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EM-390-360L
TRAINING NOTES

Please see Notes

[redacted]

varian
instrument division

PART NO.996309

Notes:

- THE EM 360L SPECTROMETER DOES'T HAVE A TRAINING BOOK WITH DETAILS OF BOARDS AND REPAIRS.
- AS FAR THE 360L HAVE THE CONSOLE SIMILAR OF 390 (MAGNET ARE DIFFERENT)
  ALL BOARDS ARE IDENTICAL LESS:
  - H' TX XTALL DIFERENT FREQ.
  - SHIM CONTROL HAS TWO EXTRA GRADIENT IN 390 _

SO FOR REPAIRS AND TRAINING THIS BOOK IS OK

[redacted]

P.S. Chemical Shift AND SPECTRA VALUES OF FIRST PART ARE CONCERNING EM 390 _ [redacted]

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VARIAN ASSOCIATES
INSTRUMENT DIVISION
TECHNICAL SUPPORT
MAGNETICS GROUP

EM-390 TRAINING NOTES

SECTION 1.0
BLOCK DIAGRAM DISCUSSION

1.1 SPECIFICATIONS

Magnet Field Strength	21.14 Kilogauss
Standard Operating Frequency	90 MHz (^1H)
Sample Tube Size	5 millimeter OD, 4.2 millimeter ID
Typical Sample Volume	0.4 cc
Sensitivity	Greater than 50:1 signal-to-average noise ratio on the largest in the methylene quartet of a one per-cent by volume ethylbenzene solution.
Resolution	Less than 0.5 Hertz full linewidth at half maximum amplitude.
Spinning Sidebands	Less than 2.5 percent of main signal amplitude at a sample spin rate of 50 rps.
Line Shape	Less than 10 Hertz linewidth at 0.55 percent amplitude level.
	Less than 35 Hertz linewidth at 0.11 percent amplitude level.
Average RF Field At Sample	0.005 to 0.5 milligauss, continuously variable.
Field Stability	Locked: Deviation less than 0.2 Hertz in a 5 minute scan.
	Unlocked: Deviation less than 2 Hertz in a 5 minute scan.

Resolution Stability	Linewidth will not degrade by more than 0.5 Hertz in 8 hours without AUTOSHIM.
Integral Reproducibility	Average deviation less than 2 percent for 5 consecutive scans of a 5 percent by volume ethylbenzene solution.
Sweep Widths	0.2, 0.5, 1.0, 2.0, 5.0, 10.0, 20.0, 50.0, and 100.0PPM.
Sweep Times	0.5, 1.0, 2.0, 5.0, 10.0, and 20.0 Minutes.
Field Offset Range	±200PPM digitally selectable. (Includes 0-1PPM continuous vernier.)
Internal Lock Range	±50PPM from observing channel (effective Serial 147).
Modulation Frequency	25 KHz (single sideband detection).
Filter Time Constants	0.05, 0.1, 0.2, 0.5, 1.0, 2.0, and 5.0 Seconds.
Flatbed Y-T Recorder	Platen Size: 11 x 17 inches (28 x 43 centimeters) Chart Size: 11 x 16.5 inches (28 x 42 centimeters) Writing Grid: 200 x 340 millimeters Pen Response: 0.75 seconds full scale vertical travel Linearity: 0.35 percent Chart Calibration Accuracy: ±0.2 percent of full scale.
Homogeneity Gradient Controls	Y (COARSE and FINE), CURVATURE (COARSE and FINE), X, Z, X^2, XY, YZ, ZY^2, Y^3, and Y^4.

