassemblies: the oscillator, the buffer, and the oven controller. The thermal packaging consists of three subassemblies also. These are the Dewar flask, the stable oscillator package and the spherical enclosure.

The assembly of the oscillator system is begun with the mounting of the thermistor onto the oscillator board. The mounting of the thermistor is critical because the thermistor provides the feedback in the temperature stabilization scheme of the oscillator.

A. MOUNTING OF THERMISTOR AND CRYSTAL ONTO OSCILLATOR BOARD

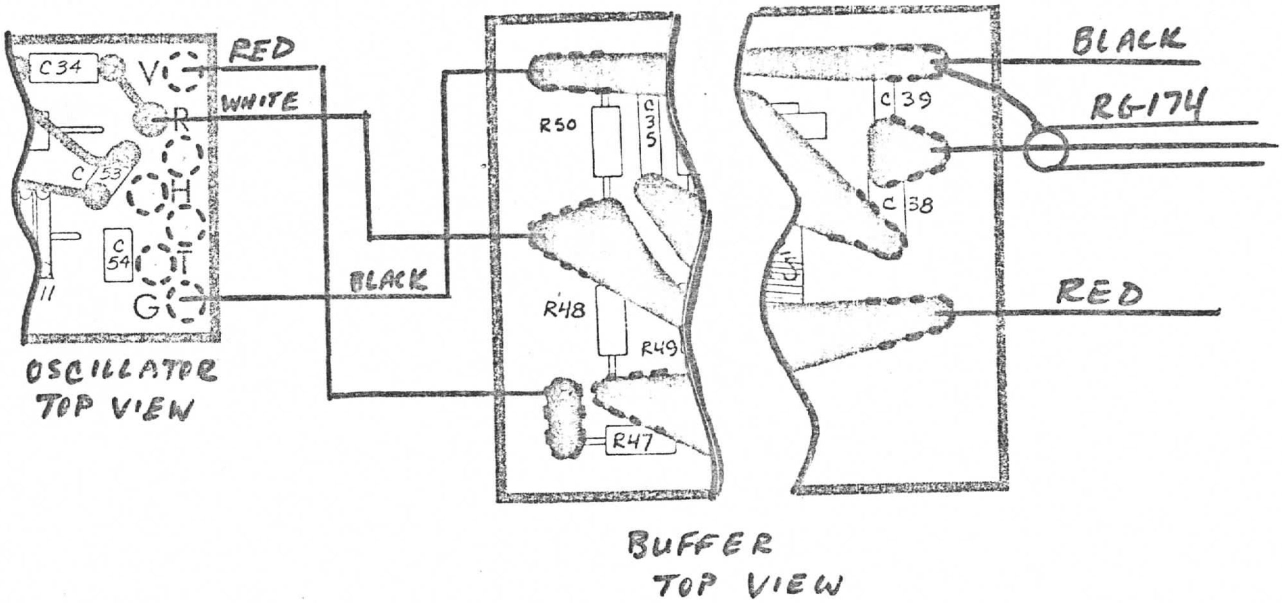
1. Mount the thermistor, R55, between the two heater resistors, R53 and R54, using 5-minute epoxy. The thermistor should be touching both heater resistors at their midpoint with a minimum of epoxy at the point of contact. This scheme of mounting ensures a fast thermal response.
2. Position the crystal can above the heater resistors so that the can is in contact with both the thermistor and the heater resistors. Fix the crystal can in place using 5-minute epoxy. The assembly should appear as shown in the sketch below:



B. CHECKOUT OF THE OSCILLATOR-BUFFER ASSEMBLY

1. Interconnect the oscillator and the buffer boards using appropriately colored #32 insulated, stranded wire as shown below. The lengths

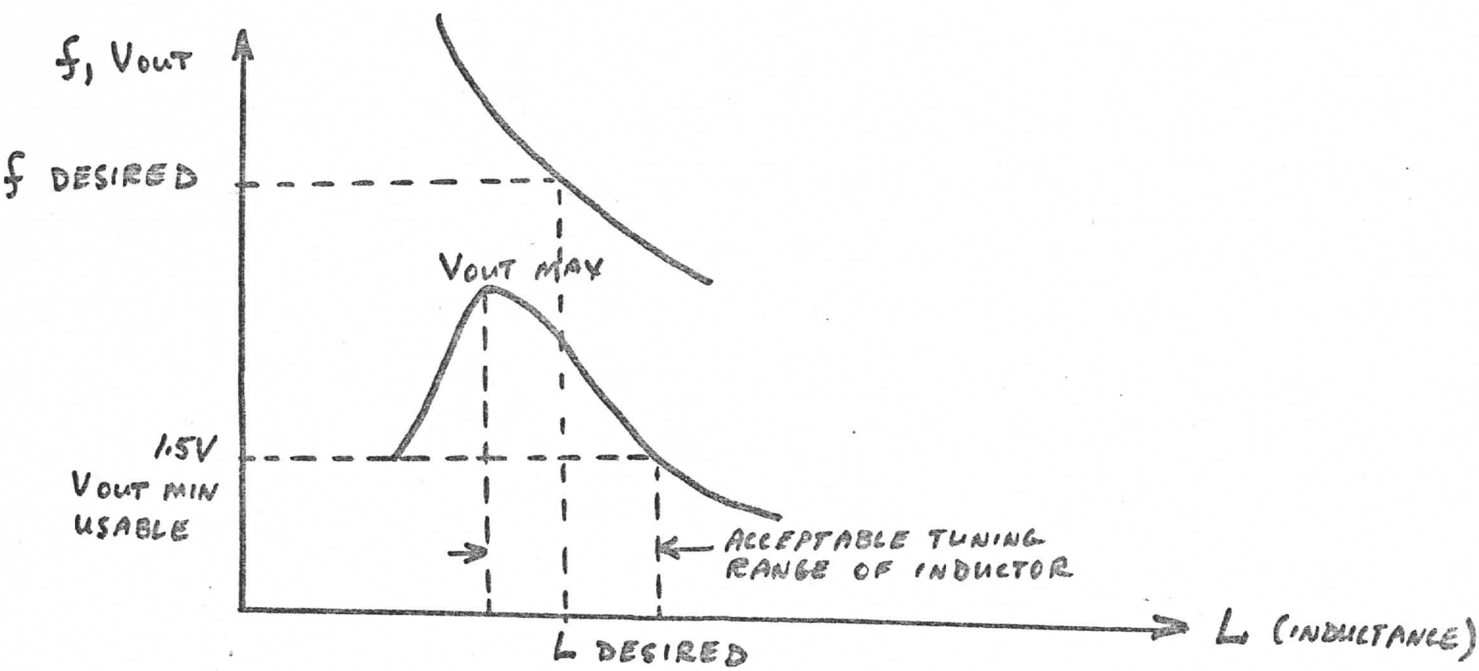
shown are approximate and will be trimmed during final packaging. Attach +12V and ground wires from the output of the buffer to a suitable power supply.



2. Attach a 50Ω miniature coaxial cable (RG174) to the RF output of the buffer and connect via a miniature coax connector and "T" adapter to a 50Ω input impedance 500 MHz scope and to a high impedance frequency counter.
3. Apply power to the oscillator-buffer assembly and observe the 50 MHz waveform which should be quite sinusoidal in shape. Current drawn should be about 10 ma.
4. Tune the buffer output coil, L12, for maximum RF amplitude using an insulating tuning wand. An amplitude of 1.5 volts peak to peak, or greater, passes the rough acceptance test.
5. Observe the counted frequency. A frequency of between 50,147,800 and 50,152,200 Hz passes the rough acceptance test.
6. Allow the oscillator-buffer system to run continuously for two weeks to age the crystal.
7. Insert the oscillator into the Dewar flask and observe the resultant RF amplitude and frequency. The amp frequency should increase slightly. If upon insertion the resultant amplitude is equal to or greater than 1.5 volts peak to peak and the resultant frequency is within the range of 50,149,750 - 50,150,250 Hz, the unit passes the fine acceptance test for RF amplitude and frequency.

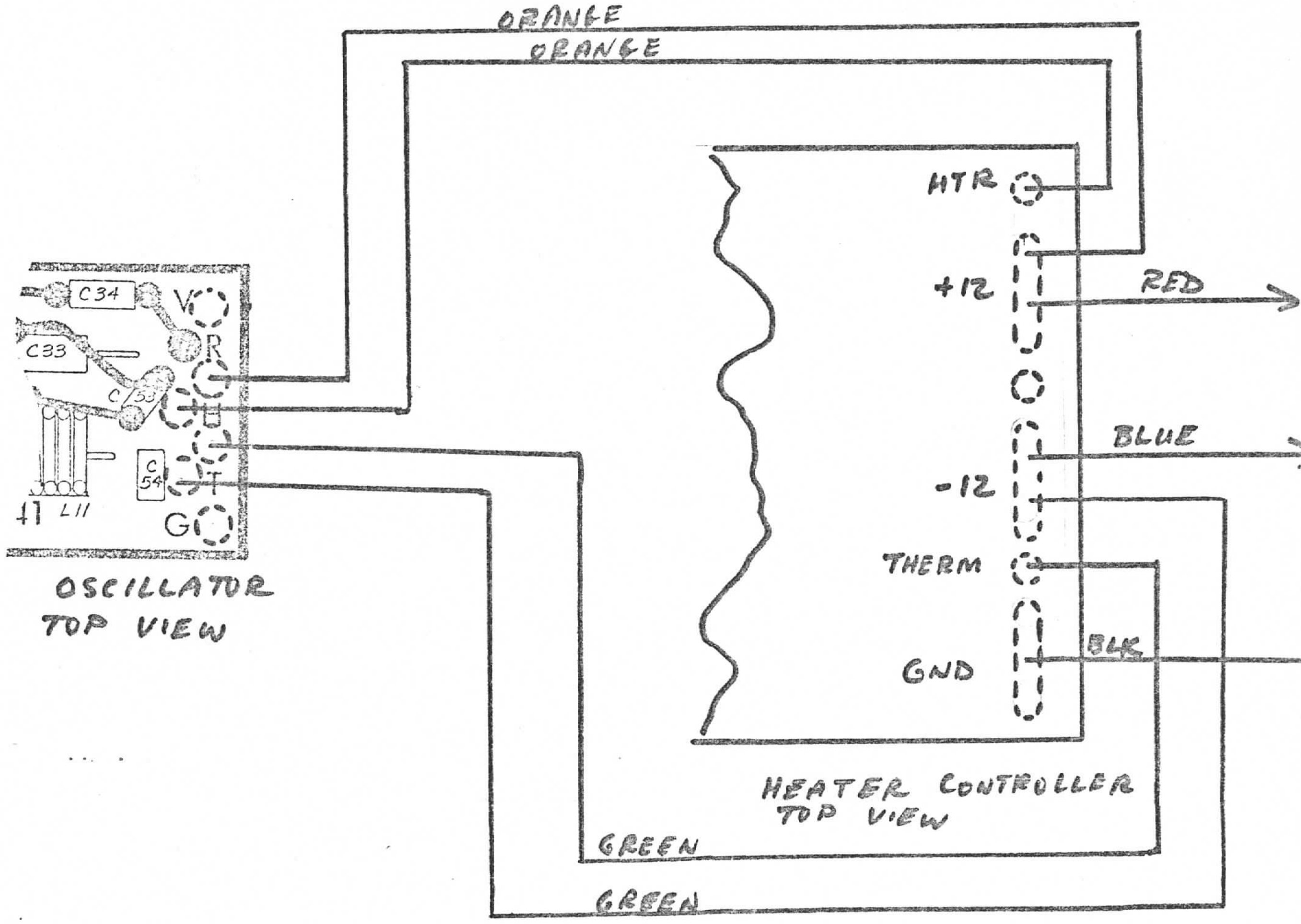
8. If the oscillator-buffer assembly cannot pass item 7., the amplitude and/or the frequency of the oscillator output must be adjusted. The frequency can be adjusted most conveniently by changing the inductance of the oscillator coil (L11). Spreading the turns lowers the inductance of the coil. Compressing the turns has the opposite effect. The adjustment process is iterative. A simple tuning wand made of a polystyrene rod with a ferrite bead mounted on one end and a brass slug mounted on the other simplifies the oscillator coil adjustment. When inserted into the coil, the ferrite end increases coil inductance; the brass end decreases the inductance.

9. Adjust the coil inductance until the operating point of the oscillator lies within the proper operating area as specified in the composite operation curve diagram below. Fine tuning of the inductor, within the operating range, brings the oscillator to the desired frequency.



C. OVEN CONTROLLER ATTACHMENT AND SETTING OF OVEN TEMPERATURE

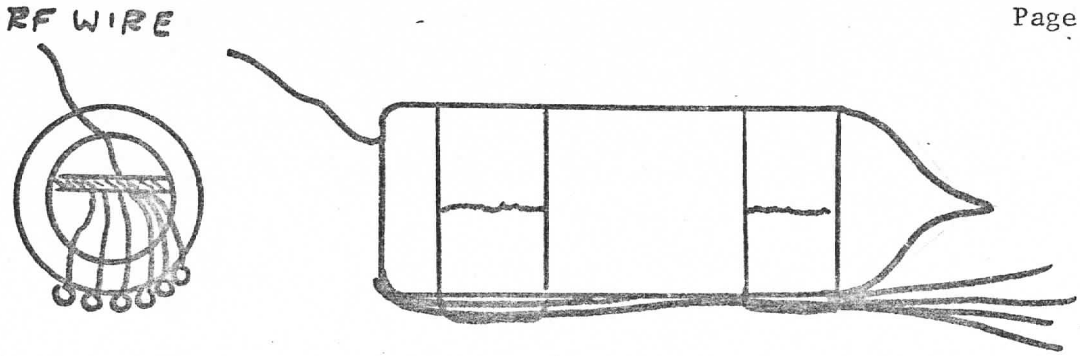
1. Connect the oven controller to the oscillator using #32 insulated, stranded wires, 8" long. For the heater use orange wires; for the thermistor use green wires. Also attach the specified color wires to the power supply pads on the oven controller. All wires will be trimmed during final packaging.



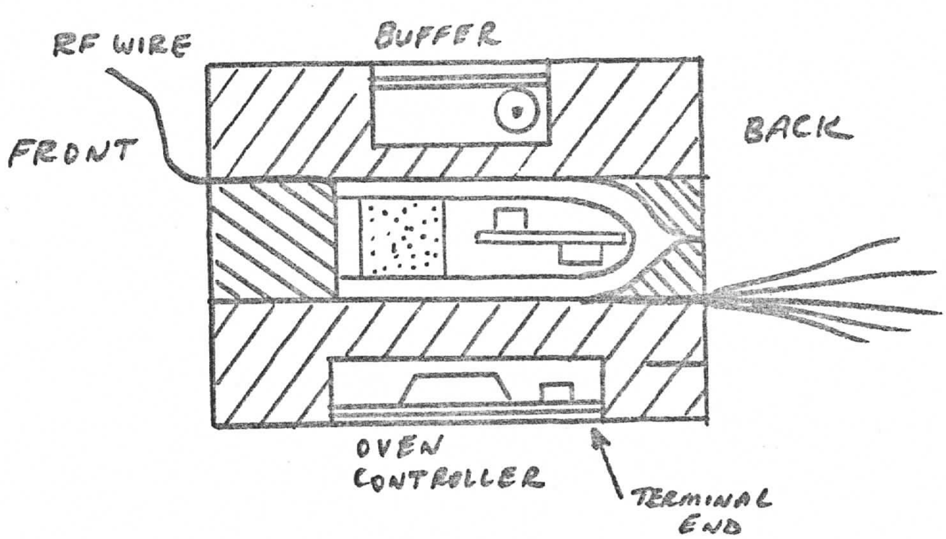
2. Apply power to the assembly. The total current drawn from the +12V supply should be about 11 - 35 ma and the current drawn from the -12V supply should be about 6 - 30 ma.

D. ASSEMBLY OF THE OSCILLATOR INTO THE THERMAL PACKAGE

1. Disconnect all oscillator wires at the buffer and oven controller end.
2. Insert the oscillator board into the Dewar flask as far as possible.
3. Separate the RF wire from the rest of the wires. Arrange the larger group of wires in an orderly fashion around one side of the flask and tape the wires near the neck and near the pointed end using cellophane tape (scotch magic tape). The assembly will appear as shown in the drawing.



4. Insert the flask, open end first, into the inner component support jacket (TTX 662) until the pointed end of the flask lies just inside the styrofoam jacket. Press a 3/4" long, 1" diameter styrofoam plug over the pointed end of the Dewar flask. Cut off any excess flush with the styrofoam jacket.
5. Insert a 1" long, 1" diameter soft polyurethane foam plug into the neck of the flask.
6. Press a 1" long, 1" diameter styrofoam plug into the front hole in the insulating jacket and cut off any excess flush with the jacket. The assembly will appear as follows:



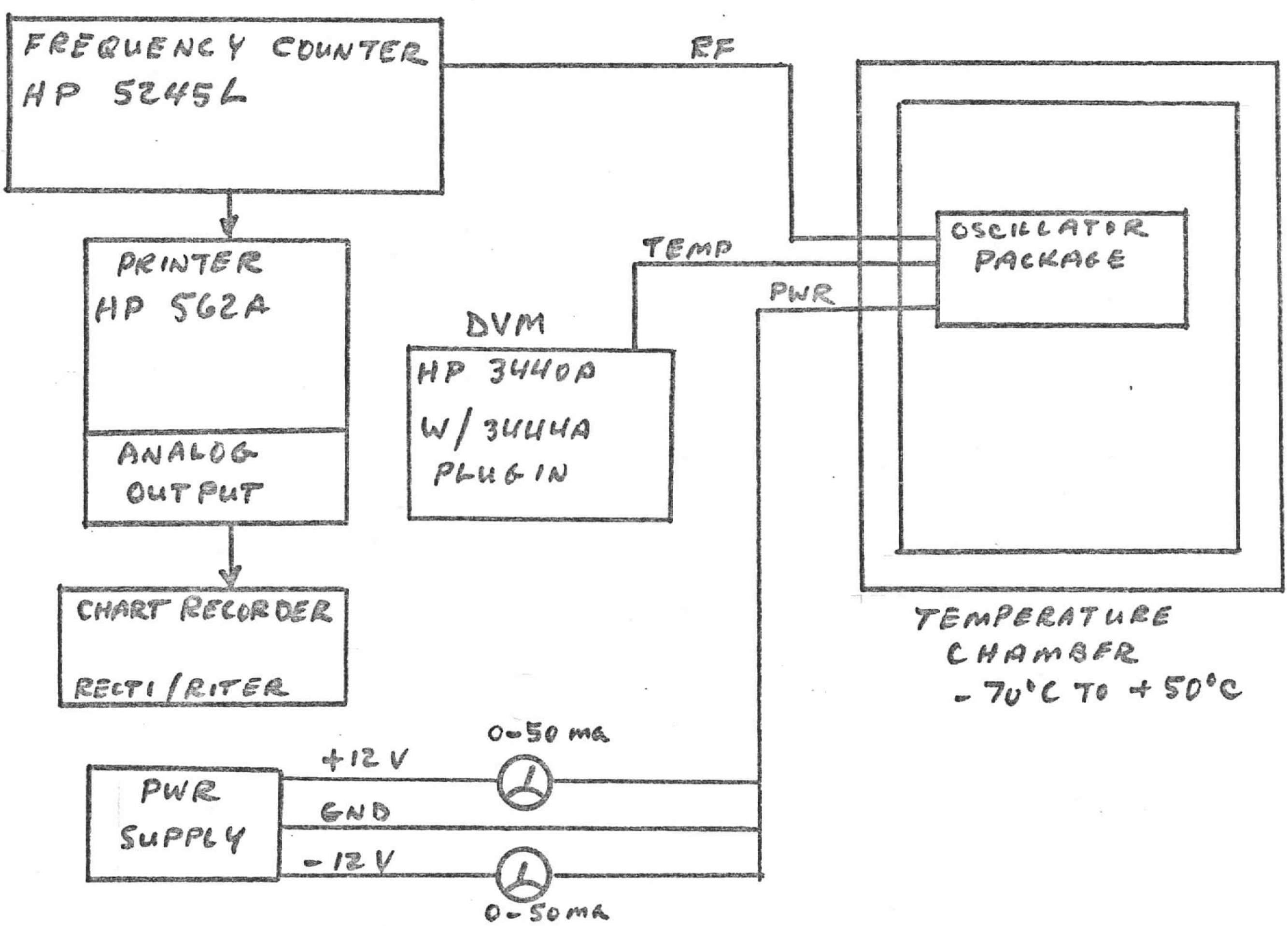
7. Place buffer and oven controller boards into the pockets of the inner jacket as shown above and reconnect the wires from the oscillator to the buffer and the oven controller, trimming off any excess wire length.

Use a hot soldering iron tip to form appropriate wire channels. The white RF wire should be completely separate from the other wires.

8. Connect separate 8" long supply leads to both the buffer (+12V, GND) and the oven controller (±12V, GND) and an 8" piece of RG174 coaxial cable to the RF output of the buffer.
9. Press the outer insulating jacket (TTX661) over the front of the inner jacket until the back edges are flush.
10. Solder the power supply leads and the coaxial cable to the terminals on the terminal strip (TTX667).
11. Wrap the styrofoam assembly with the foil pattern (TTX663) and fasten the foil at the terminals using flat washers, lock washers, and nuts

E. FREQUENCY STABILITY TEST FOR OSCILLATOR

1. Assemble the test system shown below.



The temperature is measured via a thermistor taped to the side of the oscillator package. The oscillator package is enclosed in a plastic bag to keep any air currents away from the thermistor.

2. Set the temperature chamber to -10°C and allow to stabilize.
3. Turn on the power to the oscillator and observe the currents after the oven has stabilized. The current drawn from the +12V supply should be about 12.5 ma and that from the -12V supply about 7.5 ma.
4. Mark the frequency at -10°C when the system has stabilized (~ 2 hours).
5. Make a temperature step to -40°C and observe the frequency plot once the system has stabilized at -40°C. For a 30°C step the frequency change should be equal to or less than 30 Hz for an acceptable oscillator system.
6. Record the absolute frequencies at -10°C and at -40°C, and the corresponding supply currents.

F. ASSEMBLY OF OSCILLATOR PACKAGE INTO SPHERICAL ENCLOSURE

1. Attach the 50 MHz cable and the power supply lead-connector assembly.
2. Insert the completed package into the spherical shell, bring out the coaxial cable and power leads, and tape the spherical shell shut with aluminized mylar tape.
3. Encase the spherical shell in the support net and fasten the net tight.

TEST SPECIFICATIONS FOR ACCEPTANCE

The following test should be performed by the manufacturer before the unit is accepted by NCAR.

In general the acceptance test should use the transmitter test system (TTX600-5-1, Page 5), and the stable oscillator test system (TTX600-5-2, Page 6) or parts thereof.