Ambient Temperature Requirements	18°C to 32°C with a maximum variation of ±3°C over 24 hours.
Utility Requirements	Line Voltage: 115, 208, or 220 volts, 50 or 60 Hertz.
	Line Power: 260 watts maximum
System Weight	Magnet Console: 2100 lbs (952 Kg)
	Control Console (incl stand): 100 lbs (45 Kg)
Physical Dimensions (D x W x H)	Magnet Console: 33.5 x 41 x 34 inches (85 x 104 x 86 centimeters)
	Control Console (incl stand): 24.3 x 37 x 38 inches (62 x 94 x 96 centimeters)
Variable Temperature Accessory	Range: -100°C to +175°C, digitally selectable
	Accuracy: ±2°C
	Resettability: ±1°C
	Stability: ±0.5°C
	Cooling: Joule-Thompson gas expansion
	Minimum Pressure for -100°C: 1400 psi using nitrogen 1000 psi using argon
	Typical Gas Flow Rate: 25 CFH or less.
Spin Decoupler Accessory	Operating Modes: FREQUENCY SWEEP DECOUPLING, SPIN TICKLING, INDOR.
	Decoupling Field at Sample: 0.08 to 8 milli-gauss, continuously variable (0.008 to 0.8 milli-gauss for SPIN TICKLING and INDOR).

Offset Range: ±50PPM from Observing Channel.

Frequency Stability: Less than 0.2 Hz deviation in a 5 minute period.

1.2 BLOCK DIAGRAM - FIGURE 1-1

The EM-390 is a high resolution NMR Spectrometer designed for routine analyses of ^{1}H as well as other nuclei. It has a 21.2 Kilogauss field produced by a permanent magnet. The yoke and magnet assembly is thermally insulated and then enclosed in a thermostatted oven along with layers of magnetic shielding. Weight of this magnet assembly is about 2,000 lbs. Spinner air must be provided from an external source or from a pump assembly available with the system.

The console assembly contains all the electronics and is floor mounted. It is normally positioned on the left of the magnet as convenient for the operator. The PC boards making up the electronics are as follows:

- Interconnect (Mother) board
- Observe Channel PCB
- Lock Channel PCB
- Field Control PCB
- Wide Sweep Adapter PCB
- Shim Control PCB
- Autoshim PCB
- Field Modulator PCB
- Magnet Temperature Control PCB
- Receiver PCB
- ^{1}H Transmitter Preamplifier PCB
- ^{19}F Transmitter Preamplifier PCB
- Console Power Supply PCB
- Recorder Amplifier PCB
- Switch Assembly
- Accessory Panel

Accessories for the system include:

- Variable Temperature
- Spin Decoupler
- Oscilloscope
- Time Averaging Computer

The spectrometer is designed for an ambient temperature from 18°C to 32°C with not more than 3°C change per day to meet stability requirements. Line voltages of ±10 percent from 115, 208, or 230 VAC can be accommodated.

For low temperature variable temperature operation, a pump is required to provide a closed cycle for prevention of any moisture being introduced into the system.

The NMR frequency for protons is 90 MHz and NMR excitation is on the upper magnetic side-band or 25 KHz below the Larmor frequency. The EM-390 is a Field Sweep system with the observe frequency constant and the lock frequency swept to move the field. The Spin Decoupler Accessory is tuned to radiate a spectral multiplet and is then swept with the Homonuclear Lock frequency to maintain irradiation of the selected multiplet.

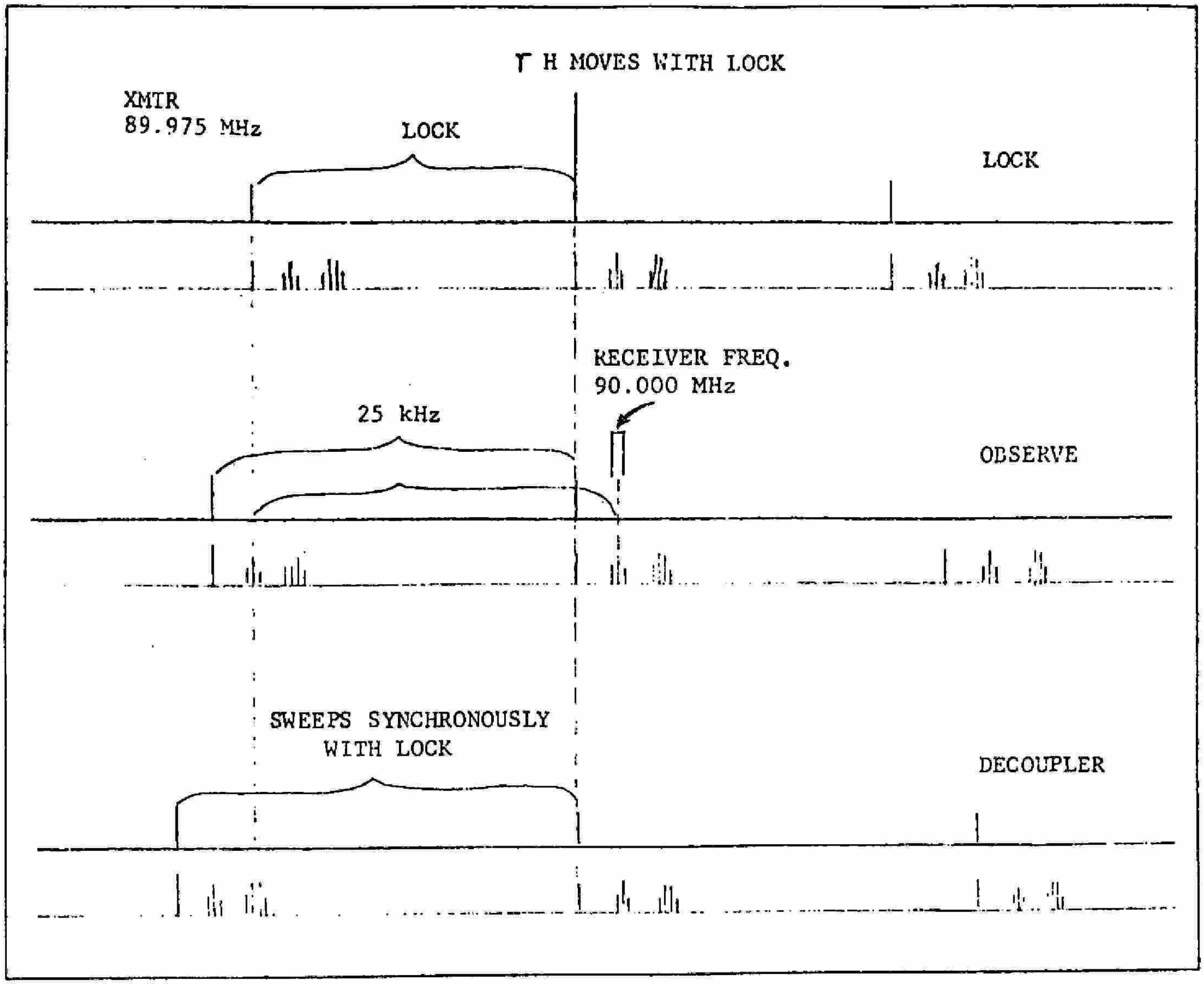

FIGURE 1-2. EM-390 FREQUENCIES
AND SIDEBANDS

1.2.1 MAGNET

This magnet is of box-type construction using an integral Alnico steel box yoke for four sides of the yoke. The top and bottom plates are thin sheets of Alnico steel with the top plate machined for probe mounting. Each pole of the magnet consists of three cylindrical pole pieces, a tapered or conical section pole piece, a tapered spacer, cylindrical shim spacers, and a pole cap or magnetic lens. Around each pole is a multilayered cylindrical compensator to help shape the field and reduce fringing effects. Inside each pole is a hollow cylinder which mounts the various pieces to the yoke. Inside this cylinder is the shunt which sets the exact value of the field. On each end of the magnet arranged around the shunt are shimming set screws in the X and Y shim planes. When rotated these screws apply pressure to the pole to minutely change the parallelity of the pole caps. This minute motion is sufficient to shape the field since this magnet changes its field by 40 gauss for every one-thousandth inch gap change. The Sweep Coil Assembly is mounted on one pole piece at its junction with the Alnico Steel Yoke.