1. Transmitter

   a. Temperature cycling--Bring the non-operating transmitter to -70°C for a period of 2 hours, up to room temperature for 2 hours, down to -70°C for 2 hours, and up to room temperature again.

   b. Connect the transmitter to the test system described in the alignment procedure (TTX600-5-1) with the following inputs:

      (1) RF: 50.15 MHz ± 0.1MHz, 1.5V ptp ± 0.1V, 50 Ohms (from the signal generator)

      (2) DC: ± 12V ± 0.1V

      (3) MOD: +6V ± 1V (from the Mod switch)

   c. Switch power on, and carrier on, recheck the SWR for both the transmitter under test and the reference transmitter, and readjust if SWR >1.01.

   d. RF power output should be greater than 0.7W

   e. RF frequency should be locked to the S.G. frequency (8 x 50.15 MHz = 401.2 MHz)

   f. DC current consumption from each voltage supply should be less than 65 mA

   g. Switch carrier off. Adjust the S.G. frequency to 50.75 MHz ± 0.1 MHz and switch carrier on. The output frequency should lock at 406 MHz (= 8 x 50.75 MHz)

   h. Switch carrier off, adjust the S.G. frequency to 49.50 MHz ± 0.1 MHz and switch carrier on. The output frequency should lock at 396 MHz (= 8 x 49.50 MHz)

   i. Replace the S.G. with the crystal-controlled 50.15 MHz signal input. Switch the reference transmitter carrier on. Find the null on the slotted line and readjust the 0-15 dB attenuator for a minimum null.

j. Recheck the null position and mark it as the 0 degrees position.

k. Switch the Modulation switch to -60 degrees (OV), and find the new position of the null. The -60 degrees position should be 62.5 mm ± 6 mm from the 0 degrees position, toward the transmitter under test.

l. Switch the Modulation switch to +60 degrees (+12 V), and find the new position of the null. The +60 degrees position should be 62.5 mm ± 6 mm from the 0 degrees position, toward the reference transmitter.

2. <u>Stable Oscillator</u>

a. Temperature cycling--Bring the non-operating but connected oscillator to -70°C for a period of 2 hours, up to -10°C for a period of 2 hours, and down to -40°C for a period of 2 hours.

b. After 2 hours at -40°C switch power on and wait for an additional 2 hours before performing the next measurement.

c. DC current consumption should be less than: 20 mA from the + 12V
15 mA from the - 12V

d. The output signal voltage should be between 1.5 V and 2 V.

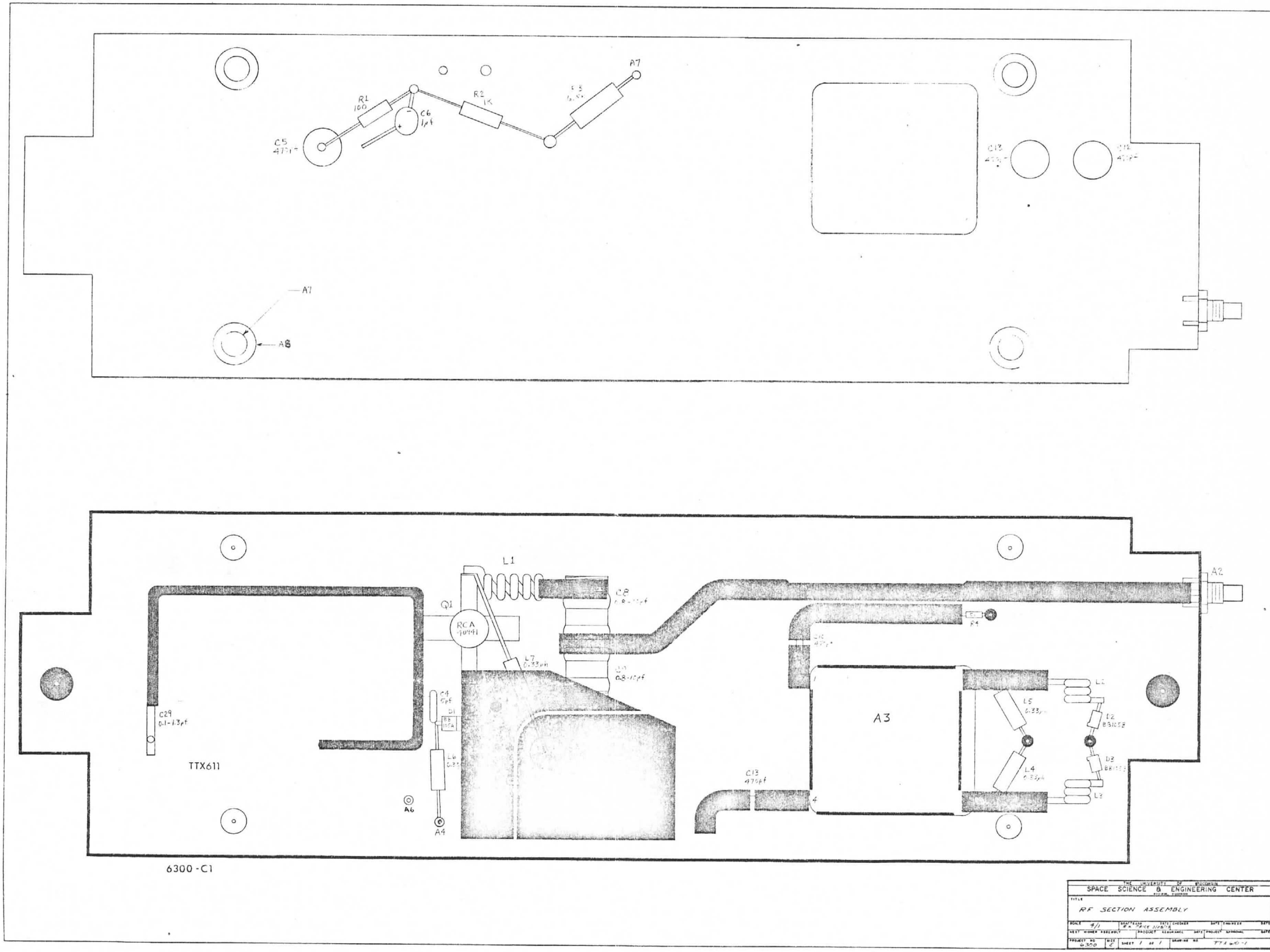
e. The signal frequency should be between 50,149,600 Hz and 50,150,400 Hz. Record the exact frequency as the -40°C frequency f(-40°C).

f. Make a temperature step to -10°C and allow 1 hour before performing the next measurement.

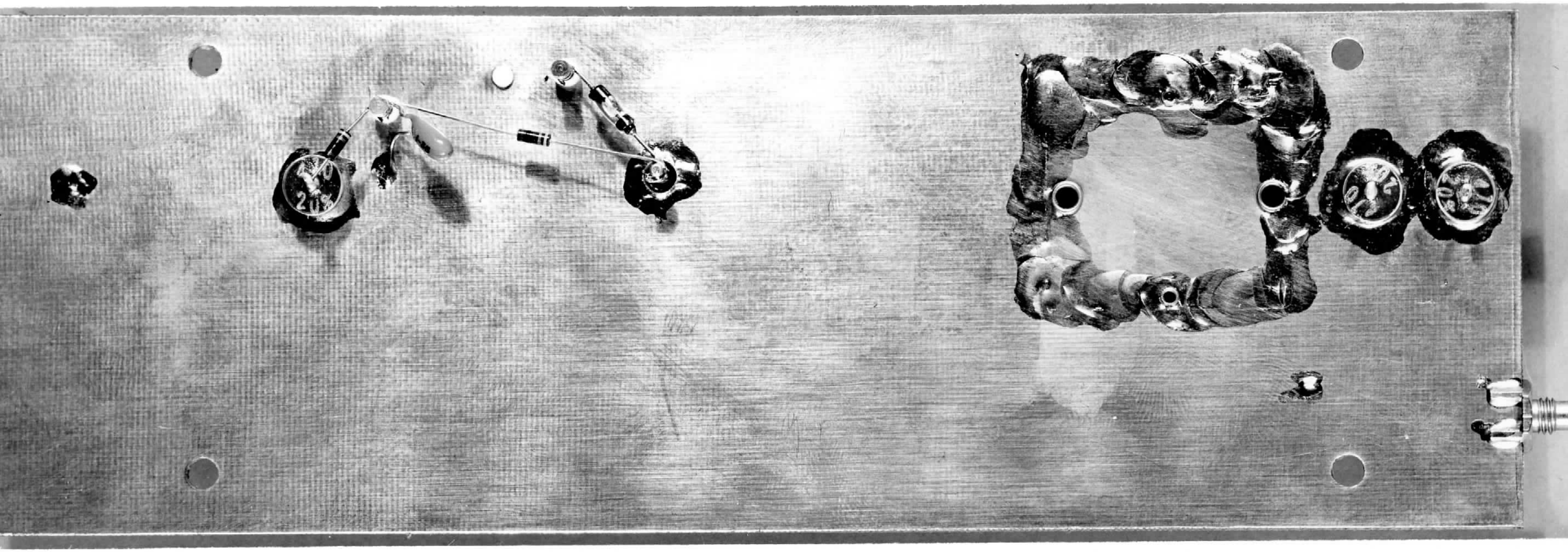
g. Measure the frequency, and record it as the -10°C frequency f(-10°C). The difference between this frequency and the frequency measured at -40°C should be less than ± 30 Hz.

$$|f(-10°C) - f(-40°C)| < 30 \text{ Hz}$$

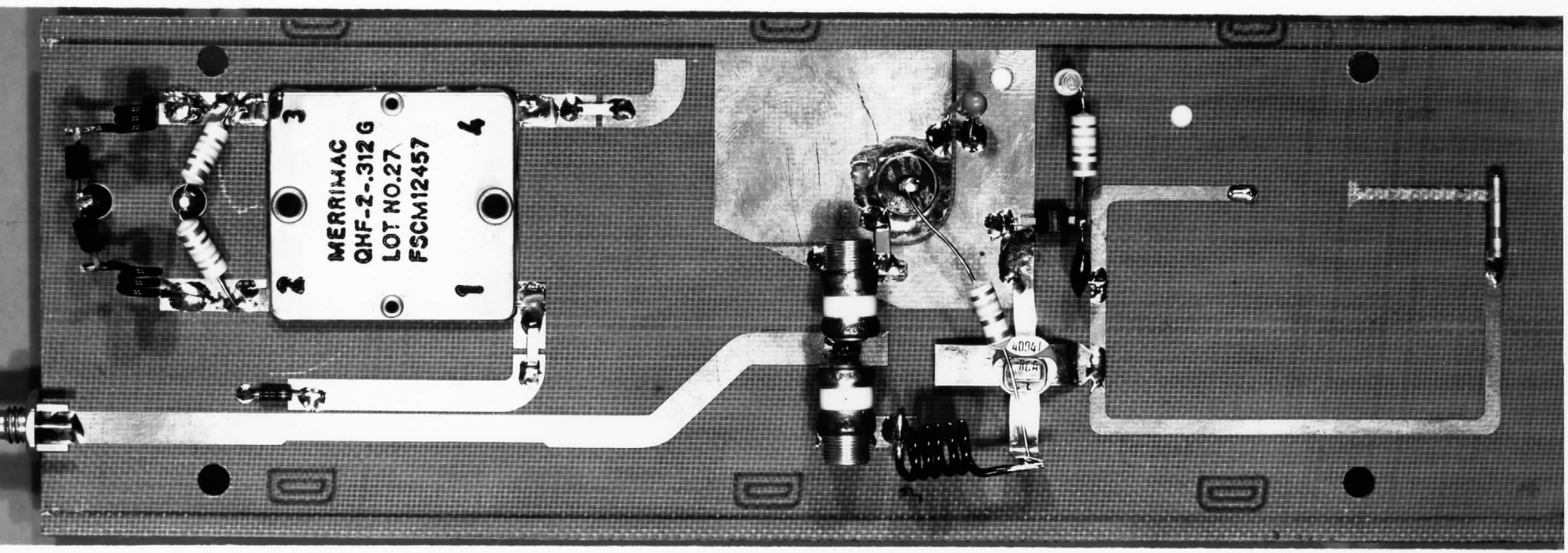
h. Repeat d.



A7
R1
100
C6
1µf
R2
1K
C5
47µf
C13
C12
A8
L1
C8
Q1
RCA
A2
R4
A3
L2
D2
L5
L4
D3
L3
L7
0.33µh
0.8-10pf
C4
5pf
D1
L6
C29
0.1-1.3pf
TTX611
C13
470pf
A6
A4
6300-C1
THE UNIVERSITY OF WISCONSIN
SPACE SCIENCE & ENGINEERING CENTER
TITLE
RF SECTION ASSEMBLY
SCALE 4/1
DRAFTSMAN R.A. PRICE
CHECKER
ENGINEER
NEXT HIGHER ASSEMBLY
PRODUCT ASSURANCE
PROJECT APPROVAL
PROJECT NO 6300
SIZE C
SHEET 1 OF 1
DRAWING NO



RF SECTION ASSEMBLY
TTX 610-2a



RF SECTION ASSEMBLY

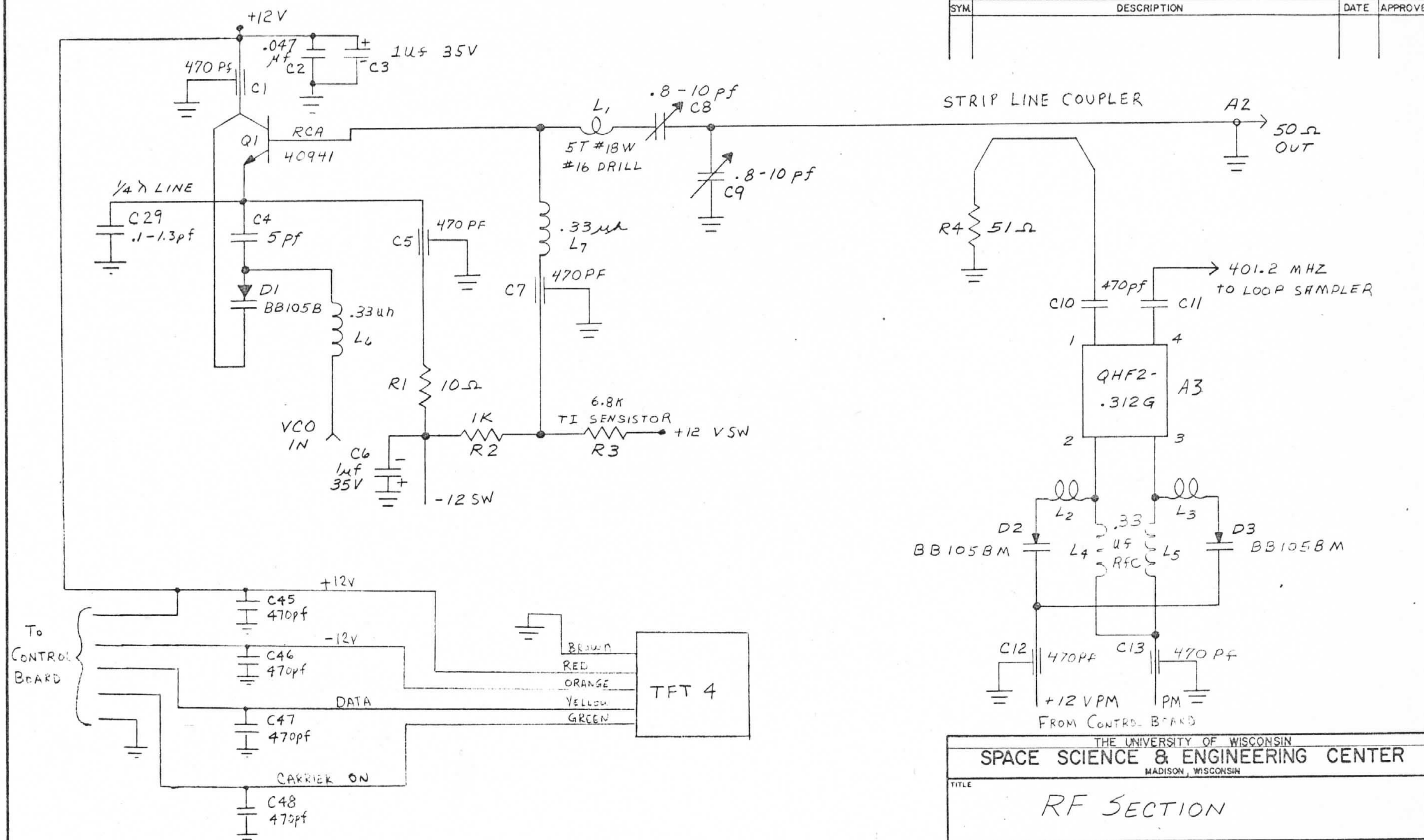
TTX 610-2b

T W E R L E TRANSMITTER TTX 610 Date 16 March 1973 Page 1 of 2

REFERENCE Dwg. No	SCHEM.	DESCRIPTION	SOURCE	QUAN. ASSY.	
610-4	C1	Capacitor, 470 pf 20% Ceramic Feed Thru	Allen Bradley FA5C-4712	5	
"	C2	Capacitor, 0.047µf 20% Ceramic Chip	Allen Bradley MB007BA473M	1	
"	C3	Capacitor, 1µf Tantalum 35V	Sprague 196D 105X9035HA1	2	
"	C4	Capacitor, 5 pf $\pm$ 1 pf Silver Mica	Cornell Dubilier CD6CD050C	1	
"	C5	Same as C1			
"	C6	Same as C3			
"	C7	Same as C1			
"	C8	Capacitor, Variable 0.8 - 10. pf	JFD MVM010W	2	
"	C9	Same as C8			
"	C10	Capacitor, 470 pf 20% Ceramic Chip	Allen Bradley MB005DC471K	2	
"	C11	Same as C10			
"	C12	Same as C1			
"	C13	Same as C1			
"	C29	Capacitor, Variable 0.1 - 1.3 pf	Johanson 7201	1	
"	C45	Capacitor, Ceramic Stand Off 470 pt. 20%	Allen Bradley SS5D-4712	4	
"	C46	Same as C45			
	C47	Same as C45			
	C48	Same as C45			
610-4	D1	Diode, Varactor	Motorola BB105B	3	
"	D2	Same as D1			
"	D3	Same as D1			
610-4	L1	Inductor, (P/N TTX 612)	In House Manufacturer	1	
"	L2	Inductor, (P/N TTX 613)	In House Manufacturer	1	
"	L3	Inductor, (P/N TTX 614)	In House Manufacturer	1	
"	L4	Inductor, 0.33µh	Nytronics Wee Wee 0.33	4	
"	L5	Same as L4			
"	L6	Same as L4			
"	L7	Same as L4			

T W E R L E TRANSMITTER TTX 610 Date 16 March 1973

REFERENCE wg. No	SCHEM.	DESCRIPTION	SOURCE	QUAN. ASSY.	
610-4	R1	Resistor, Carbon Composition 10K 1/8W 5%	Allen Bradley RC05GF103J	1	
"	R2	Resistor, Carbon Composition 1K 1/8W 5%	Allen Bradley RC05GF102J	1	
"	R3	Resistor, Silicon 6800 ohms 1/8W	Texas Instruments TG 1/8 6800	1	
"	R4	Resistor, Carbon Composition 51 1/8W 5%	Allen Bradley RC05GF510J	1	
610-4	Q1	Transistor, RF NPN	RCA 40941	1	
611	A1	RF Printed Circuit, Teflon		1	
610-4	A2	Connector 50 ohm miniature	Sealectro 50-051-0000	1	
"	A3	Coupler, 90 degree 225 - 400 MHz	Merrimac QHF 2 - .312G		
610-1	A4	Feed Thru Terminal, Teflon	Sealectro FTSM16	2	
"	A5	Same as A4			
"	A6	Stand Off Terminal, Teflon	Sealectro STSM16	1	
"	A7	Spacer, Teflon	Sealectro 227282	4	
"	A8	Washer, Flat Nylon #6	GC & Walsco No. 9959-C	4	
615	A9	Connector, 50 ohm coaxial	Sealectro 50-007-0000	2	
"	A10	Same as A9			
"	A11	Cable 1 foot RG174	Belden		
10-1	A12	Same as A6			



REVISIONS			
SYM.	DESCRIPTION	DATE	APPROVED

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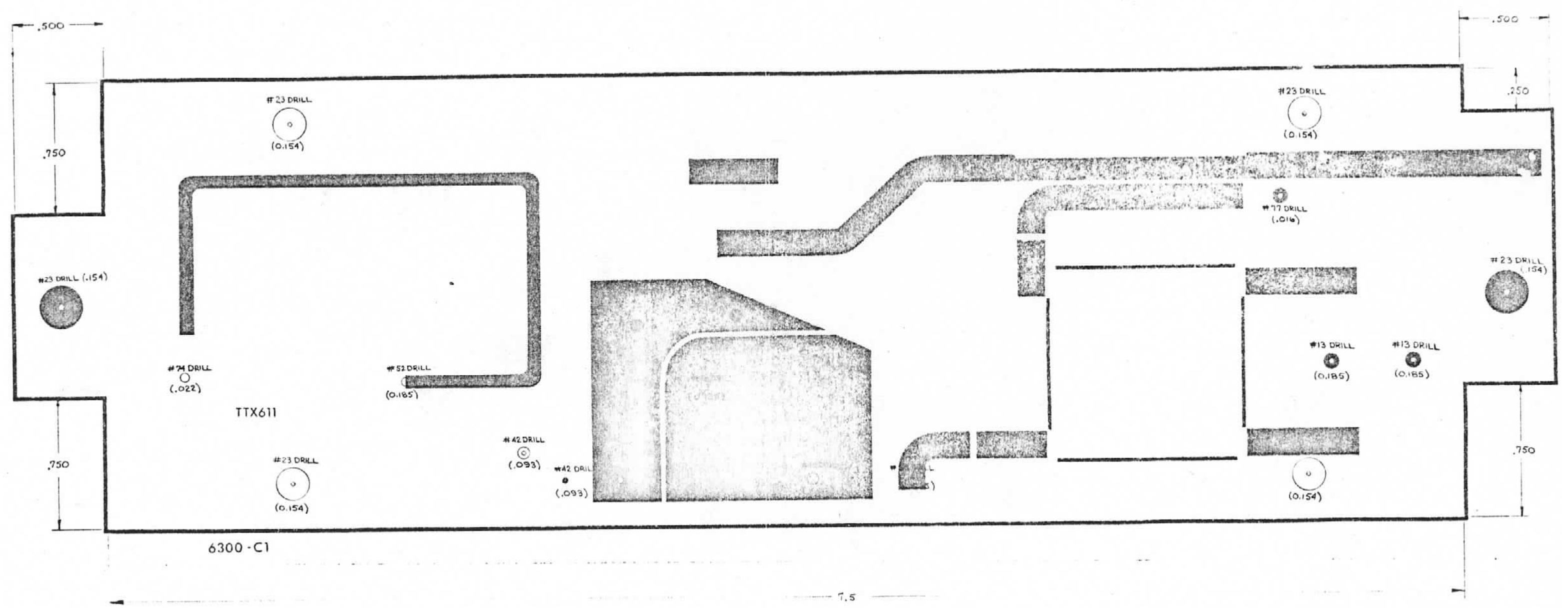
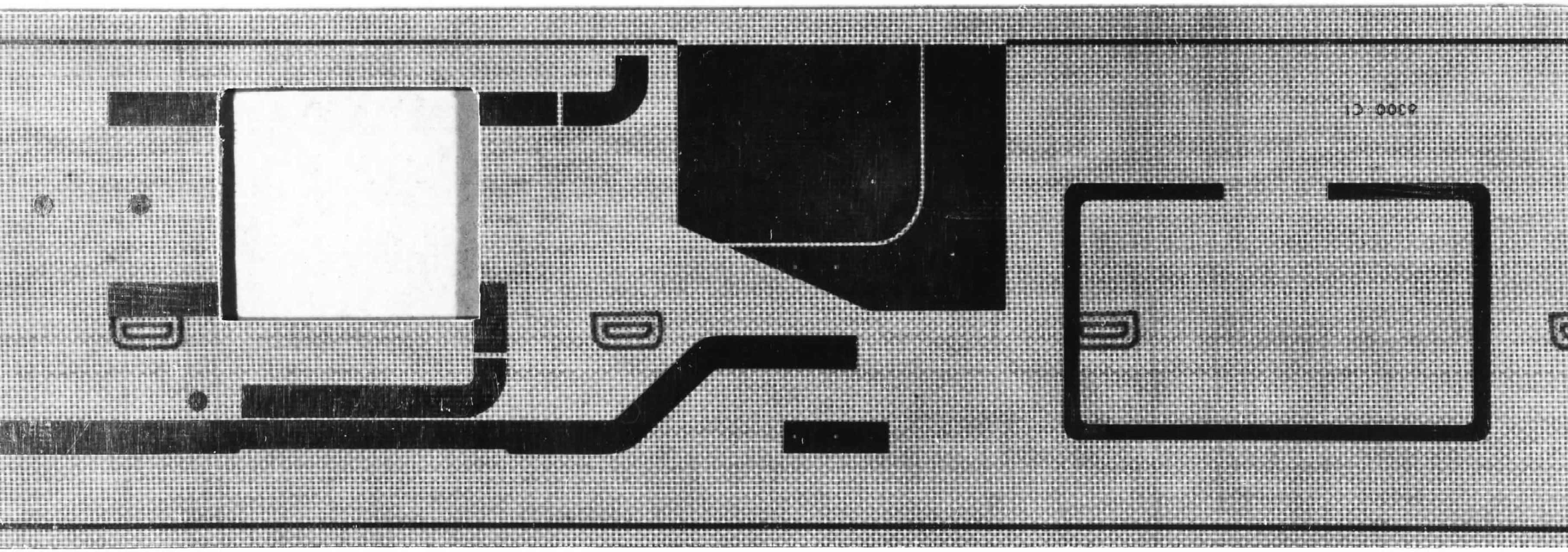
TITLE: RF SECTION