Two test thermistors are mounted inside the magnet when built and the leads brought out to test points on the Magnet Temperature Control PCB. One, known as the Alnico Thermistor, is on the pole itself on the tapered or conical pole piece section and is connected to TP1 and TP2. The other, known as the Yoke thermistor, is on the yoke frame itself and is connected to TP3 and TP4. The temperature vs resistance characteristics are included in the Magnet Temperature Control, Section 2.0.

A layer of plastic foam insulation surrounds the basic magnet assembly completely except for the probe opening. A layer of four silicone steel sheets on each side, top, and bottom are used for magnetic insulation. This is surrounded by another foam thermal insulation layer. A mu-metal shield is then placed around the assembly which in turn is thermally insulated by plastic foam. An aluminum shield containing a total of 33 heater elements with six temperature sensing thermistors is then installed. The heater total resistance is 7½ ohms and the temperature vs resistance table of the thermistors is included in Section 2.0. This oven maintains the temperature of the magnet at +34°C as regulated by the Magnet Temperature Controller PCB. This oven is again shrouded with foam insulation with an additional mu-metal shield over all. Another foam insulation is installed and the entire unit is placed in the magnet console. Figure 1-3 illustrates the principal features of the magnet construction.

In Figure 1-4, the closed cycle air system is shown for low range variable temperature work. The source, in this case a pump, supplies air or recirculated nitrogen to the unit for spinning and sample ejection. For low temperature work, nitrogen or argon gas is recirculated for these functions and in addition provide the cooling through the Joule-Thompson cryostat valve.

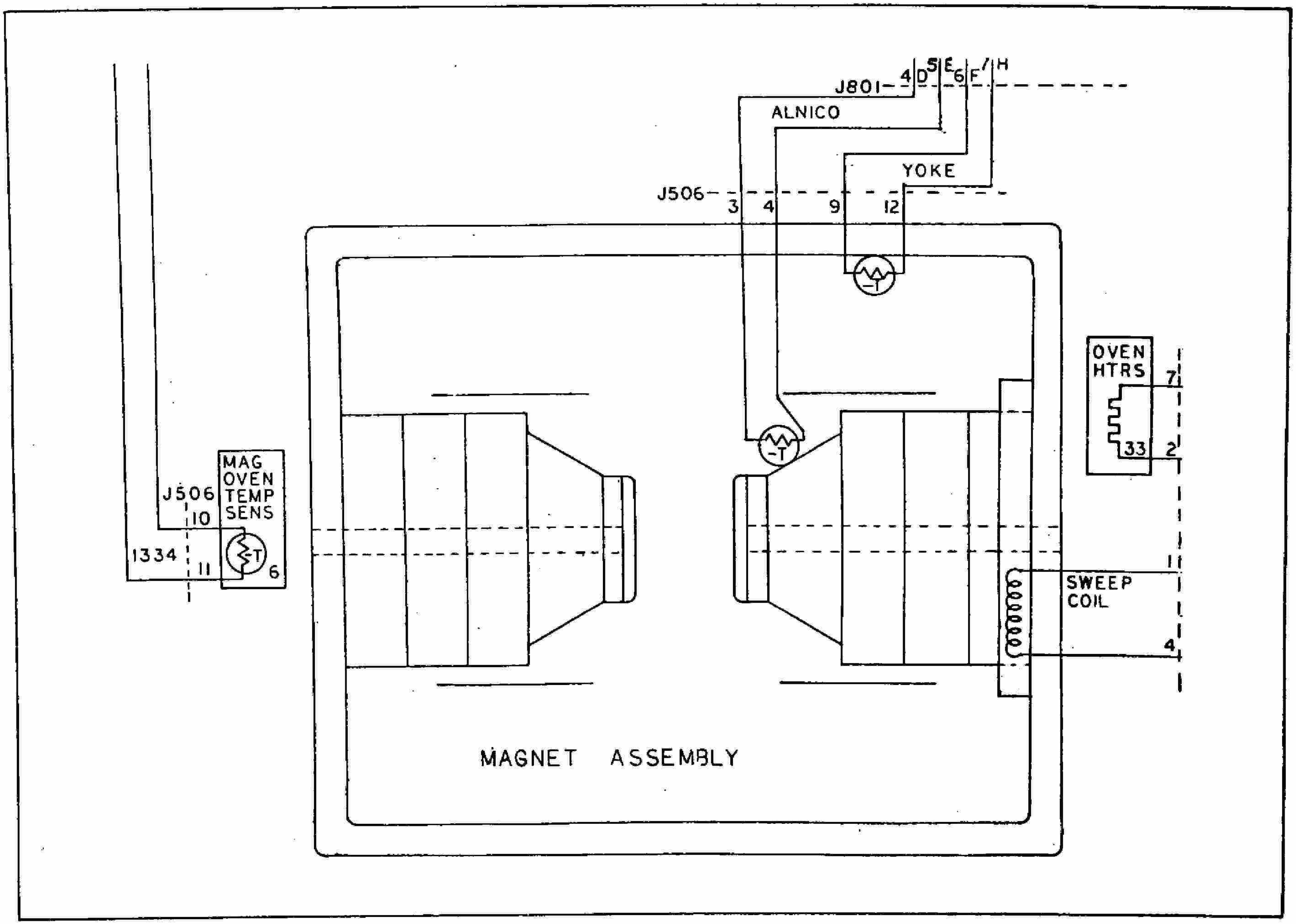

FIGURE 1-3. MAGNET CONSTRUCTION

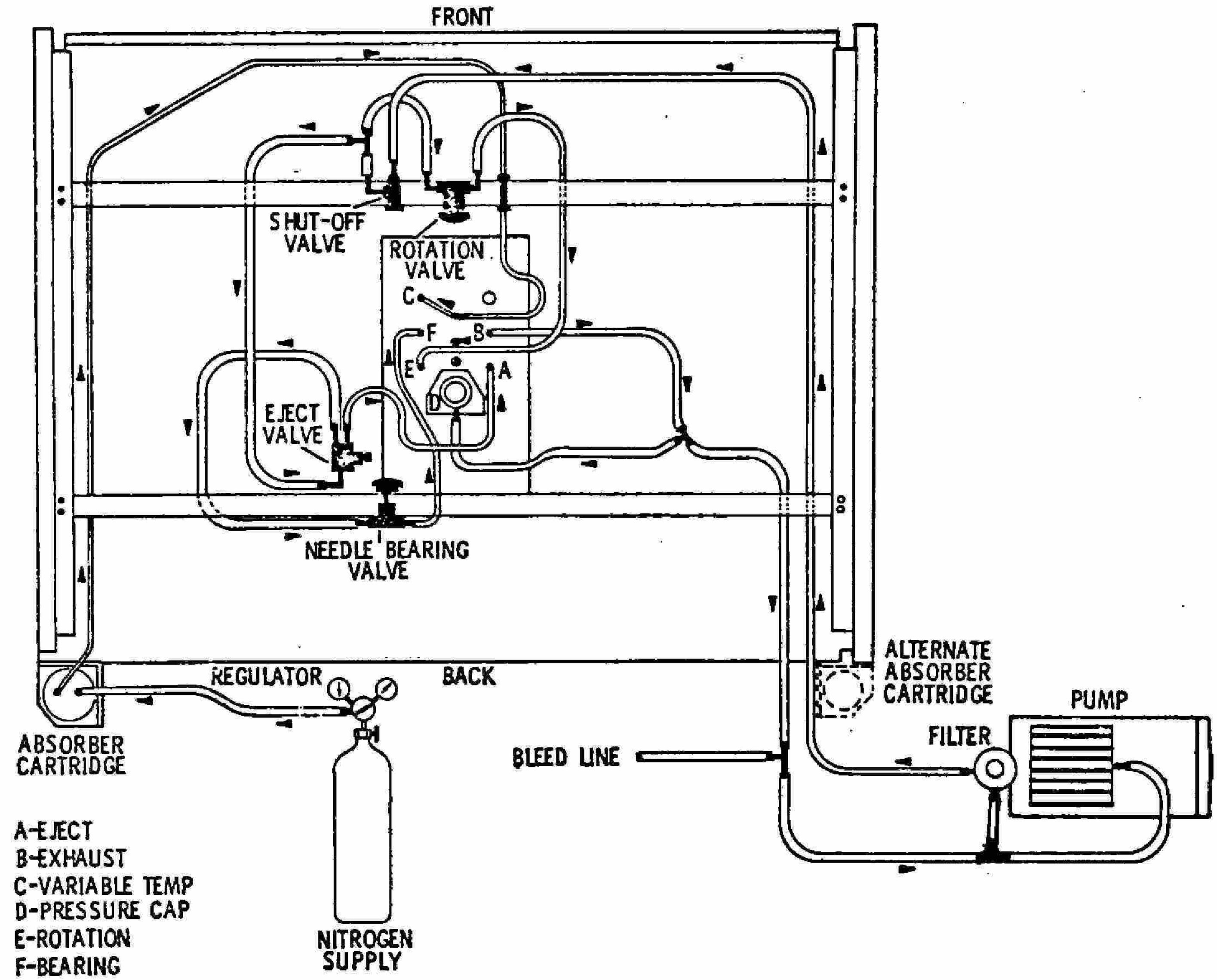

FIGURE 1-4. PNEUMATIC DIAGRAM

1.2.2 MAGNET TEMPERATURE CONTROL (Figure 1-5)

The 6 Magnet Oven Temperature Sensors are part of an input resistive bridge circuit and is connected to the PCB circuitry through J801-8,J and J801-9,K then through J506-10 and J506-11. When the bridge is balanced at +34°C the sensor resistance (total) is 1334 ohms.

The bridge output is fed to differential amplifier U1C which drives output transistor Q1 which in turn controls the external pass gate transistor.

If the sensor were disconnected, it would normally cause the oven to be full on but this is prevented by U1D conduction which turns on Q2. Q2 then turns on only when the input is open and at that time clamps the base of Q1 to zero preventing magnet heater current flow.

The current through the external pass gate flows through 33 heater elements with a total resistance of 7½ ohms. This circuit then provides continuous proportional control of magnet temperature at +34°C.

Four test points are used on this PCB to monitor magnet temperature. The resistance TP1 to TP2 and TP3 to TP4 should be 2000 ohms at +34°C.

1.2.3 FIELD CONTROL