SCALE	DRAFTSMAN / DATE	CHECKER / DATE	ENGINEER / DATE
NONE	J. DENNIS 3-13-73		R OEHLKERS 3-28-73
APPROVAL	DATE / DESIGN ACTIVITY APPROVAL	DATE / ADDITIONAL APPROVAL	DATE
PROJECT NO. 6300	SIZE B	SHEET 1 OF 1	DRAWING NO. TTX 610-4



MATERIAL:
DODGE INDUSTRIES
FLUOR GLASS 601/2
P/N E601/2-.62CB
THICKNESS: 0.62

SPACE SCIENCE & ENGINEERING CENTER
4/1



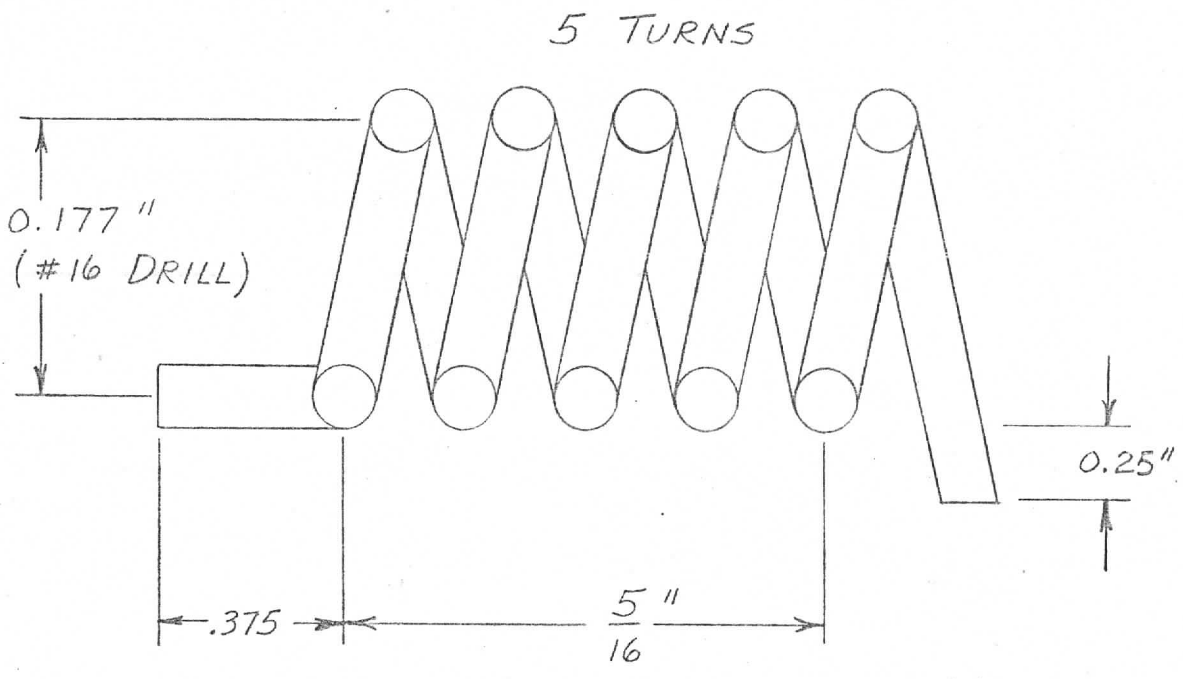
RF SECTION PC
TTX 611-3

REVISIONS			
LTR.	DESCRIPTION	DATE	APPROVED

MATERIAL: HEAVY FORMVAR MAGNET WIRE

WIRE SIZE: #20

NOTE: LEADS STRIPPED & TINNED .25"



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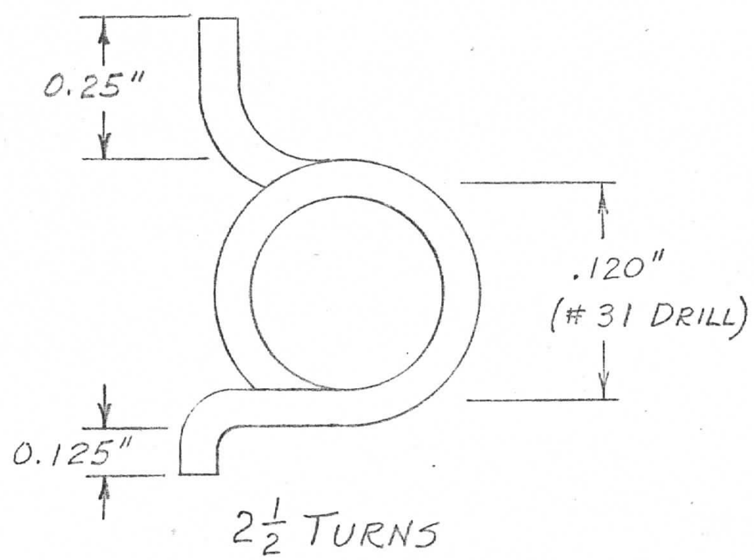
SPACE SCIENCE & ENGINEERING CENTER
MADISON, WISCONSIN

TITLE: INDUCTOR – L1			
SCALE: NONE	DRAFTSMAN: J. DENNIS — DATE: 3-15-73	CHECKER — DATE	ENGINEER — DATE
NEXT HIGHER ASSEMBLY	PRODUCT ASSURANCE — DATE	PROJECT APPROVAL — DATE	
PROJECT NO. 6300 — SIZE A	SHEET 1 OF 1	DRAWING NO. TTX-612	

REVISIONS			
LTR.	DESCRIPTION	DATE	APPROVED

MATERIAL: HEAVY FORMVAR MAGNET WIRE

WIRE SIZE: #18



NOTE: LEADS STRIPPED & TINNED $\frac{1}{4}$"

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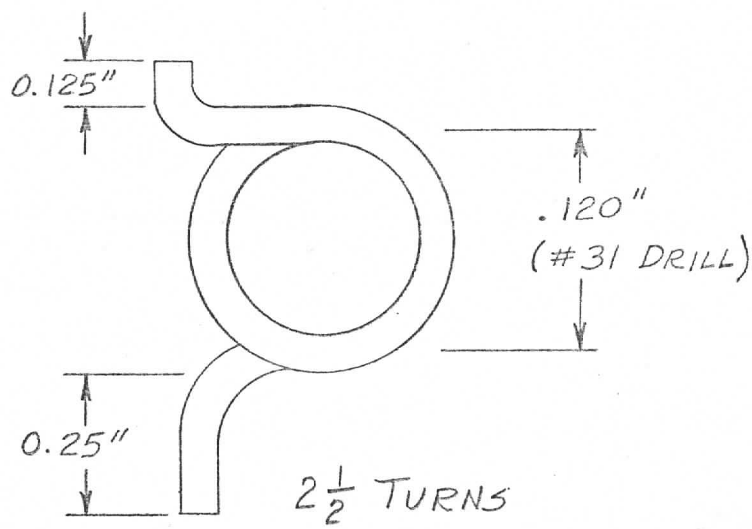
TITLE: INDUCTOR - L2			
SCALE: NONE	DRAFTSMAN: J. DENNIS, DATE: 3-15-73	CHECKER, DATE	ENGINEER, DATE
NEXT HIGHER ASSEMBLY	PRODUCT ASSURANCE, DATE	PROJECT APPROVAL, DATE	
PROJECT NO. [illegible]	SIZE [illegible]	SHEET 1 OF 1	DRAWING NO. TTX 613

REVISIONS

LTR.	DESCRIPTION	DATE	APPROVED

MATERIAL: HEAVY FORMVAR MAGNET WIRE

WIRE SIZE: #18



NOTE: LEADS STRIPPED & TINNED 1/4"

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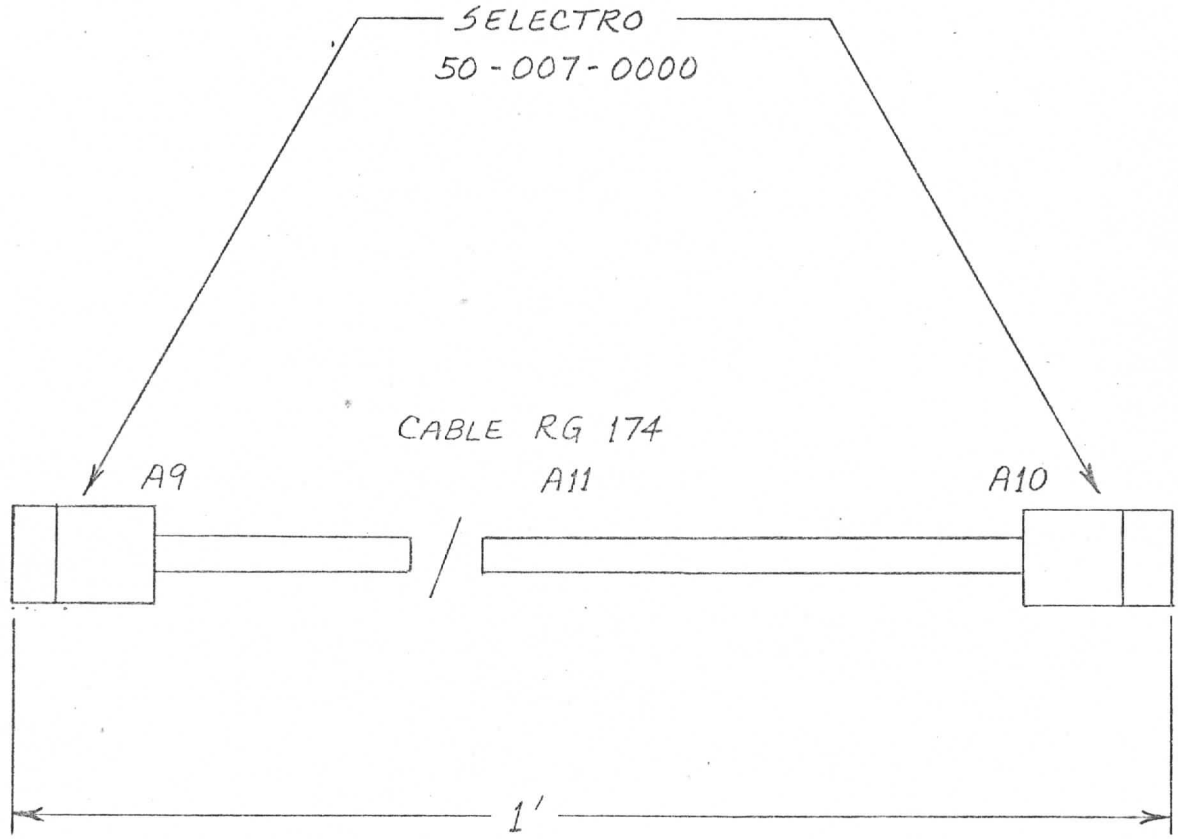
TITLE: INDUCTOR - L3

SCALE NONE	DRAFTSMAN J. DENNIS	DATE 3-15-73	CHECKER	DATE	ENGINEER	DATE
NEXT HIGHER ASSEMBLY		PRODUCT ASSURANCE		DATE	PROJECT APPROVAL	DATE
PROJECT NO.	SIZE		DRAWING NO.			

REVISIONS

LTR.	DESCRIPTION	DATE	APPROVED



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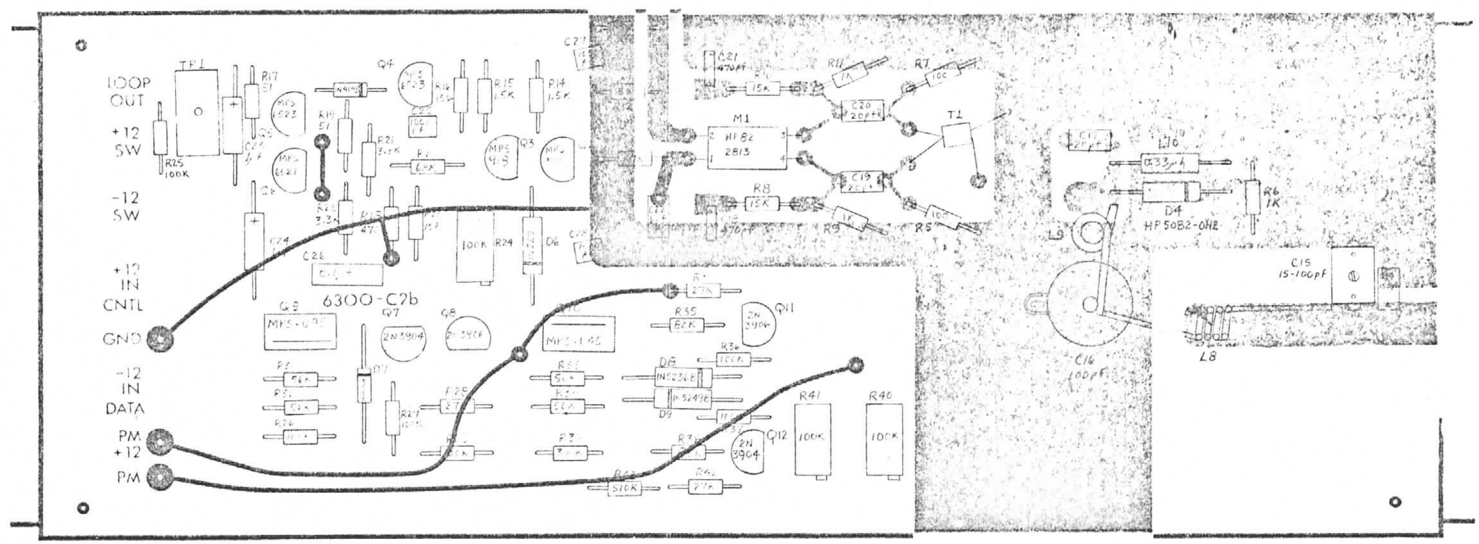
MADISON, WISCONSIN

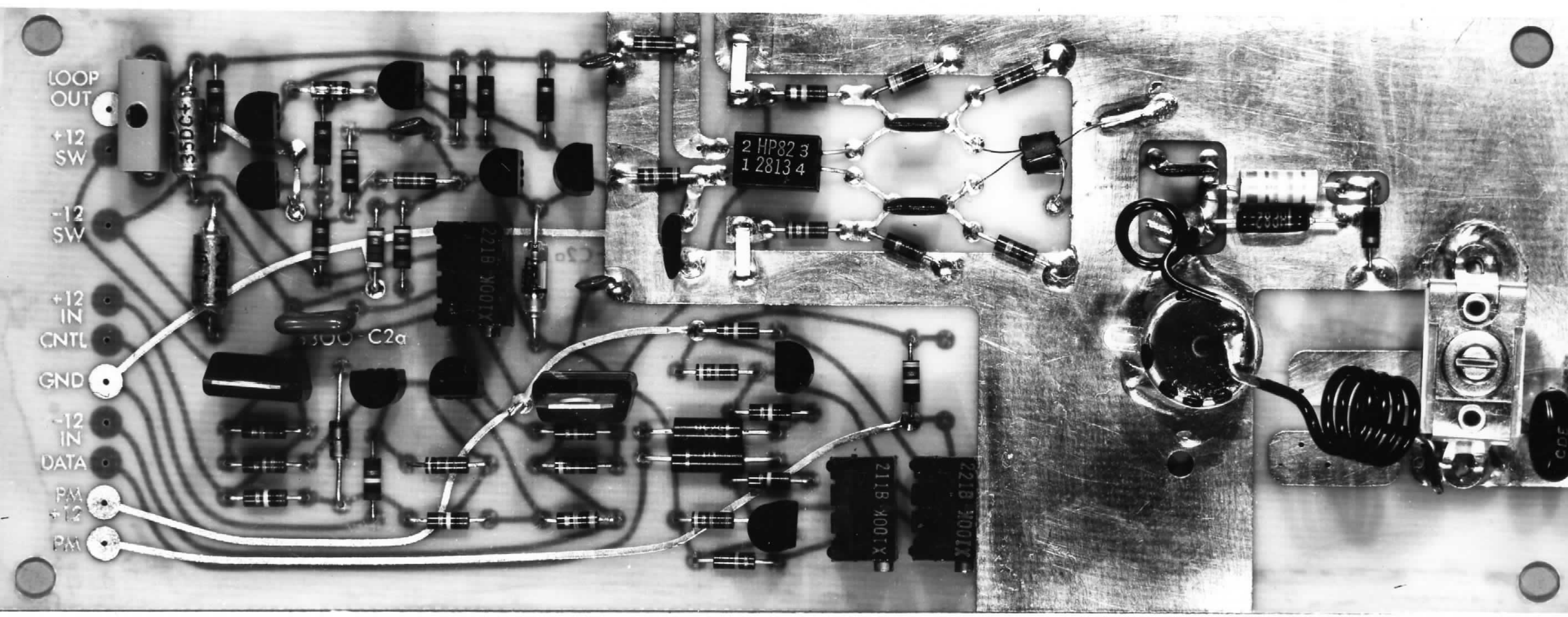
TITLE
ANTENNA CABLE

SCALE NONE	DRAFTSMAN J. DENNIS	DATE	CHECKER	DATE	ENGINEER	DATE
NEXT HIGHER ASSEMBLY		PRODUCT ASSURANCE	DATE	PROJECT APPROVAL		DATE
PROJECT NO. 6300	SIZE A	SHEET 1 OF 1	DRAWING NO. TTX 615			

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



THE UNIVERSITY OF WISCONSIN SPACE SCIENCE & ENGINEERING CENTER MADISON, WISCONSIN			
TITLE Transmitter Control Assembly			
SCALE 4:1	CRAFTSMAN J. Dennis DATE [illegible]	CHECKER DATE	ENGINEER DATE
NEXT HIGHER ASSEMBLY	PRODUCT ASSURANCE DATE	PROJECT APPROVAL DATE	
PROJECT NO 6300	SIZE D	SHEET 1 OF 1	DRAWING NO TTX 620-1



CONTROL ASSEMBLY

TTX 620-2

REFERENCE Dwg. No	SCHEM.	DESCRIPTION	SOURCE	QUAN. ASSY.	
620-4	C14	Capacitor, 150 pf 5% Silver Mica	Cornell Dubilier CD07FD151J	1	
"	C15	Capacitor, Trimmer 15-115 pf	Elmenco - 406	1	
"	C16	Capacitor, 100 pf Standoff 10%	Erie CB21PD101K	1	
"	C17	Capacitor, 20 pf 5% Silver Mica	Cornell Dubilier CD6CD200J	3	
"	C18	Capacitor, 470 pf 20% Ceramic Chip	Allen Bradley MB005DC471K		
"	C19	Same as C17			
"	C20	Same as C17			
"	C21	Same as C18			
"	C22	Capacitor, 6 pf $\pm$ 1 pf Silver Mica	Cornell Dubilier CD6CD060C	1	
"	C23	Capacitor, 1µf 35V Tantalum	Sprague 150D-105X0035A2	2	
"	C24	Same as C23			
"	C25	Capacitor, 1000 pf 10% Ceramic	Erie 8121-100W5R0102K	4	
"	C26	Capacitor, 0.1µf 20% Ceramic	Erie 8131-100651-104M	1	
"	C27	Same as C25			
"	C28	Same as C27			
"	C49	Same as C25			
620-4	D4	Diode, Step Recovery	Hewlett Packard 5082-0112	1	
"	D5	Diode, 1N4148	1N4148	2	
"	D6	Diode, 1MA Constant Current	Motorola 1N5297	1	
"	D7	Same as D5			
"	D8	Diode, 7.5V Zener 500mW 5%	Motorola 1N5236B	1	
"	D9	Diode, 19V Zener 500mW 5%	Motorola 1N5249B	1	
620-4	L8	Inductor (P/N TTX 622)	In House Manufacturer	1	
"	L9	Inductor (P/N TTX 623)	In House Manufacturer	1	
"	L10	Inductor 0.33µh	Nytronics Wee-Wee 0.33	1	

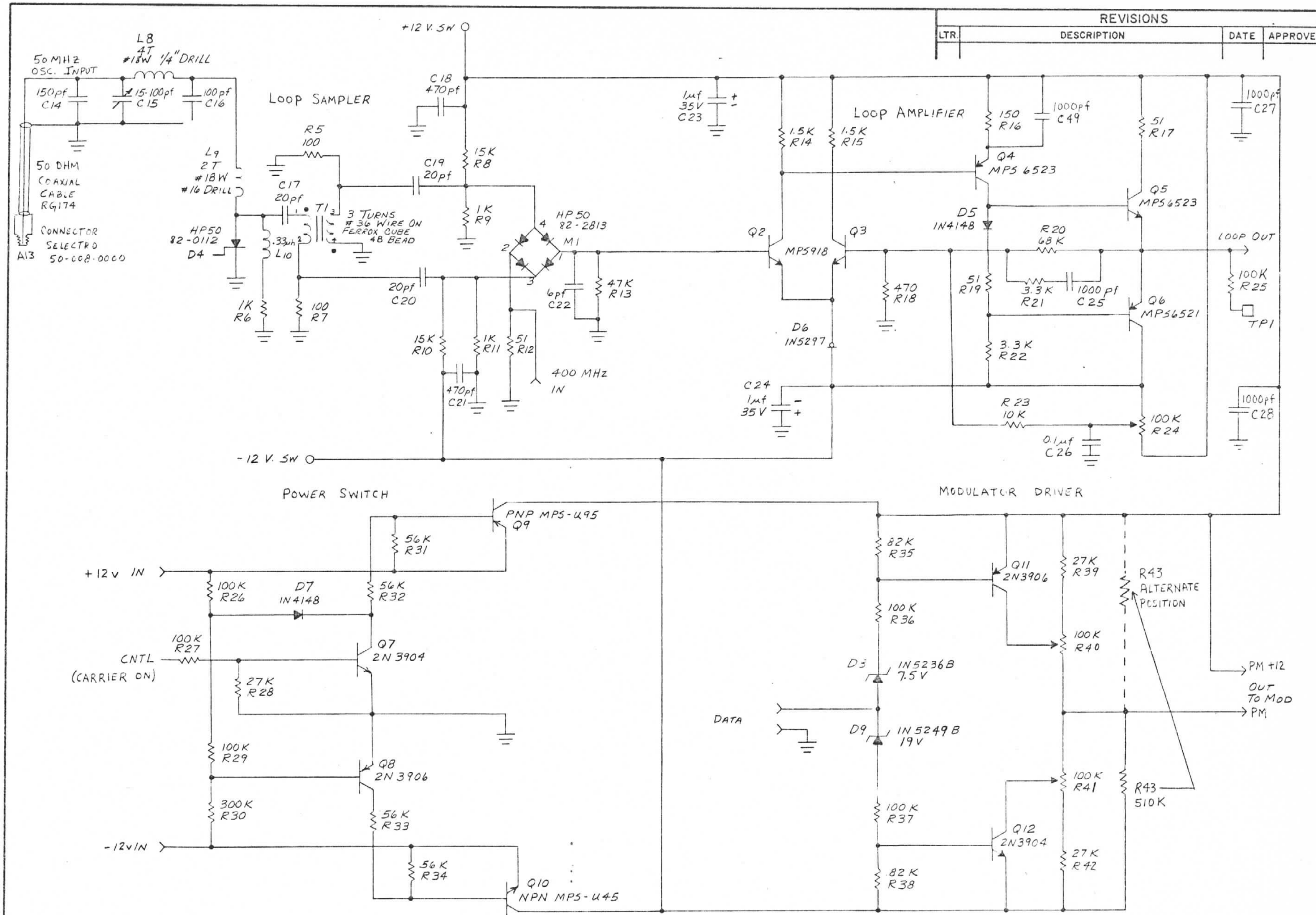
#TTX620-3

REFERENCE Dwg. No	SCHEM.	DESCRIPTION	SOURCE	QUAN. ASSY.	
620-4	M1	Diode, Bridge Hot Carrier	Hewlett Packard 5082-2813	1	
620-4	R5	Resistor, Carbon Composition 100 1/8W 5%	Allen Bradley RC05GF101J	2	
"	R6	Resistor, Carbon Composition 1K 1/8W 5%	Allen Bradley RC05GF102J	3	
"	R7	Same as R5			
"	R8	Resistor, Carbon Composition 15K 1/8W 5%	Allen Bradley RC05GF153J	2	
"	R9	Same as R6			
"	R10	Same as R8			
"	R11	Same as R6			
"	R12	Resistor, Carbon Composition 51 1/8W 5%	Allen Bradley RC05GF510J	3	
"	R13	Resistor, Carbon Composition 47K 1/8W 5%	Allen Bradley RC05GF473J	1	
"	R14	Resistor, Carbon Composition 1.5K 1/8W 5%	Allen Bradley RC05GF152J	2	
"	R15	Same as R14			
"	R16	Resistor, Carbon Composition 150 1/8W 5%	Allen Bradley RC05GF151J	1	
"	R17	Same as R12			
"	R18	Resistor, Carbon Composition 470 1/8W 5%	Allen Bradley RC05GF471J	1	
"	R19	Same as R12			
"	R20	Resistor, Carbon Composition 68K 1/8W 5%	Allen Bradley RC05GF683J	1	
"	R21	Resistor, Carbon Composiiion 3.3K 1/8W 5%	Allen Bradley RC05GF332J	2	
"	R22	Same as R21			
"	R23	Resistor, Carbon Composition 10K 1/8W 5%	Allen Bradley RC05GF103J	1	
"	R24	Resistor, Variable 100K	Bourns 3299X 100K	3	
"	R25	Resistor, Carbon Composition 100K 1/8W 5%	Allen Bradley RC05GF104J	6	
"	R26	Same as R25			
"	R27	Same as R26			
"	R28	Resistor, Carbon Composition 27K 1/8W 5%	Allen Bradley RC05GF273J	3	
"	R29	Same as R26			
"	R30	Resistor, Carbon Composition 300K 1/8W 5%	Allen Bradley RC05GF304J	1	
"	R31	Resistor, Carbon Composition 56K 1/8W 5%	Allen Bradley RC05GF563J	4	
"	R32	Same as R31			
"	R33	Same as R31			
"	R34	Same as R31			
"	R35	Resistor, Carbon Composition 82K 1/8W 5%	Allen Bradley RC05GF823J	2	
"	R36	Same as R26			
"	R43	Resistor Carbon Composition 510K 1/8W 5%	Allen Bradley RC05GG514J	1	

#TTX620-3

REFERENCE Dwg. No.	SCHEM.	DESCRIPTION	SOURCE	QUAN. ASSY.	
620-4	R37	Same as R26			
"	R38	Same as R35			
"	R39	Same as R28			
"	R40	Same as R24			
"	R41	Same as R24			
"	R42	Same as R28			
"	R43	Resistor, Carbon Composition - Selected as Required	Allen Bradley	1	
620-4	Q2	Transistor, NPN	Motorola MPS918	2	
"	Q3	Same as Q2			
"	Q4	Transistor, PNP	Motorola MPS6523	2	
"	Q5	Same as Q4			
"	Q6	Trnasistor, NPN	Motorola MPS6521	1	
"	Q7	Transistor, NPN	Motorola 2N3904	2	
"	Q8	Trnnsistor, PNP	Motorola 2N3906	2	
"	Q9	Transistor, PNP Darlington	Motorola MPS-U95	1	
"	Q10	Transistor, NPN Darlington	Motorola MPS-U45	1	
"	Q11	Same as Q8			
"	Q12	Same as Q7			
620-4	T1	Transformer (P/N TTX 624)	In House Manufacturer	1	
620-4	TP1	Test Point, Yellow Color	E. F. Johnson 105-0757-001	1	
620-4	A13	Connector, 50 Ohm Coaxial	Sealectro 50-008-0000	1	

TTX620-3



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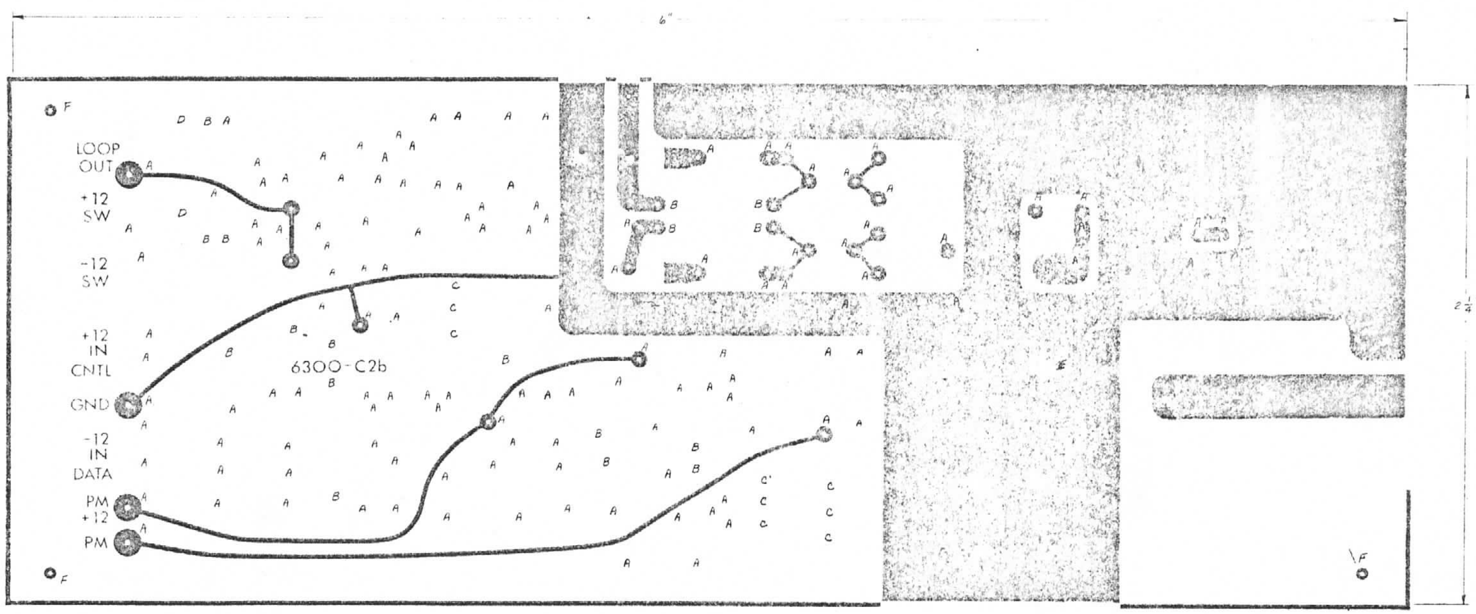
MADISON, WISCONSIN

TITLE: TRANSMITTER CONTROL

SCALE	DRAFTSMAN	DATE	CHECKER	DATE	ENGINEER	DATE
NONE	J. DENNIS	3-14-73			R. OEHLKERS	3-29-73

NEXT HIGHER ASSEMBLY	PRODUCT ASSURANCE	DATE	PROJECT APPROVAL	DATE
TTX 600				

PROJECT NO.	SIZE	SHEET	DRAWING NO.
6300	C	1 OF 1	TTX-620-4



MATERIAL SPEC. NOTES	
BOARD MATERIAL :	G 10 DOUBLE-SIDED
THICKNESS :	1/64"
COPPER WEIGHT :	1 OZ.
FINISH :	SOLDER PLATE

DRILL SCHEDULE	
DESIGNATION	DRILL SIZE
A	# 76
B	# 74
C	# 70
D	# 55
E	# 41
F	# 23

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

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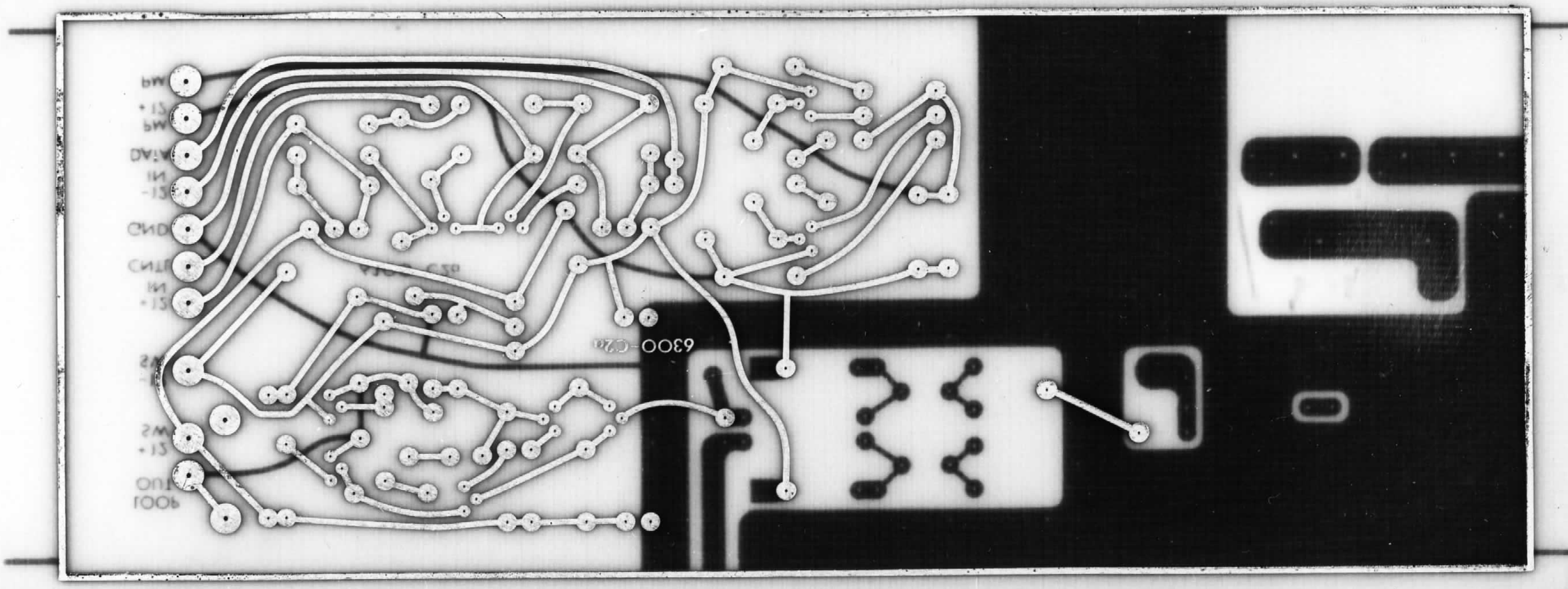
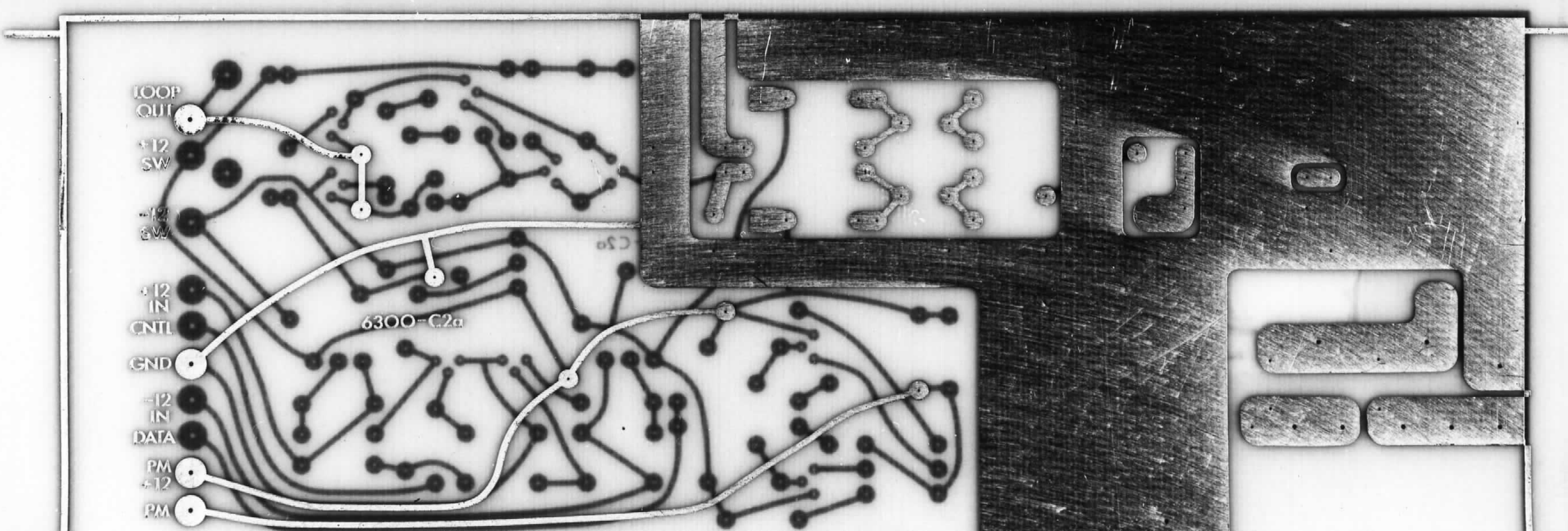
TITLE: CONTROL ASSEMBLY – PRINTED CIRCUIT

SCALE 4:1	DRAFTSMAN J. DUNHAM	DATE	CHECKER	DATE	ENGINEER	DATE
NEXT HIGHER ASSEMBLY	PRODUCT ASSURANCE	DATE	PROJECT APPROVAL	DATE		
PROJECT NO 6300	SIZE D	SHEET 1 OF 1	DRAWING NO TX 621-1			



TRANSMITTER CONTROL PC
TTX 621-3

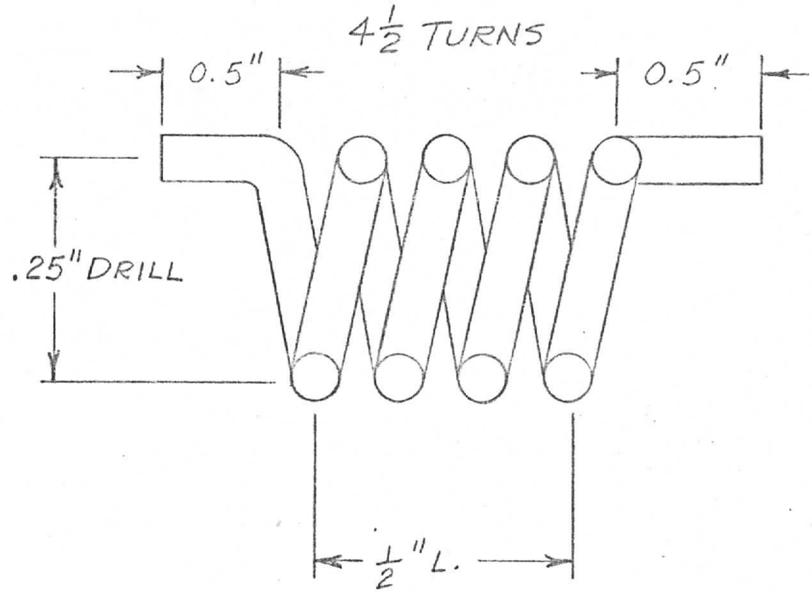


REVISIONS			
LTR.	DESCRIPTION	DATE	APPROVED

MATERIAL: HEAVY FORMVAR MAGNET WIRE

WIRE SIZE: #18

NOTE: LEADS STRIPPED & TINNED .25"



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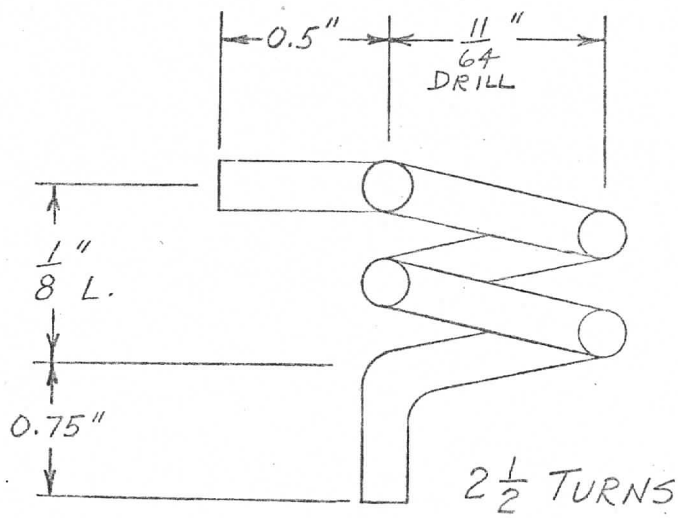
MADISON, WISCONSIN

TITLE: INDUCTOR - L8					
SCALE: NONE	DRAFTSMAN: J. DENNIS	DATE: 3-17-73	CHECKER / DATE	ENGINEER / DATE	
NEXT HIGHER ASSEMBLY	PRODUCT ASSURANCE / DATE		PROJECT APPROVAL / DATE		
PROJECT NO.	SIZE	SHEET 1 OF 1	DRAWING NO.		

REVISIONS			
LTR.	DESCRIPTION	DATE	APPROVED

MATERIAL: HEAVY FORMVAR
MAGNET WIRE

WIRE SIZE: #18



NOTE: LEADS STRIPPED &
TINNED 1/4"

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TITLE: INDUCTOR - L9

SCALE	DRAFTSMAN	DATE	CHECKER	DATE	ENGINEER	DATE
NONE	J. DENNIS	3-16-73				

NEXT HIGHER ASSEMBLY	PRODUCT ASSURANCE	DATE	PROJECT APPROVAL	DATE

PROJECT NO.	SIZE	SHEET	DRAWING NO.
6300	A	SHEET 1 OF 1	TTX 623

REVISIONS			
LTR.	DESCRIPTION	DATE	APPROVED

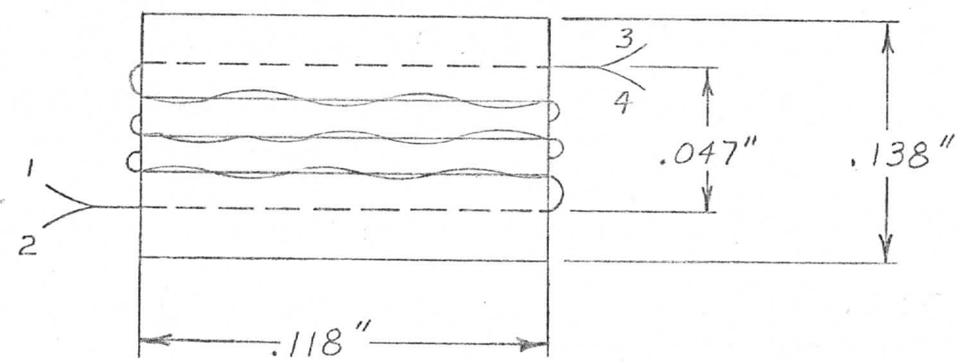
CORE: FERROX CUBE P/N 56 590 65/4B

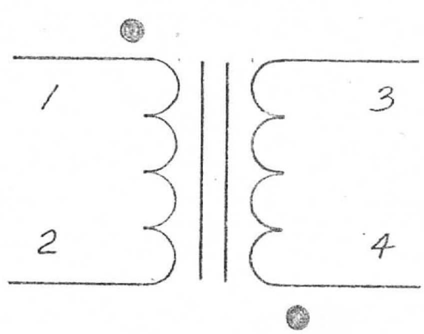
WIRE: #36 INSULATED MAGNET WIRE
2 COLORS

LEAD LENGTH: 0.5"

STRIPPED & TINNED 0.25"