The regulated -10 VDC from the Field Modulator is applied to a voltage regulator, U1 and Q1, on the Field Control PCB. This regulator outputs -5 volts DC. This -5 volts is inverted in U2 and Q2 to +5 volts DC as a regulated supply.

The -5 VDC is applied to the recorder sweep potentiometer as a precision source. The -5 VDC and +5 VDC are applied to the COARSE and FINE FIELD OFFSET controls and to the thumbwheel switch OFFSET CONTROL.

The output of the thumbwheel switch OFFSET, called END OF SWEEP, is applied to buffer amplifier U5 then to operational amplifier U7. The recorder sweep potentiometer is applied to buffer amplifier U3 to the SWEEP WIDTH switch. A portion of this signal is applied to U4 for further buffering thence to operational amplifier U7 in the NORMAL mode. The combined END OF SWEEP and Recorder Sweep level is applied to a summing amplifier U8. Here it is combined with COARSE and FINE FIELD OFFSET as well as the LOCK CORRECTION signal from the AUTOSHIM. This combined signal before amplification is used as the VCO TRACKING signal in the Field Modulator. After amplification the signal is applied to the DC SWEEP coils to vary the field.

In the INDOR mode, the recorder does not sweep the field but is used to sweep the Spin Decoupler frequency through U6.

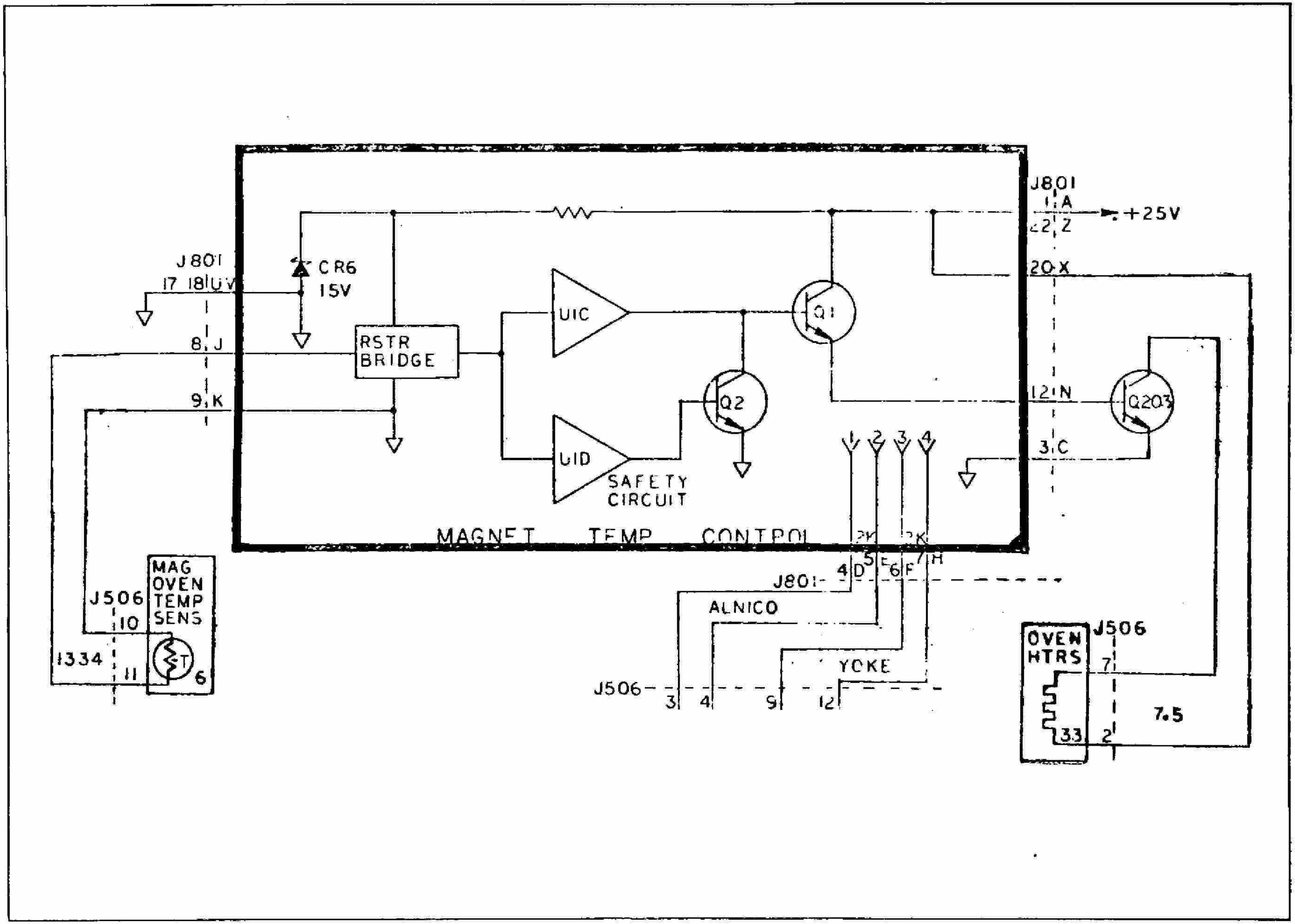

FIGURE 1-5. MAGNET TEMPERATURE CONTROL