3 TURNS, TWISTED PAIR
2 COLORS





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MADISON, WISCONSIN

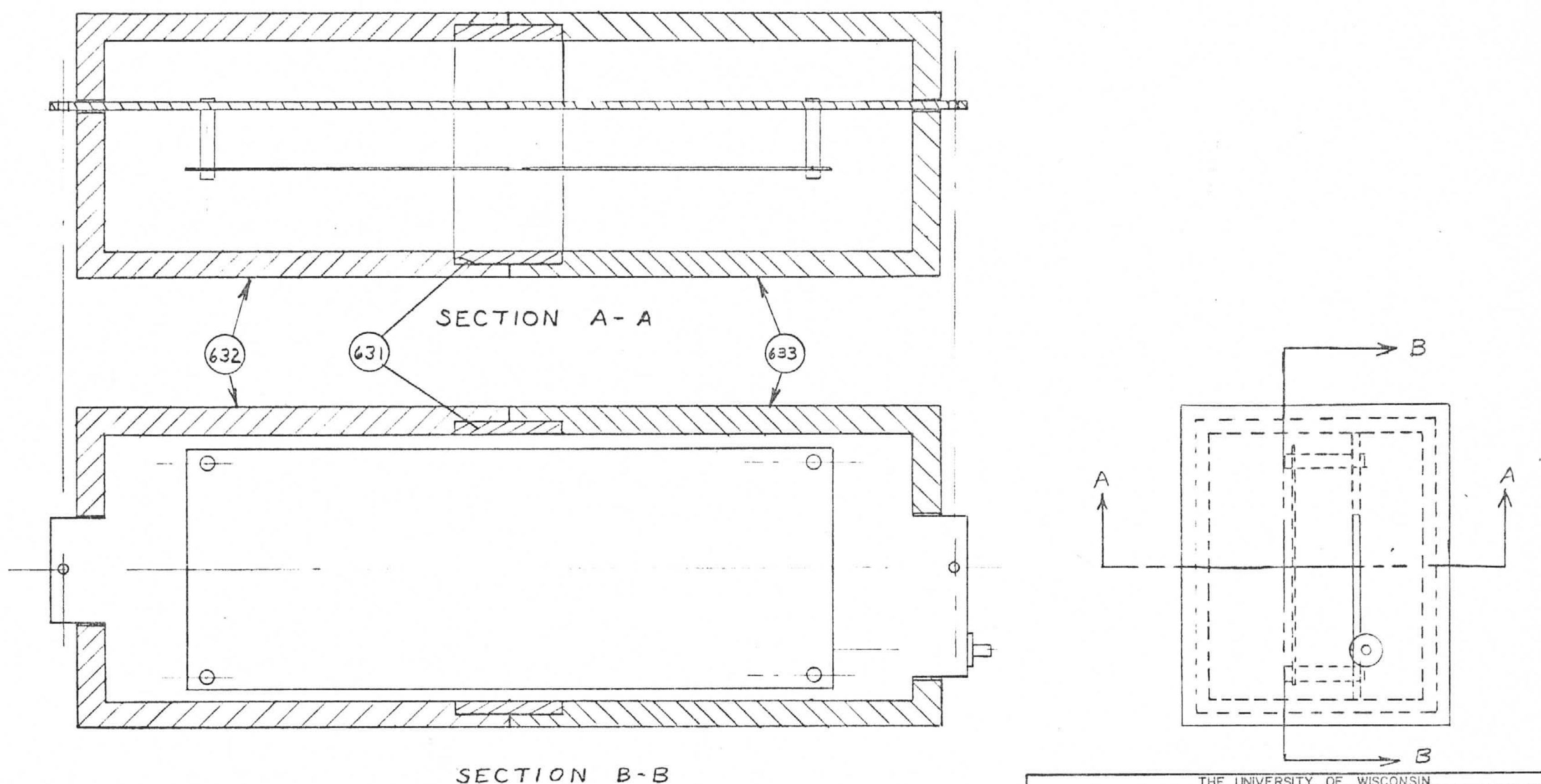
TITLE: TRANSFORMER T1

SCALE	DRAFTSMAN	DATE	CHECKER	DATE	ENGINEER	DATE
NONE	J. DENNIS	3-15-73				

NEXT HIGHER ASSEMBLY	PRODUCT ASSURANCE	DATE	PROJECT APPROVAL	DATE

PROJECT NO.	SIZE	SHEET	DRAWING NO.
6300	A	1 OF 1	TTX 624

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



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MADISON, WISCONSIN

TITLE TRANSMITTER PACKAGE CONTAINER ASSEMBLY			
SCALE FULL	DRAFTSMAN J.G.M. DATE 3/19/73	CHECKER J.G.M DATE 3/19/73	ENGINEER J.G.M DATE 3/19/73
APPROVAL	DATE	DESIGN ACTIVITY APPROVAL DATE	ADDITIONAL APPROVAL DATE
PROJECT NO. 6310	SIZE B	SHEET 1 OF 1	DRAWING NO. TTX 630-1

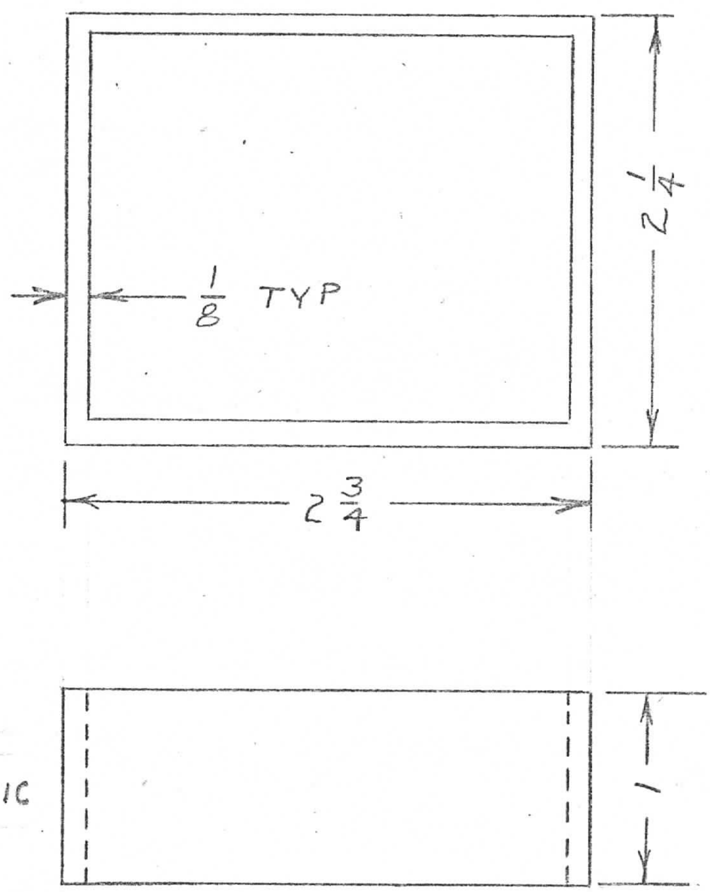
TTX630-3   T W E R L E Transmitter TTX630   Date______

REFERENCE		DESCRIPTION	SOURCE	QUAN. ASSY.	
g. No	SCHEM.				
TX631		Container, Center Spacer		1	
TX632		Container, Small End		1	
TX633		Container, Connector End		1	

#TTX630-3

REVISIONS

LTR.	DESCRIPTION	DATE	APPROVED



MATERIAL:
FOAMED PLASTIC
DENSITY OF
3 lbs./ft.³

ONE REQ.

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MADISON, WISCONSIN

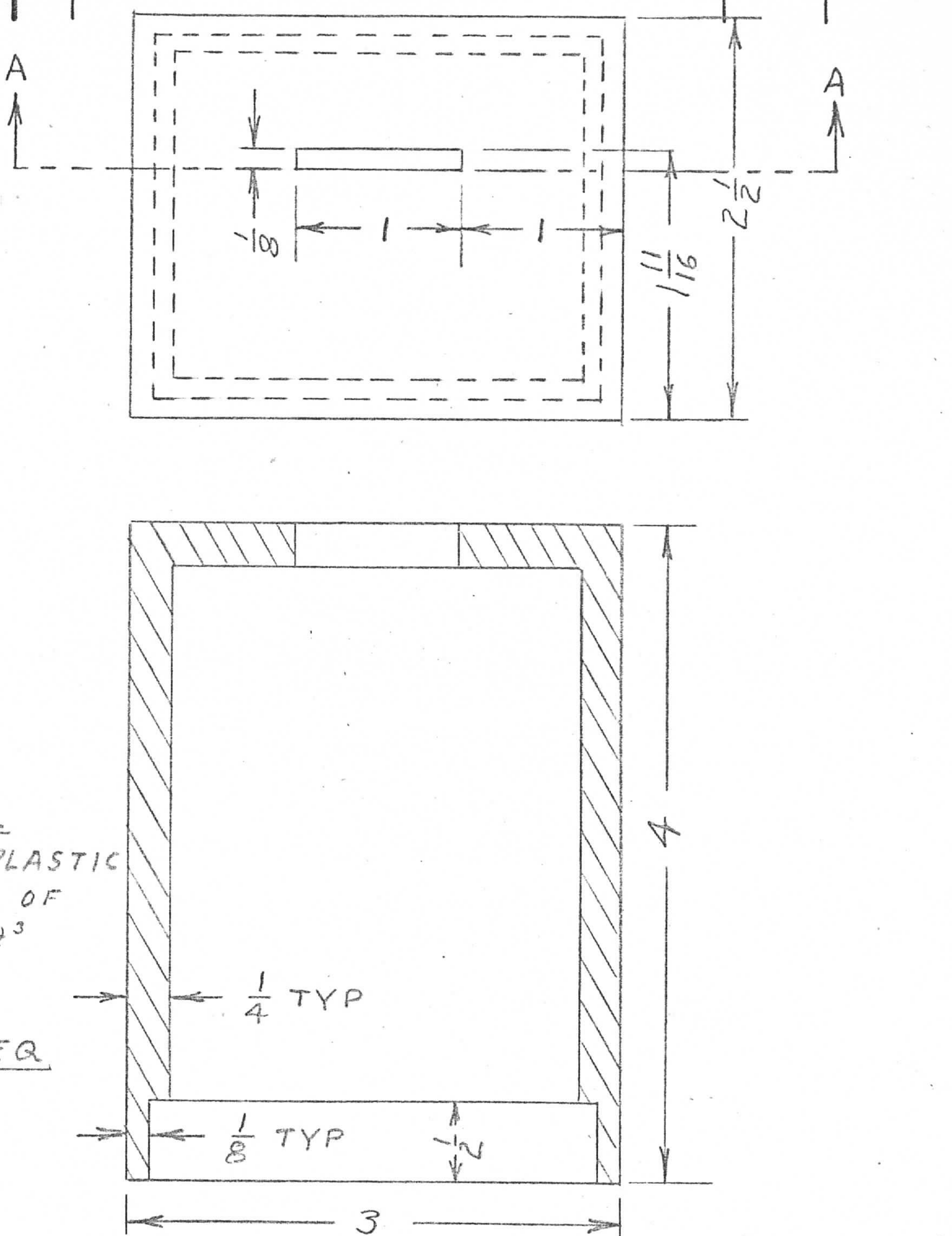
TITLE: TRANSMITTER PACKAGE CONTAINER CENTER SPACER

SCALE	DRAFTSMAN	DATE	CHECKER	DATE	ENGINEER	DATE
FULL	JGM	3/19/73	J.G.M	3/19/73	J.G.M	3/19/73

NEXT HIGHER ASSEMBLY	PRODUCT ASSURANCE	DATE	PROJECT APPROVAL	DATE
TTX 630-1				

PROJECT NO.	SIZE	SHEET	DRAWING NO.
6310	A	1 OF 1	TTX-631

REVISIONS			
LTR.	DESCRIPTION	DATE	APPROVED



MATERIAL
FOAMED PLASTIC
DENSITY OF
3 lbs/ft³

ONE REQ

SECTION A-A

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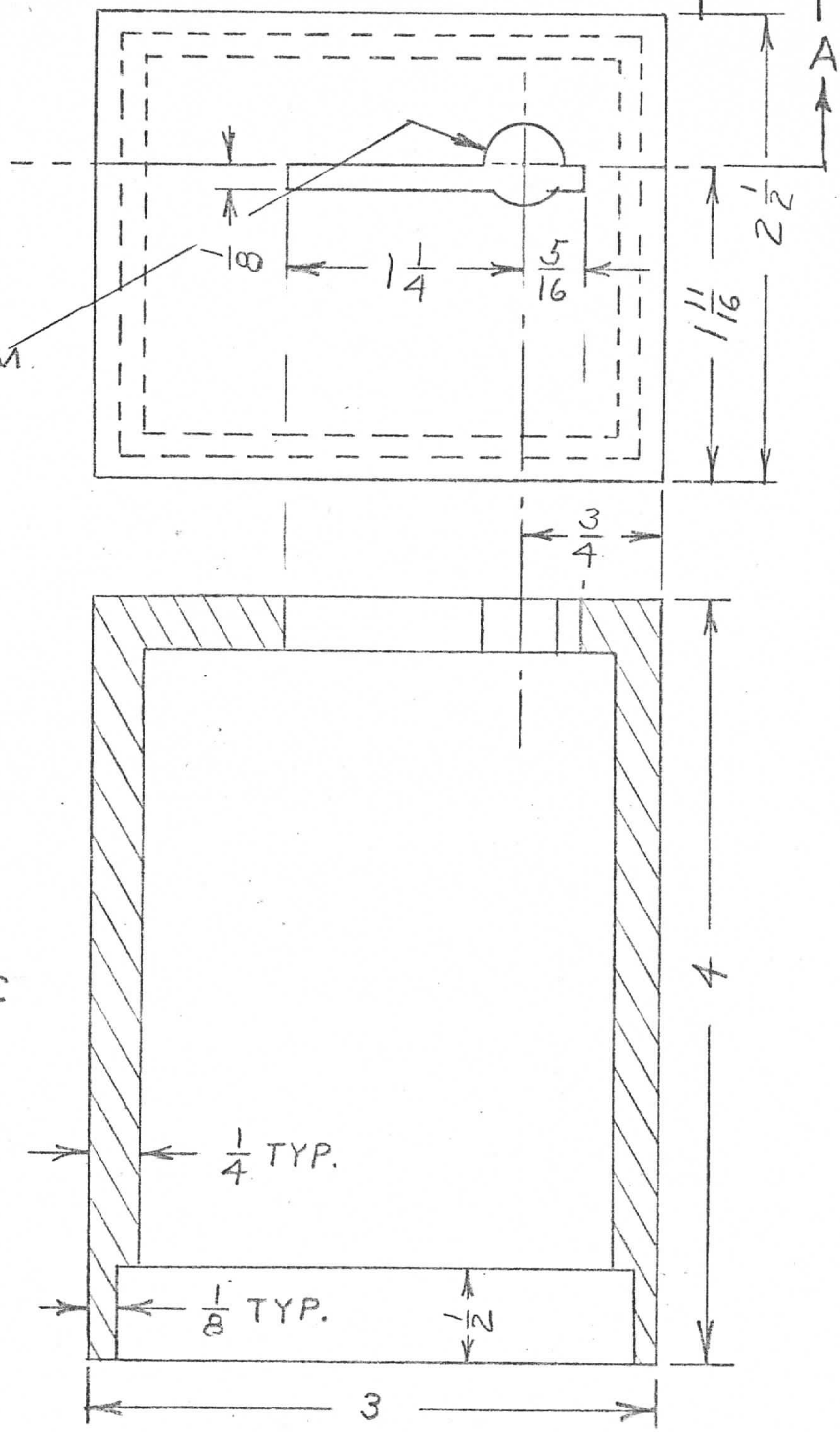
TITLE: TRANSMITTER PACKAGE CONTAINER SMALL END			
SCALE: FULL	DRAFTSMAN: JGM DATE: 3/19/73	CHECKER: JGM DATE: 3/19/73	ENGINEER: JGM DATE: 3/19/73
NEXT HIGHER ASSEMBLY: TTX 630-1	PRODUCT ASSURANCE DATE	PROJECT APPROVAL DATE	
PROJECT NO.: 6310	SIZE: A	SHEET 1 OF 1	DRAWING NO.: TTX-632

REVISIONS			
LTR.	DESCRIPTION	DATE	APPROVED



SECTION A-A

MATERIAL
FOAMED PLASTIC
DENSITY OF
3 lbs/ft^3

ONE REQ

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MADISON, WISCONSIN

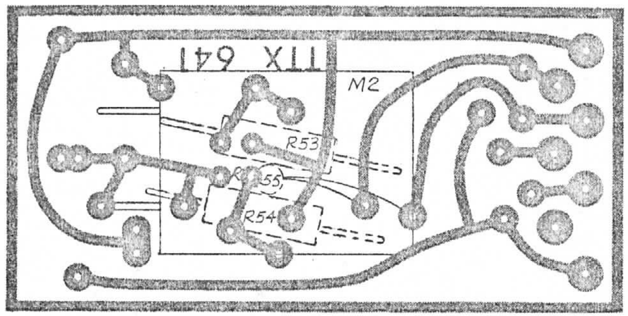
TITLE: TRANSMITTER PACKAGE CONTAINER CONNECTOR END

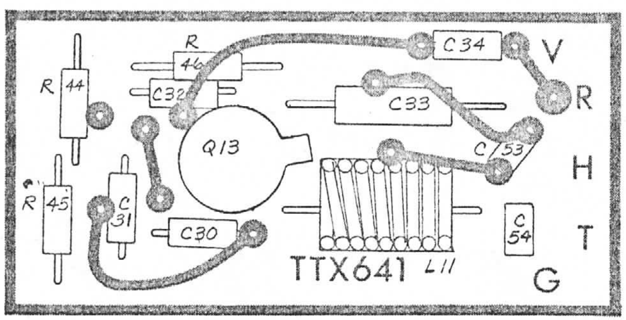
SCALE	DRAFTSMAN	DATE	CHECKER	DATE	ENGINEER	DATE
FULL	JGM	3/19/73	JGM	3/19/73	JGM	3/19/73

NEXT HIGHER ASSEMBLY	PRODUCT ASSURANCE	DATE	PROJECT APPROVAL	DATE
TTX 630-1				

PROJECT NO.	SIZE	SHEET	DRAWING NO.
6310	A	1 OF 1	TTX-633

REVISIONS			
SYM.	DESCRIPTION	DATE	APPROVED





PARTS LIST	
PART	VALUE
R44	10 K
R45	10 K
R46	3.9 K
R53	510 Ω
R54	510 Ω
R55	THERMISTOR (SELECTED)
C30	47 pf
C31	33 pf
C32	.001
C33	0.1
C34	20 pf
L11	P/N TTX 644
Q13	2N2957

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MADISON, WISCONSIN

TITLE: OSCILLATOR ASSEMBLY

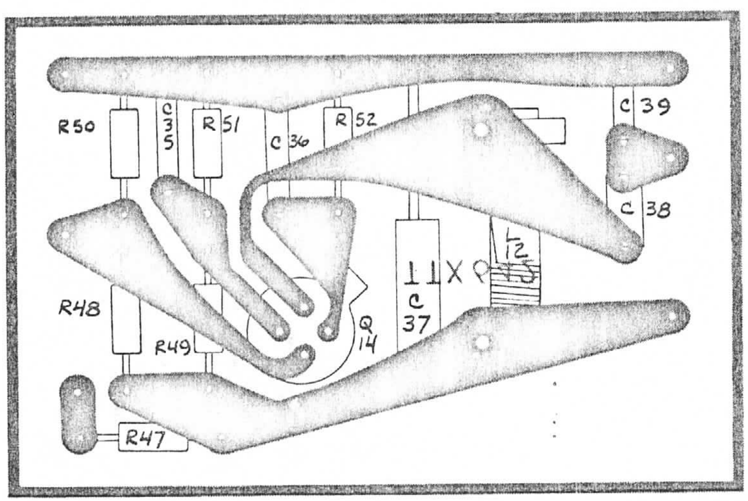
SCALE	DRAFTSMAN	DATE	CHECKER	DATE	ENGINEER	DATE
4 : 1	J. DENNIS	3-29-73				

APPROVAL	DATE	DESIGN ACTIVITY APPROVAL	DATE	ADDITIONAL APPROVAL	DATE

PROJECT NO.	SIZE	SHEET	DRAWING NO.
6300	B	SHEET 1 OF 1	TTX 640-1-1

REVISIONS			
SYM.	DESCRIPTION	DATE	APPROVED

PARTS LIST	
PART	VALUE
R47	1 K.
R48	1.2 MEG
R49	510 K
R50	300 K
R51	510 K
R52	270
C35	.01
C36	.01
C37	0.1
C38	10 pf
C39	68 pf
L12	.645 - .715 µhy
Q14	40819



9300-002

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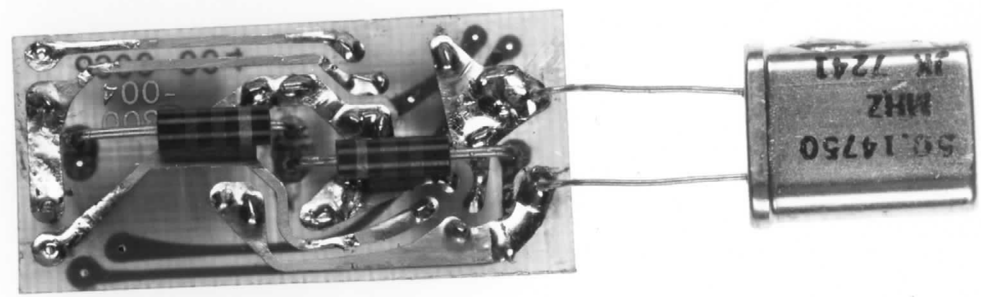
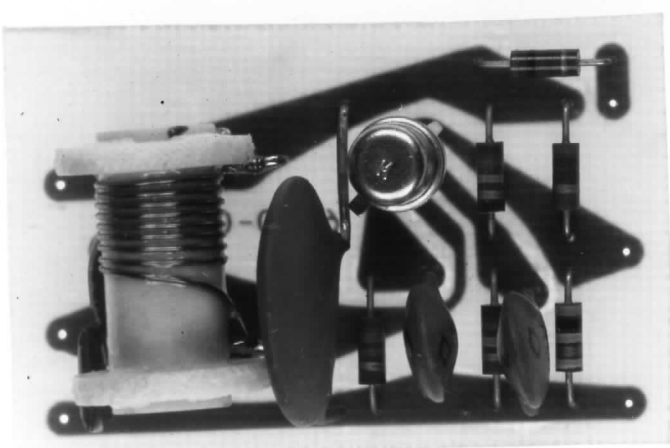
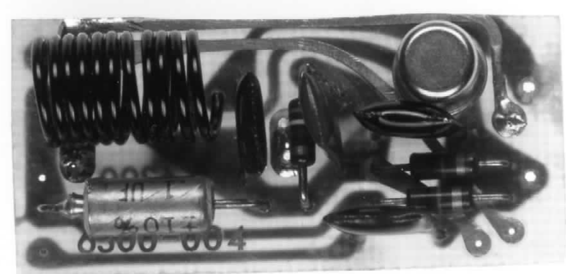
MADISON, WISCONSIN

TITLE: BUFFER ASSEMBLY			
SCALE: 4:1	DRAFTSMAN: J. DENNIS DATE: 3-28-73	CHECKER DATE	ENGINEER DATE
APPROVAL	DATE DESIGN ACTIVITY APPROVAL	DATE ADDITIONAL APPROVAL	DATE
PROJECT NO: 6300	SIZE: B	SHEET 1 OF 1	DRAWING NO.: TTX 640-1-2





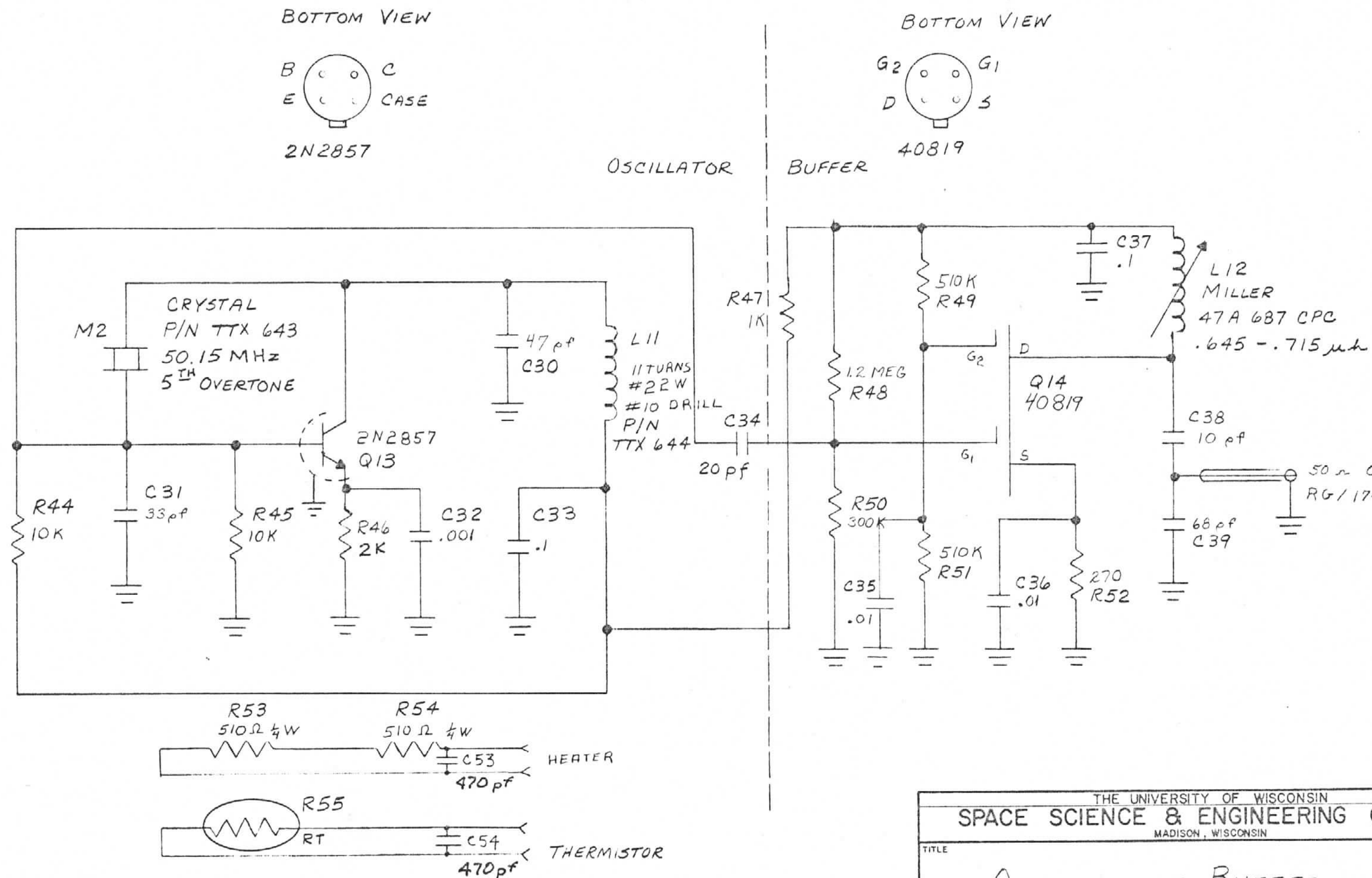


OSCILLATOR and BUFFER
TTX 640-2

REFERENCE Dwg. No.	SCHEM.	DESCRIPTION	SOURCE	QUAN. ASSY.	
640-4	C30	Capacitor, 47pf 5% Silver Mica	Cornell Dubilier CD6ED470J	1	
"	C31	Capacitor, 33pf 5% Silver Mica	Cornell Dubilier CD6ED330J	1	
"	C32	Capacitor, 1000pf Ceramic	Erie 8121-100 W5RO 102K	1	
"	C33	Capacitor, 0.1 μf Tantalum	Sprague 150D 104 x 9035A2	1	
"	C34	Capacitor, 20pf 5% Silver Mica	Cornell Dubilier CD6CD200J	1	
"	C35	Capacitor, 0.01μf 25v Disc Ceramic	Sprague HY - 520	2	
"	C36	Same as C35			
"	C37	Capacitor, 0.1μf, 16v Disc Ceramic	Sparague HY - 450	1	
"	C38	Capacitor, 10pf 10% Silver Mica	Cornell Dubilier CD6CD100K	1	
"	C39	Capacitor, 68pf	Cornell Dubilier CD6ED680J	1	
640-4	L11	Inductor (P/N TTX644)	in-house manufacturer	1	
	L12	Inductor, Variable 0.645-0.715μh	Miller 47A687cpc	1	
640-4	M2	Crystal (P/N TTX643)	To be supplied by NCAR	1	
"	Q13	Transistor, NPN	Motorola 2N2857	1	
"	Q14	Transistor, MOSFET	RCA 40819	1	
640-4	R44	Resistor, Metal Oxide Film 10K 1/8w 5%	Corning C3-10K 5%	2	
"	R45	Same as R44			
"	R46	Resistor, Metal Oxide Film 3.9K 1/8w 5%	Corning C3-3.9K 5%	1	
"	R47	Resistor, Carbon Composition 1K 1/8w 5%	Allen Bradley RC05GF102J	1	
"	R48	" " " 1.2 MEG 1/8w 5%	Allen Bradley RC05GF125J	1	
"	R49	" " " 510K 1/8w 5%	Allen Bradley RC05GF514J	2	
"	R50	" : " 300K 1/8w 5%	Allen Bradley RC05GF304	1	
"	R51	Same as R49			
"	R52	Resistor, Carbon Composition 270 1/8w 5%	Allen Bradley RC05GF271J	1	
"	R53	Resistor, Carbon Composition 510 1/4w 5%	Allen Bradley RC07GF511J	2	
"	R54	Same as R53			
"	R55	Resistor-Thermistor, 10K @ 25°C	YSI 44006	1	
640-4	C53	Capacitor, Ceramic 470pf	Erie 8101 050 651 471M	2	
	C54	Same as C53			

#TTX640-3

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



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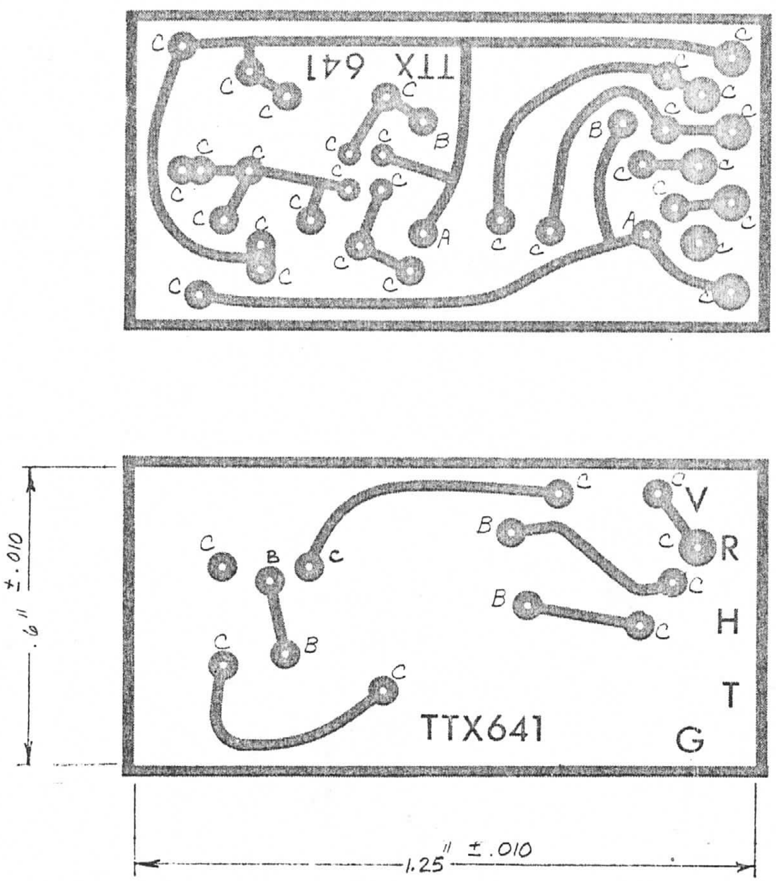
TITLE: OSCILLATOR - BUFFER

SCALE	DRAFTSMAN	DATE	CHECKER	DATE	ENGINEER	DATE
NONE		6/6/72				
APPROVAL		DATE	DESIGN ACTIVITY APPROVAL	DATE	ADDITIONAL APPROVAL	DATE
PROJECT NO. 6300	SIZE B	SHEET 1 OF 1	DRAWING NO. TTX 640-4			

REVISIONS			
SYM.	DESCRIPTION	DATE	APPROVED



DRILL SCHEDULE	
DESIGNATION	DRILL SIZE
A	#68
B	#71
C	#76

MATERIAL SPEC. NOTES	
BOARD MATERIAL:	G-10 DOUBLE-SIDED
THICKNESS:	1/64"
COPPERWEIGHT:	1 OZ
FINISH:	SOLDER PLATE

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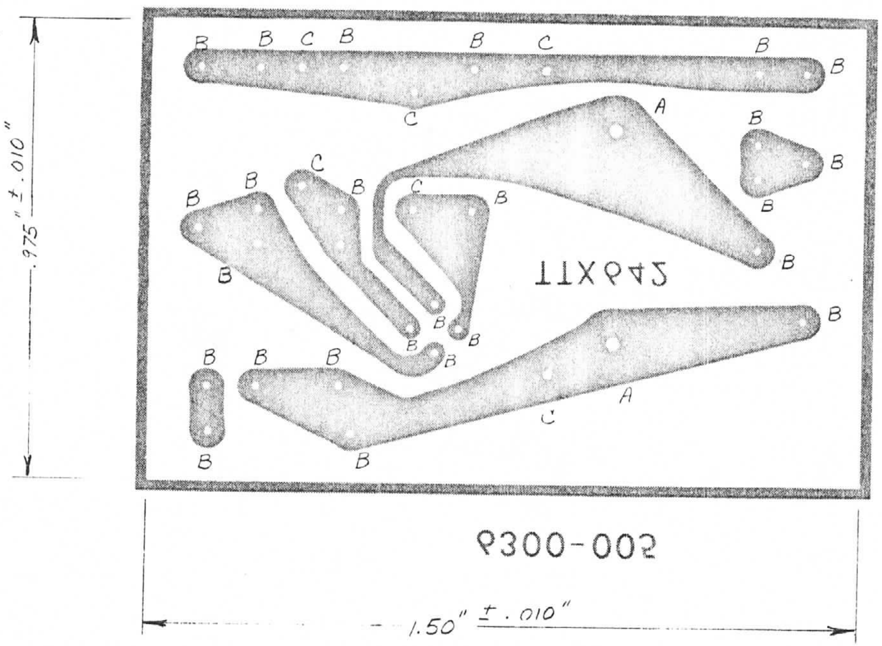
TITLE: OSCILLATOR - SPECIFICATIONS			
SCALE: 4:1	DRAFTSMAN: J. DENNIS DATE: 3-30-73	CHECKER DATE	ENGINEER DATE
APPROVAL DATE	DESIGN ACTIVITY APPROVAL DATE	ADDITIONAL APPROVAL DATE	
PROJECT NO. 6300	SIZE B, SHEET 1 OF 1	DRAWING NO. TTX 641-1	

REVISIONS			
SYM.	DESCRIPTION	DATE	APPROVED



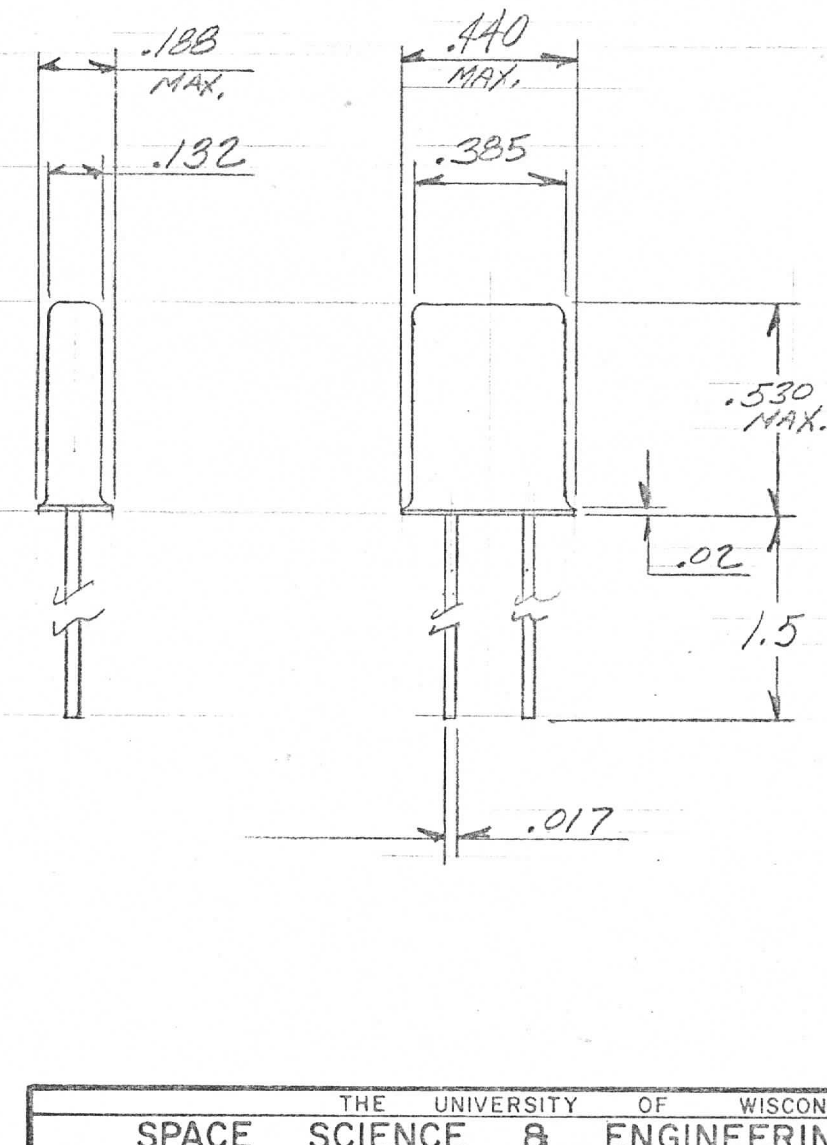
DRILL SCHEDULE	
DESIGNATION	DRILL SIZE
A	#55
B	#76
C	#71

MATERIAL SPEC. NOTES	
BOARD MATERIAL :	G-10 DOUBLE-SIDED
THICKNESS :	1/64"
COPPERWEIGHT :	1 oz.
FINISH :	SOLDER PLATE

THE UNIVERSITY OF WISCONSIN SPACE SCIENCE & ENGINEERING CENTER MADISON, WISCONSIN							
TITLE BUFFER - PRINTED CIRCUIT							
SCALE 4:1	DRAFTSMAN J DENNIS	DATE 3-27-73	CHECKER	DATE	ENGINEER	DATE	
APPROVAL		DATE	DESIGN ACTIVITY APPROVAL	DATE	ADDITIONAL APPROVAL	DATE	
PROJECT NO 6300	SIZE B	SHEET 1 OF 1	DRAWING NO. TTX 642-1				

REVISIONS

LTR.	DESCRIPTION	DATE	APPROVED



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TITLE: CRYSTAL (K3W TYPE)

SCALE	DRAFTSMAN	DATE	CHECKER	DATE	ENGINEER	DATE
2-1						

NEXT HIGHER ASSEMBLY	PRODUCT ASSURANCE	DATE	PROJECT APPROVAL	DATE

PROJECT NO.	SIZE	SHEET	DRAWING NO.
[illegible]	A	1 OF 1	[illegible]

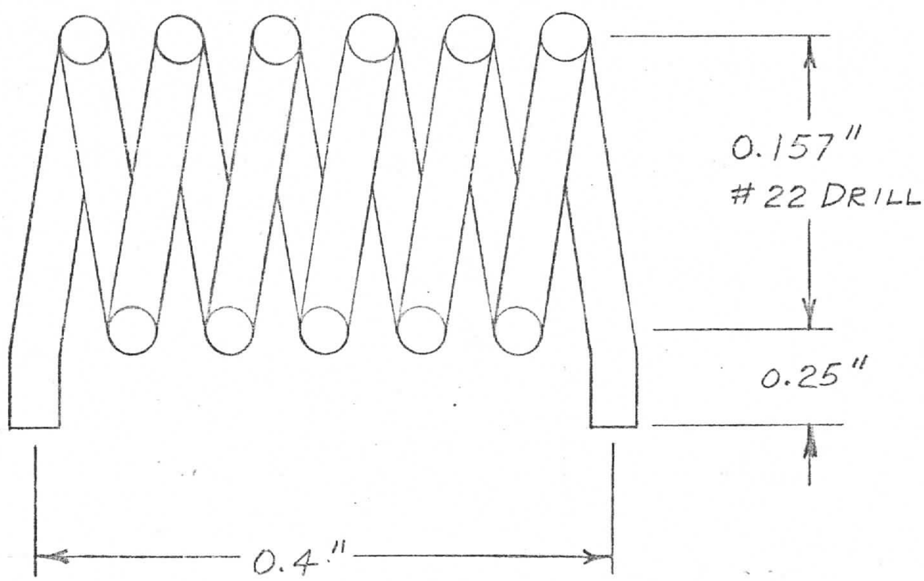
REVISIONS			
LTR.	DESCRIPTION	DATE	APPROVED

MATERIAL: HEAVY FORMVAR WIRE

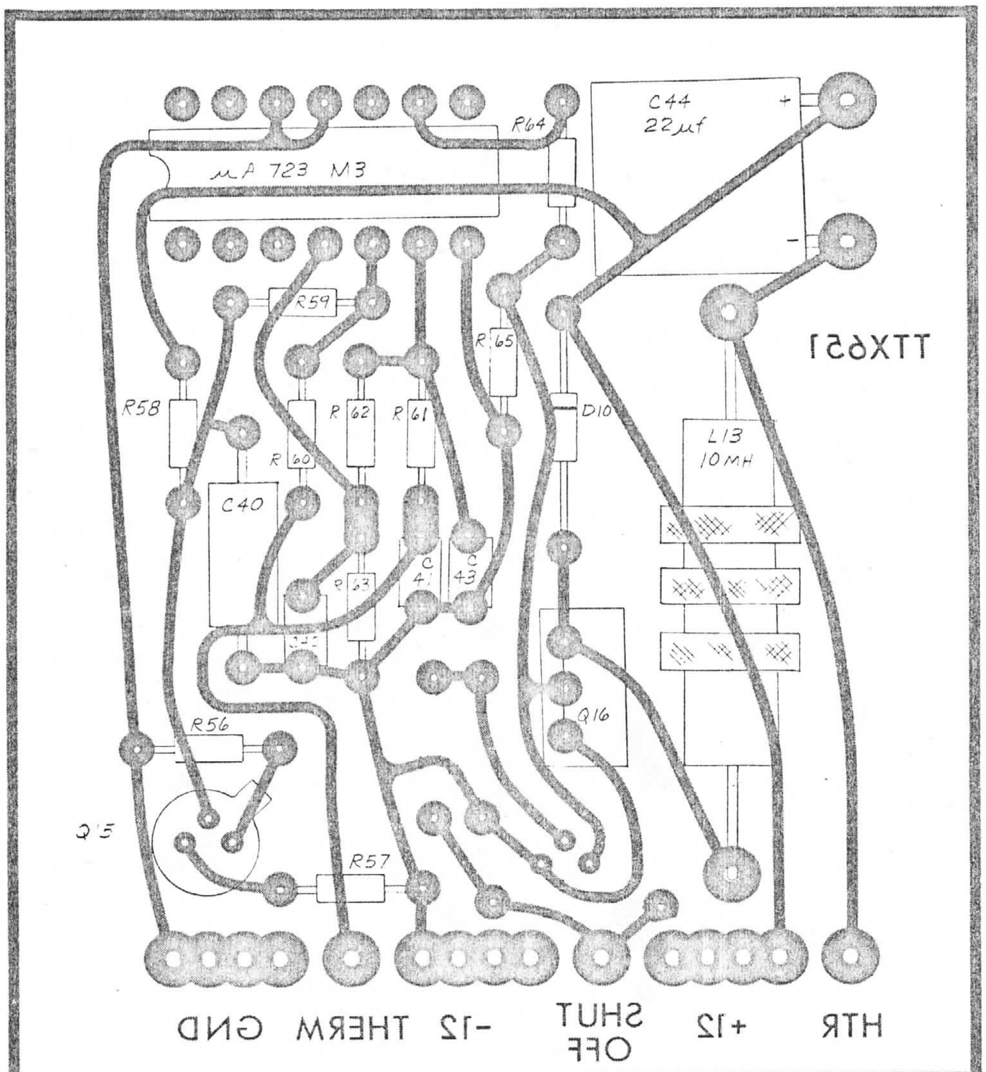
WIRE SIZE: # 22

NOTE: LEADS STRIPPED & TINNED 0.25"

11 TURNS



THE UNIVERSITY OF WISCONSIN SPACE SCIENCE & ENGINEERING CENTER MADISON, WISCONSIN					
TITLE INDUCTOR L-11					
SCALE NONE	DRAFTSMAN J. DENNIS	DATE	CHECKER	DATE	ENGINEER DATE
NEXT HIGHER ASSEMBLY		PRODUCT ASSURANCE	DATE	PROJECT APPROVAL	DATE
PROJECT NO. 6300	SIZE A	SHEET 1 OF 1	DRAWING NO. TTX 644		



REVISIONS

SYM	DESCRIPTION	DATE	APPROVED

PARTS LIST

PART	VALUE
R56	1K
R57	47
R58	43K
R59	500K
R60	2K
R61	10K
R62	10K
R63	10K
R64	5.1K
R65	10K
C40	.0018
C41	0.1
C42	0.1
C43	10µf
C44	22µf
L13	10mhy
D10	1N4148
Q15	2N4852
Q16	MPS-U45

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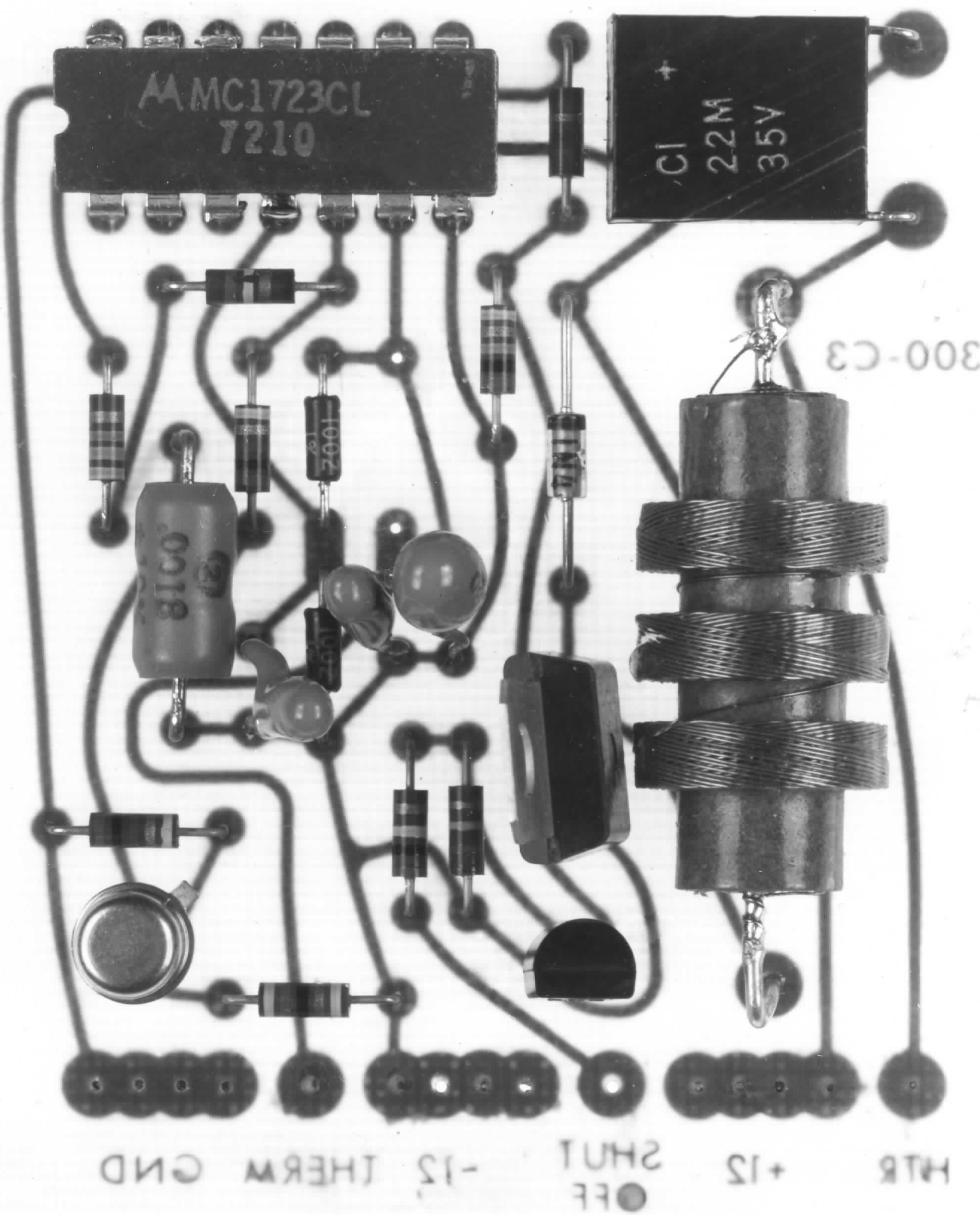
SPACE SCIENCE & ENGINEERING CENTER
MADISON, WISCONSIN

TITLE: OVEN TEMPERATURE CONTROLLER ASSEMBLY			
SCALE: 4:1	DRAFTSMAN: J. DENNIS — DATE: 3-29-73	CHECKER — DATE	ENGINEER — DATE
APPROVAL	DATE	DESIGN ACTIVITY APPROVAL — DATE	ADDITIONAL APPROVAL — DATE
PROJECT NO: 6300	SIZE: B	SHEET 1 OF 1	DRAWING NO.: TTX-650-1

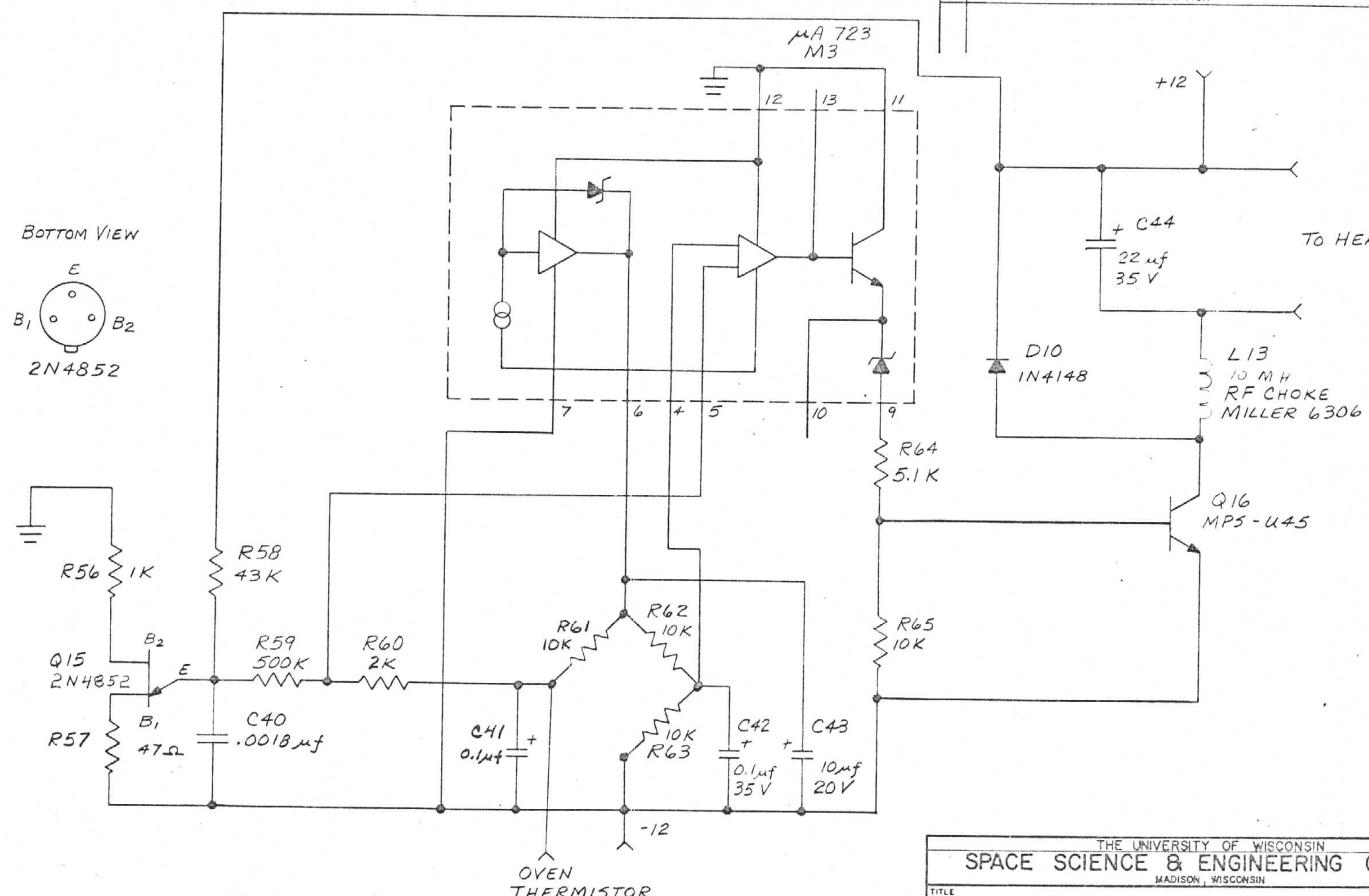
OVEN TEMPERATURE CONTROLLER
TTX 650-2



T W E R L E Transmitter TTX650 Date 16 March 73 Page 1 of 1

REFERENCE Dwg. No	SCHEM.	DESCRIPTION	SOURCE	QUAN. ASSY.	
650-4	C40	Capacitor, .0018µf 200v 10%	Sprague 192P18292	1	
"	C41	Capacitor, 0.1µf 35v Tantalum	Sprague 196D 104 x 9035HA1	2	
"	C42	Same as C41			
"	C43	Capacitor, 10µf 20v Tantalum	Sprague 196D 106 x 9020JA1	1	
"	C44	Capacitor, 22µf 35v Tantalum	Components, Inc. J226R	1	
650-4	D10	Diode, 1N4148	1N4148	1	
650-4	L13	Inductor, RF Choke 10MH	Miller 6306	1	
650-4	M3	Integrated Circuit, 723 Voltage Regulator	Fairchild U6A7723393	1	
650-4	Q15	Transistor, Unijunction 2N4852	Motorola 2N4852	1	
	Q16	Transistor, NPN Darlington	Motorola MPS-U45	1	
650-4	R56	Resistor, Carbon Composition 1K 1/8w 5%	Allen Bradley RC05GF102J	1	
"	R57	" " " 47 1/8w 5%	Allen Bradley RC05GF470J	1	
"	R58	" " " 43K 1/8w 5%	Allen Bradley RC05GF433J	1	
"	R59	" " " 500K 1/8w 5%	Allen Bradley RC05GF504J	1	
"	R60	Resistor, Carbon Composition 2K 1/8W 5%	Allen Bradley RC05GF202J	1	
"	R61	Resistor, Metal Film - 10K 1/8W 1%	Corning Type C3 10K 1%	3	
"	R62	Same as R61			
"	R63	Same as R61			
"	R64	Resistor, Carbon Composition 5.1K 1/8w 5%	Allen Bradley RC05GF512J	1	
"	R65	" " " 10K 1/8w 5%	Allen Bradley RC05GF103J	1	

#TTX650-3



REVISIONS			
SYM.	DESCRIPTION	DATE	APPROVED

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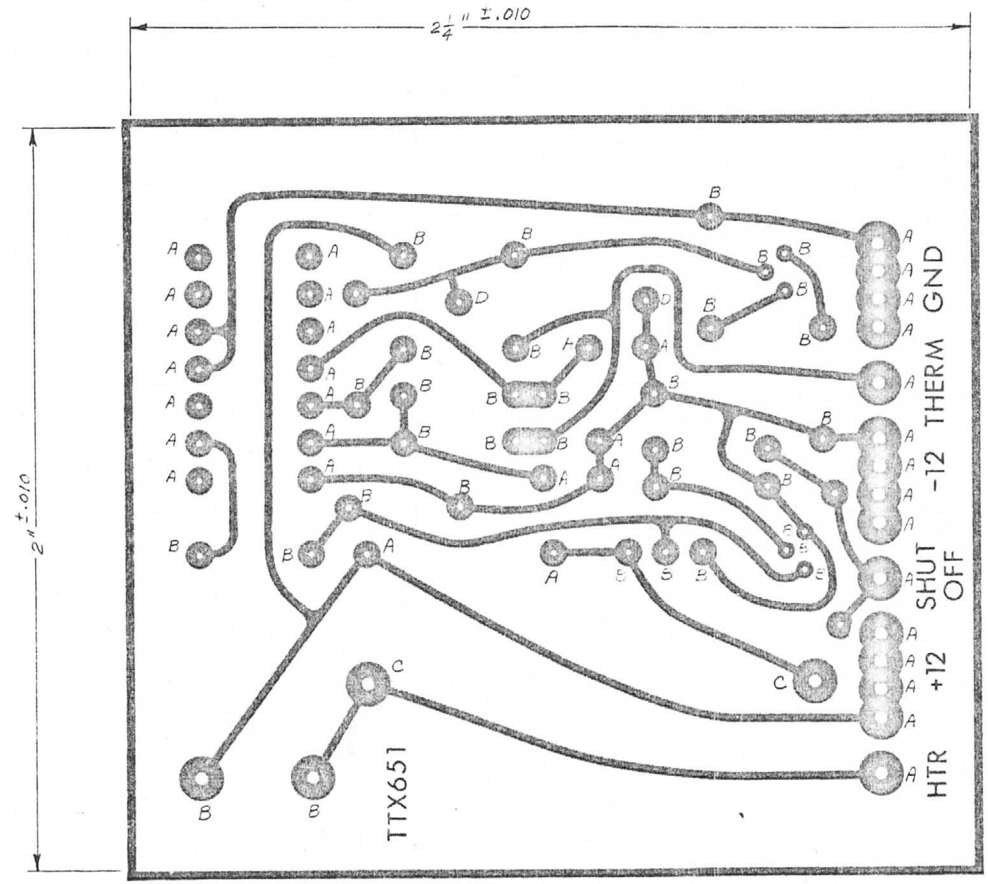
MADISON, WISCONSIN

TITLE: Oven Temperature Controller

SCALE	DRAFTSMAN	DATE	CHECKER	DATE	ENGINEER	DATE
None	T.Z.	8-2-72				
APPROVAL	DATE	DESIGN ACTIVITY APPROVAL	DATE	ADDITIONAL APPROVAL	DATE	

PROJECT NO.	SIZE	SHEET	DRAWING NO.
6300	B	1 of 1	TTX 650-4

REVISIONS			
LTR.	DESCRIPTION	DATE	APPROVED



DRILL SCHEDULE	
DESIGNATION	DRILL SIZE
A	#74
B	#76
C	#60
D	#71

MATERIAL SPEC. NOTES	
BOARD MATERIAL :	G-10 DOUBLE-SIDED
THICKNESS :	1/64"
COPPERWEIGHT :	1 OZ.
FINISH :	SOLDER PLATE

THE UNIVERSITY OF WISCONSIN
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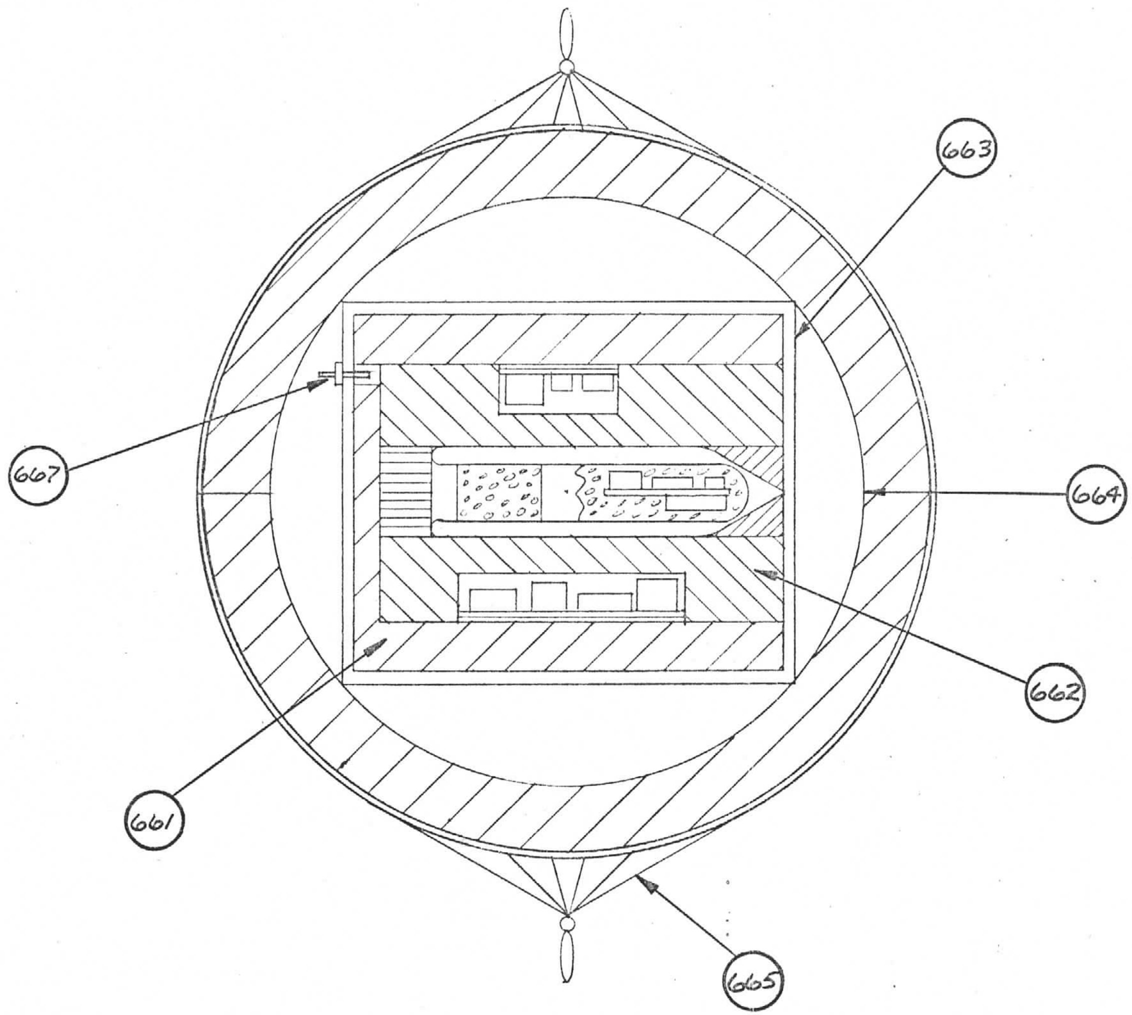
MADISON, WISCONSIN

TITLE: OVEN TEMPERATURE CONTROLLER - SPECIFICATIONS

SCALE 4:1	DRAFTSMAN J. DENNIS	DATE 3-24-73	CHECKER	DATE	ENGINEER	DATE
NEXT HIGHER ASSEMBLY	PRODUCT ASSURANCE		DATE	PROJECT APPROVAL		DATE
PROJECT NO. 6300	SIZE C	SHEET 1 OF 1	DRAWING NO. TTX-651-1			

REVISIONS			
SYM.	DESCRIPTION	DATE	APPROVED



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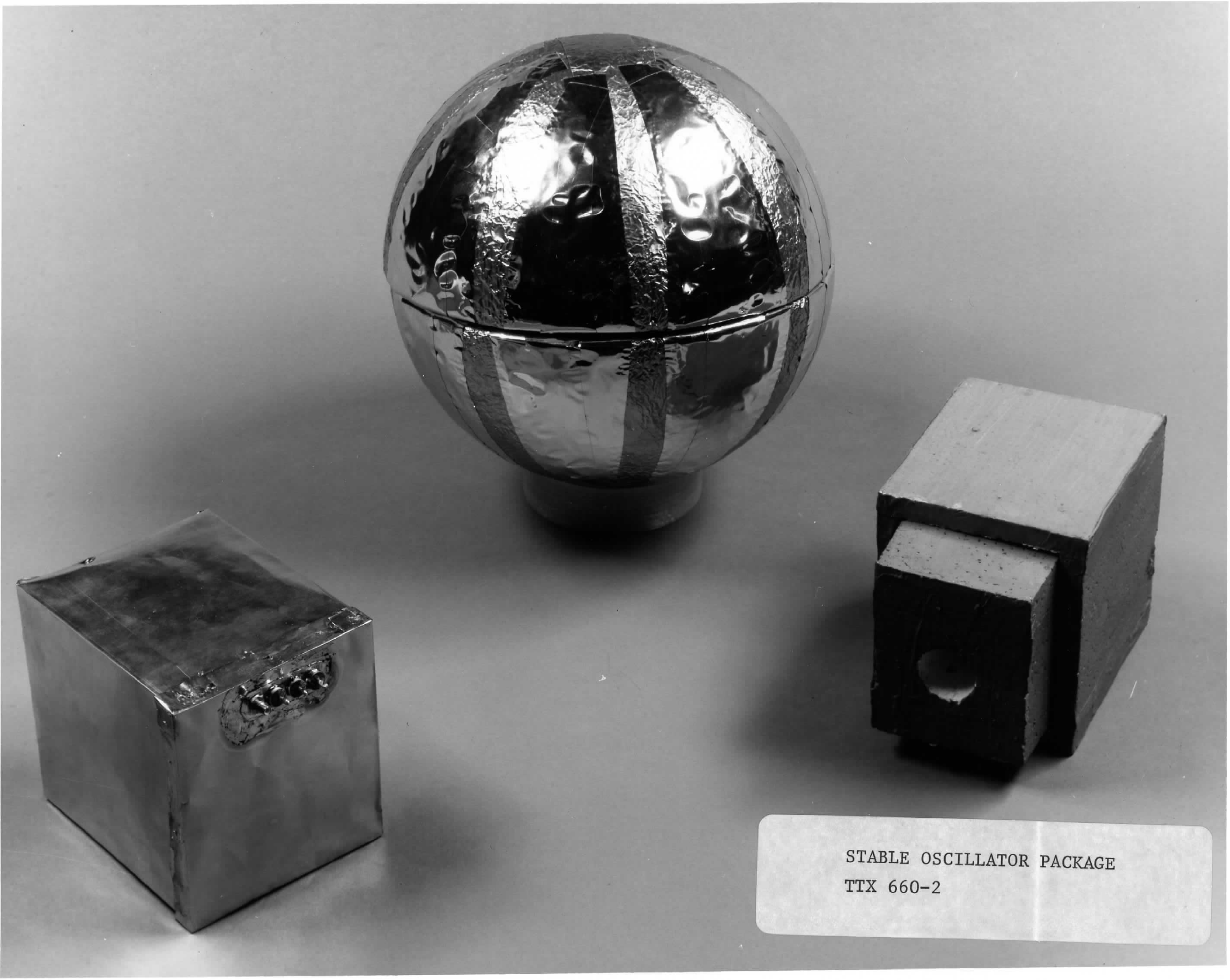
SPACE SCIENCE & ENGINEERING CENTER

MADISON, WISCONSIN

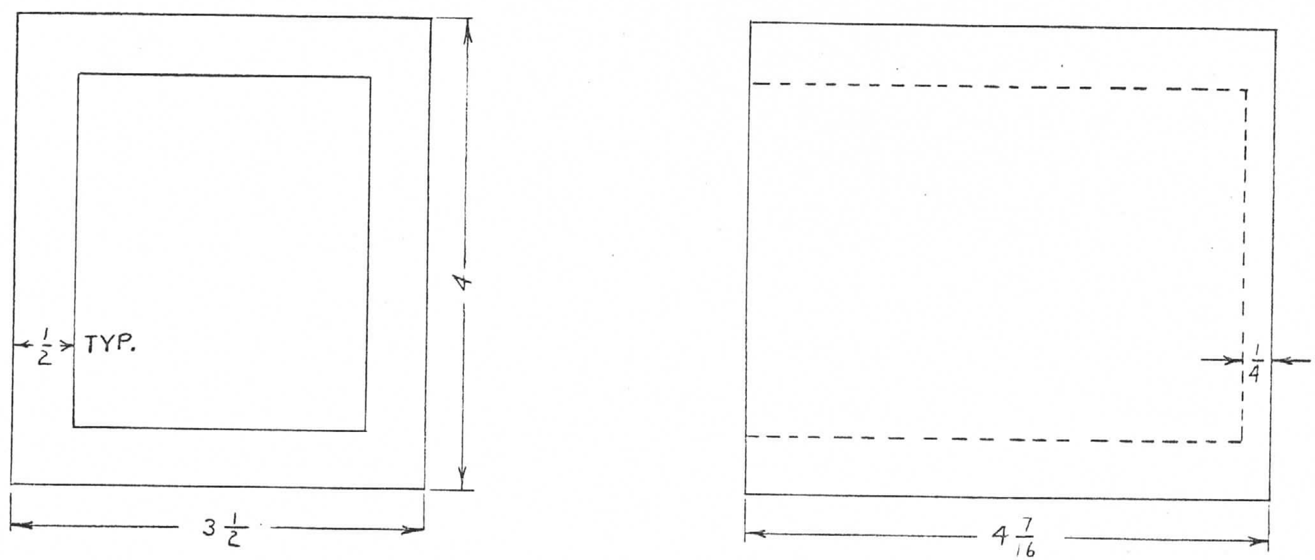
TITLE STABLE OSCILLATOR PACKAGE ASSY.			
SCALE NONE	DRAFTSMAN [illegible] DATE	CHECKER DATE	ENGINEER DATE
APPROVAL DATE	DESIGN ACTIVITY APPROVAL DATE	ADDITIONAL APPROVAL DATE	
PROJECT NO. 6300	SIZE B	SHEET 1 OF 1	DRAWING NO. TTX 660-1


STABLE OSCILLATOR PACKAGE
TTX 660-2

REFERENCE Dwg. No	SCHEM.	DESCRIPTION	SOURCE	QUAN. ASSY.	
60-1	A9	Flask, Dewar	VIZ 1017-2	1	
53	A14	Connector, 50 Ohm Bulk head	Selectro 50-043-0000	1	
"	A15	Connector, 50 Ohm Coaxial	Selectro 50-007-0000	2	
"	A16	Same as A15			
"	A17	Cable, Coaxial 50 Ohm RG174	Belden		
53	C50	Capacitor, 470 pf 20% Ceramic Feed thru	Allen Bradley FA5C-4712		
53	C51	Same as C50			
53	C52	Same as C50			
1		Insulating Jacket, Outer		1	
2		Insulating Jacket & Support, Inner		1	
3		Foil Pattern		1	
7		Terminal Strip		1	
4		Sphere Encloser 8"		1	
5		Net, Supporting		1	

#TTX660-3

REVISIONS			
SYM.	DESCRIPTION	DATE	APPROVED



MATERIAL

STYROFOAM
DENSITY 2 lb/ft³

ONE REQ

TOLERANCE $\pm\frac{1}{32}$ EXCEPT AS NOTED BELOW

NOTE

PARTS TTX 661 & 662 TO BE ASSEMBLED & DISASSEMBLED WITH LIGHT HAND PRESS

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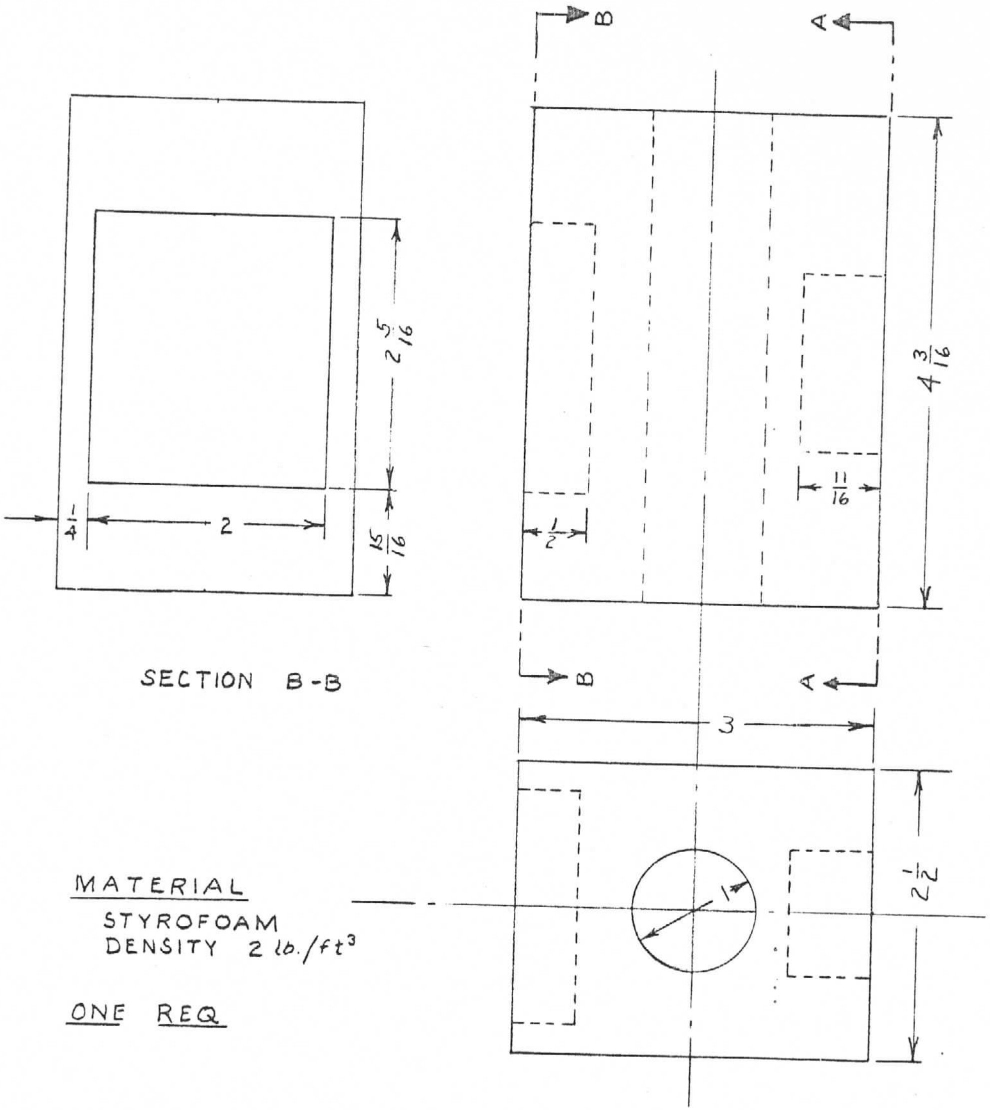
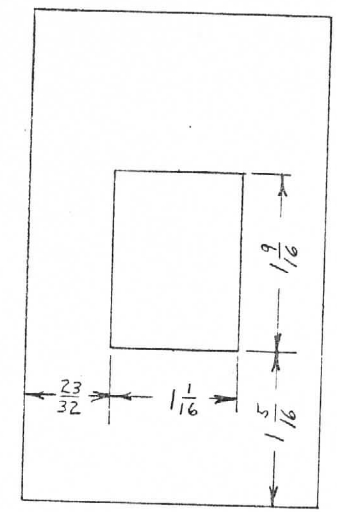
SPACE SCIENCE & ENGINEERING CENTER
MADISON, WISCONSIN

TITLE: OSCILLATOR OVEN PACKAGE OUTER INSULATING JACKET			
SCALE: FULL	DRAFTSMAN: J.G.M — DATE: 3/21/73	CHECKER: J.G.M — DATE: 3/21/73	ENGINEER: J.G.M — DATE: 3/21/73
APPROVAL	DATE	DESIGN ACTIVITY APPROVAL — DATE	ADDITIONAL APPROVAL — DATE
PROJECT NO: 6310	SIZE: B	SHEET 1 OF 1	DRAWING NO: TTX 661



SECTION B-B



SECTION A-A

TOLERANCE $\pm\frac{1}{32}$ EXCEPT AS NOTED BELOW

NOTE

PARTS TTX 661 & 662 TO BE ASSEMBLED & DISASSEMBLED WITH LIGHT HAND PUSH

1" DIAM DEWAR FLASK TO BE INSERTED & REMOVED WITH LIGHT HAND PUSH

MATERIAL

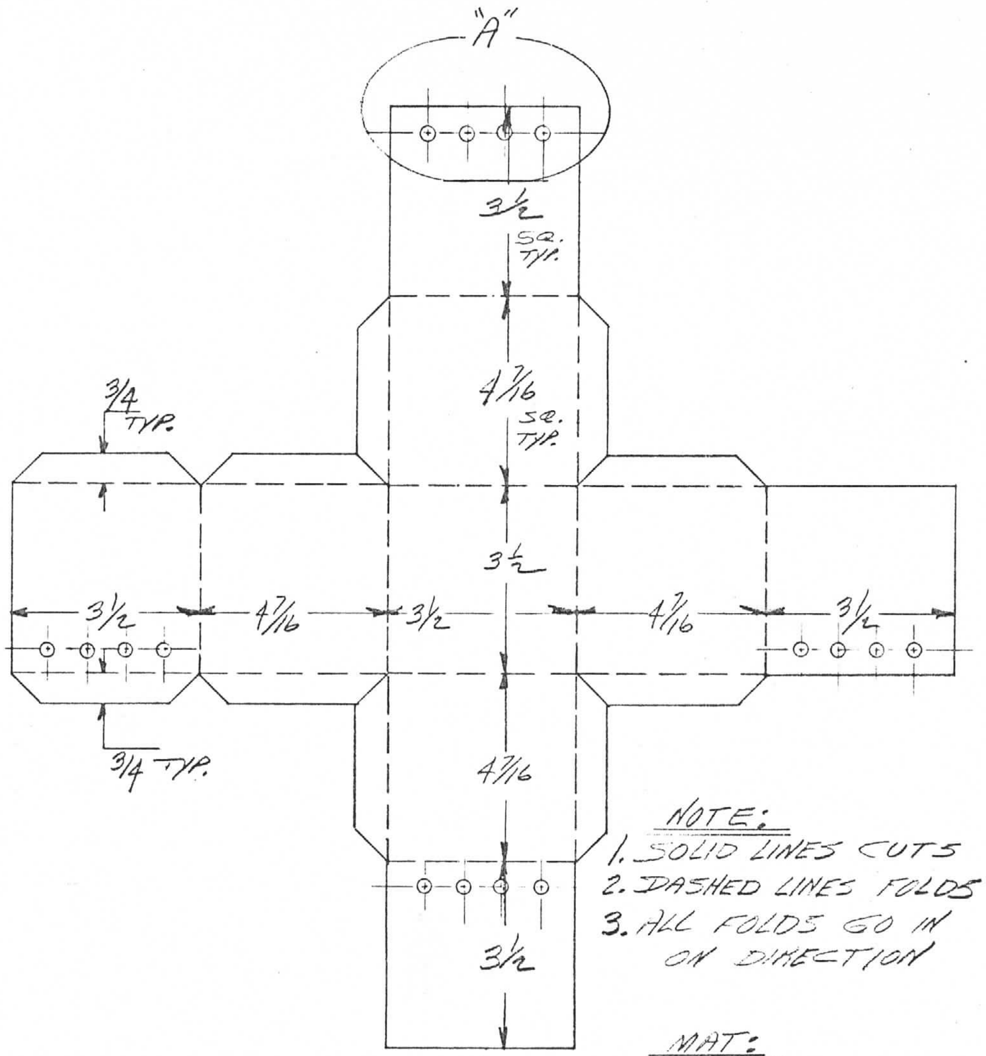
STYROFOAM
DENSITY 2 lb./ft^3

ONE REQ

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

THE UNIVERSITY OF WISCONSIN
SPACE SCIENCE & ENGINEERING CENTER
MADISON, WISCONSIN

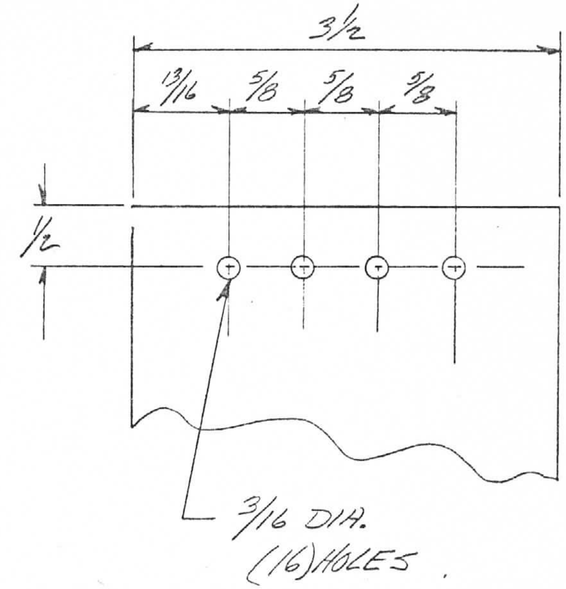
TITLE: OSCILLATOR OVEN PACKAGE — INNER INSULATION & COMPONENT SUPPORT			
SCALE: FULL	DRAFTSMAN: J.G.M DATE: 3/21/73	CHECKER: J.G.M DATE: 3/21/73	ENGINEER: J.G.M DATE: 3/21/73
APPROVAL	DATE	DESIGN ACTIVITY APPROVAL DATE	ADDITIONAL APPROVAL DATE
PROJECT NO. 6310	SIZE B	SHEET 1 OF 2	DRAWING NO. TTX 662



NOTE:
1. SOLID LINES CUTS
2. DASHED LINES FOLDS
3. ALL FOLDS GO IN ON DIRECTION

MAT:
.002 ALUMINUM FOIL SHINY SIDE IN.

REVISIONS			
SYM.	DESCRIPTION	DATE	APPROVED

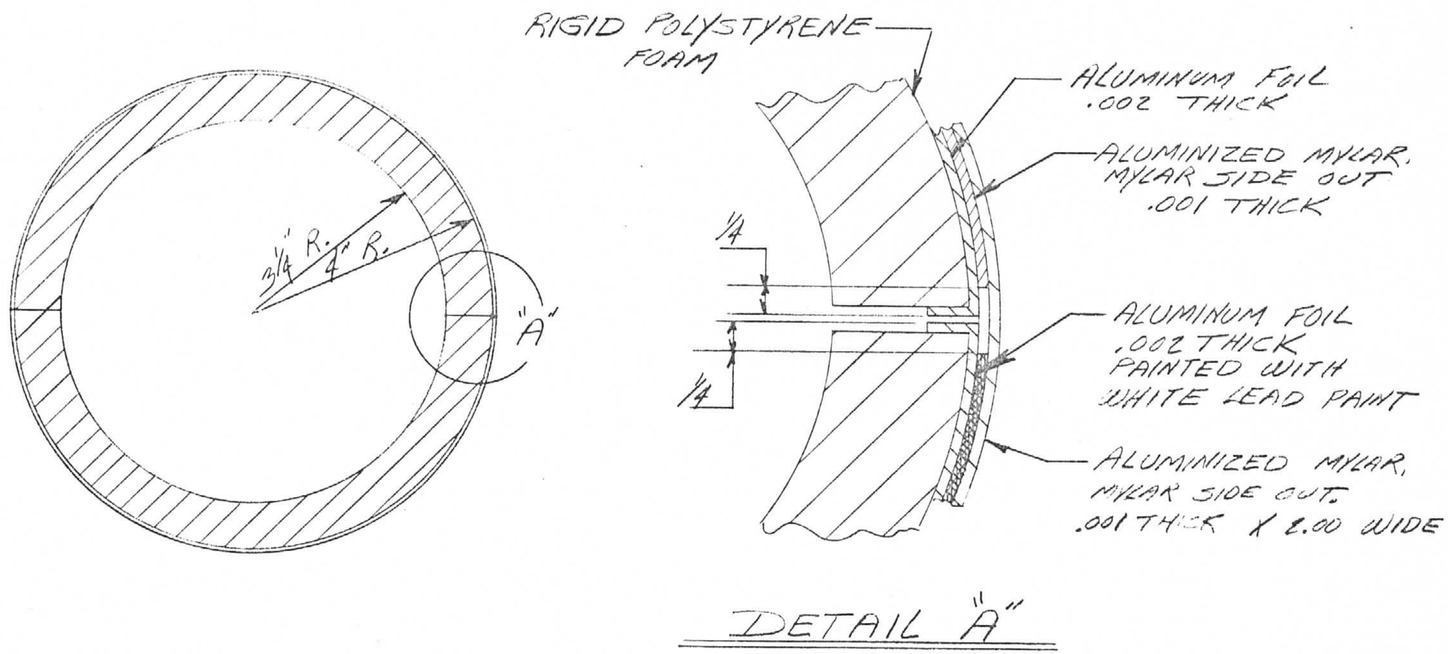


DETAIL "A" FULL SCALE

THE UNIVERSITY OF WISCONSIN
SPACE SCIENCE & ENGINEERING CENTER
MADISON, WISCONSIN

TITLE: FOIL PATTERN FOR STABLE OSSCILLATOR			
SCALE: NONE	DRAFTSMAN: HB DATE	CHECKER DATE	ENGINEER DATE
APPROVAL	DATE	DESIGN ACTIVITY APPROVAL DATE	ADDITIONAL APPROVAL DATE
PROJECT NO. 6300	SIZE D	SHEET 1 OF 1	DRAWING NO. TTX663

REVISIONS			
SYM.	DESCRIPTION	DATE	APPROVED

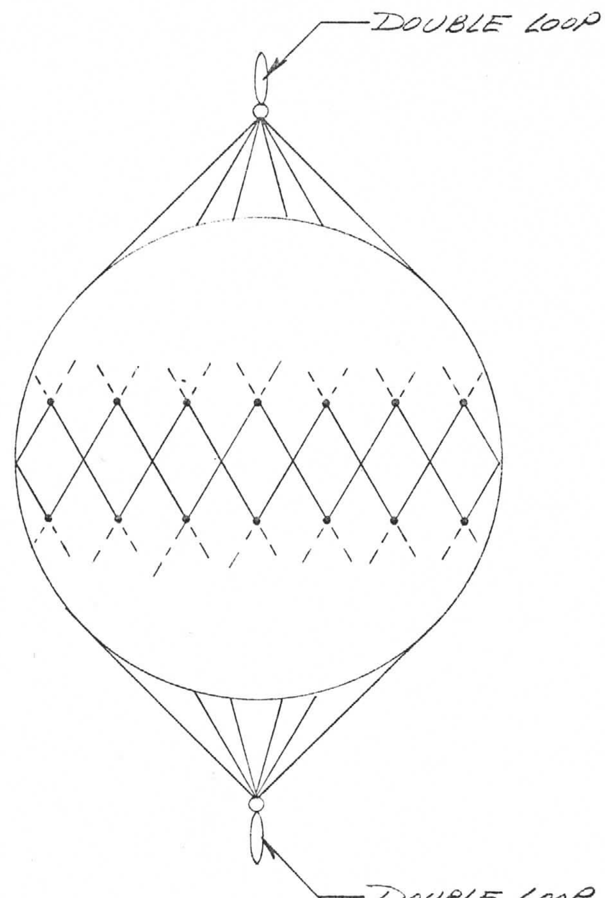


DETAIL "A"

THE UNIVERSITY OF WISCONSIN
SPACE SCIENCE & ENGINEERING CENTER
MADISON, WISCONSIN

TITLE: STABLE OSCILLATOR ENCLOSURE					
SCALE: NONE	DRAFTSMAN: [illegible]	DATE	CHECKER	DATE	ENGINEER DATE
APPROVAL		DATE	DESIGN ACTIVITY APPROVAL	DATE	ADDITIONAL APPROVAL DATE
PROJECT NO. 6300	SIZE E	SHEET 1 OF 1	DRAWING NO. TTX 664		

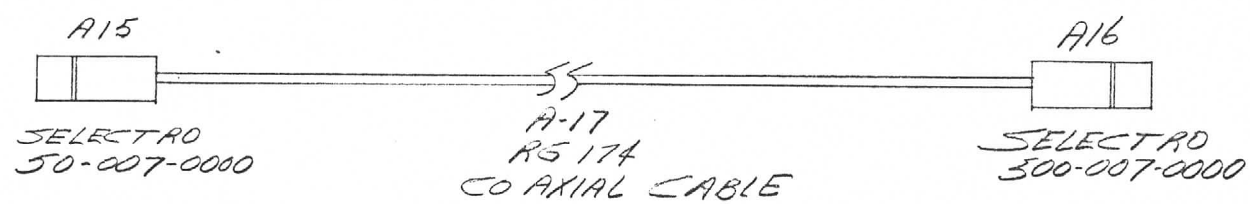
REVISIONS			
SYM.	DESCRIPTION	DATE	APPROVED



MAT:
NYLON, STRAND TEST STRENGTH 50 LBS.

THE UNIVERSITY OF WISCONSIN SPACE SCIENCE & ENGINEERING CENTER MADISON, WISCONSIN				
TITLE: SUPPORT NET				
SCALE: NONE	DRAFTSMAN: [illegible] DATE	CHECKER DATE	ENGINEER DATE	
APPROVAL DATE	DESIGN ACTIVITY APPROVAL DATE	ADDITIONAL APPROVAL DATE		
PROJECT NO. 6300	SIZE B	SHEET 1 OF 1	DRAWING NO. TTX665	

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



THE UNIVERSITY OF WISCONSIN
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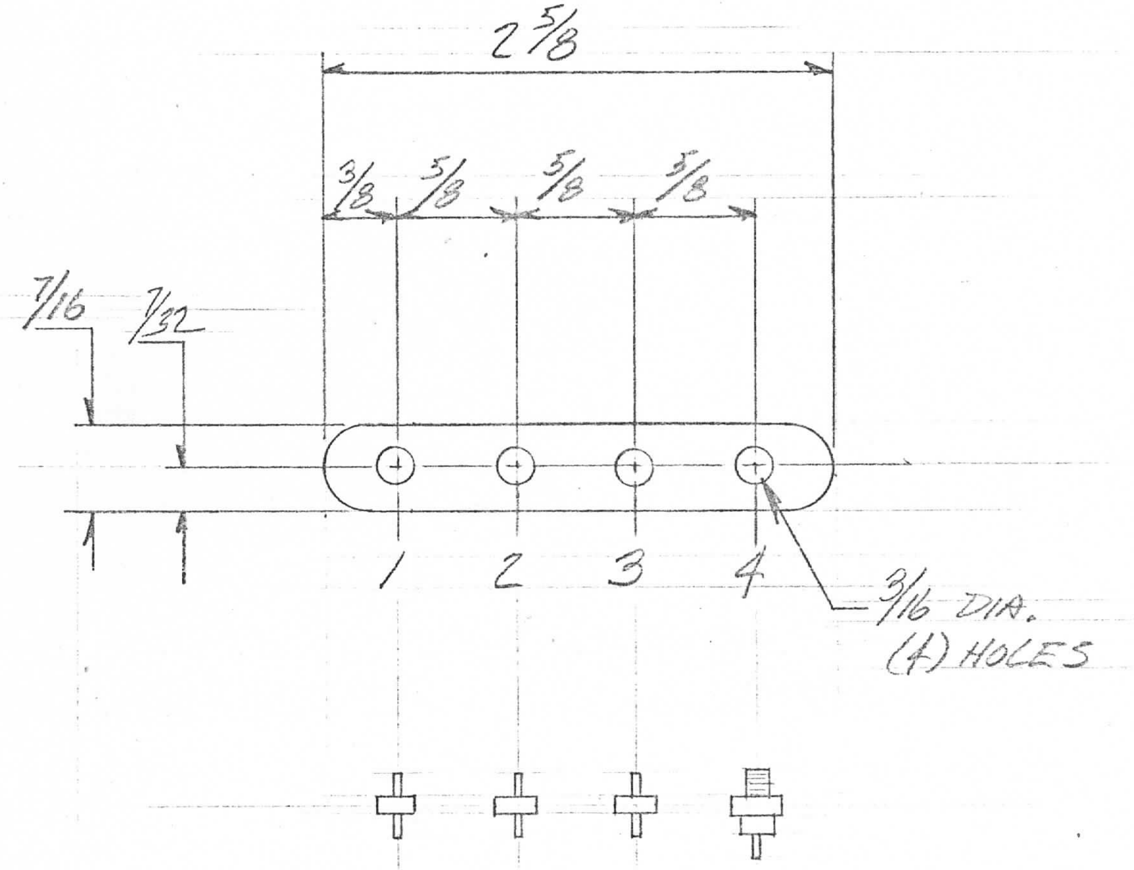
MADISON, WISCONSIN

TITLE: 50 MHZ CABLE			
SCALE: NONE	DRAFTSMAN / DATE	CHECKER / DATE	ENGINEER / DATE
APPROVAL / DATE	DESIGN ACTIVITY APPROVAL / DATE	ADDITIONAL APPROVAL / DATE	
PROJECT NO. 6300	SIZE B	SHEET 1 OF 1	DRAWING NO. TTX 666

REVISIONS			
LTR.	DESCRIPTION	DATE	APPROVED



MATL.
.005 PHOSPHOR BRONZE

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MADISON, WISCONSIN

TITLE TERMINAL MOUNTING STRIP					
SCALE 1-1	DRAFTSMAN	DATE	CHECKER DATE		ENGINEER DATE
NEXT HIGHER ASSEMBLY		PRODUCT ASSURANCE DATE		PROJECT APPROVAL DATE	
PROJECT NO.	SIZE A	SHEET 1 OF 1	DRAWING NO.		