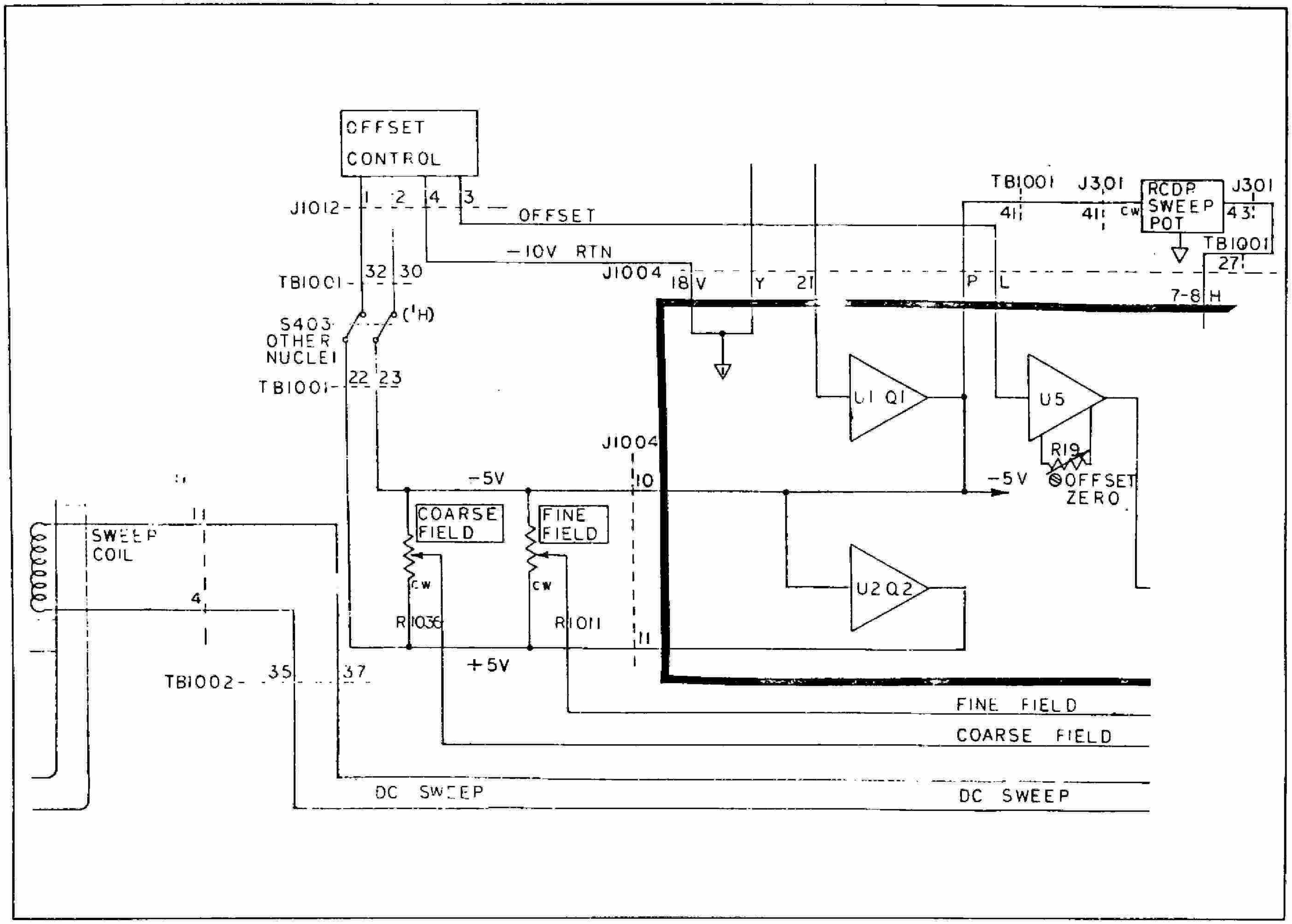

FIGURE 1-6. P/O FIELD CONTROL PCB

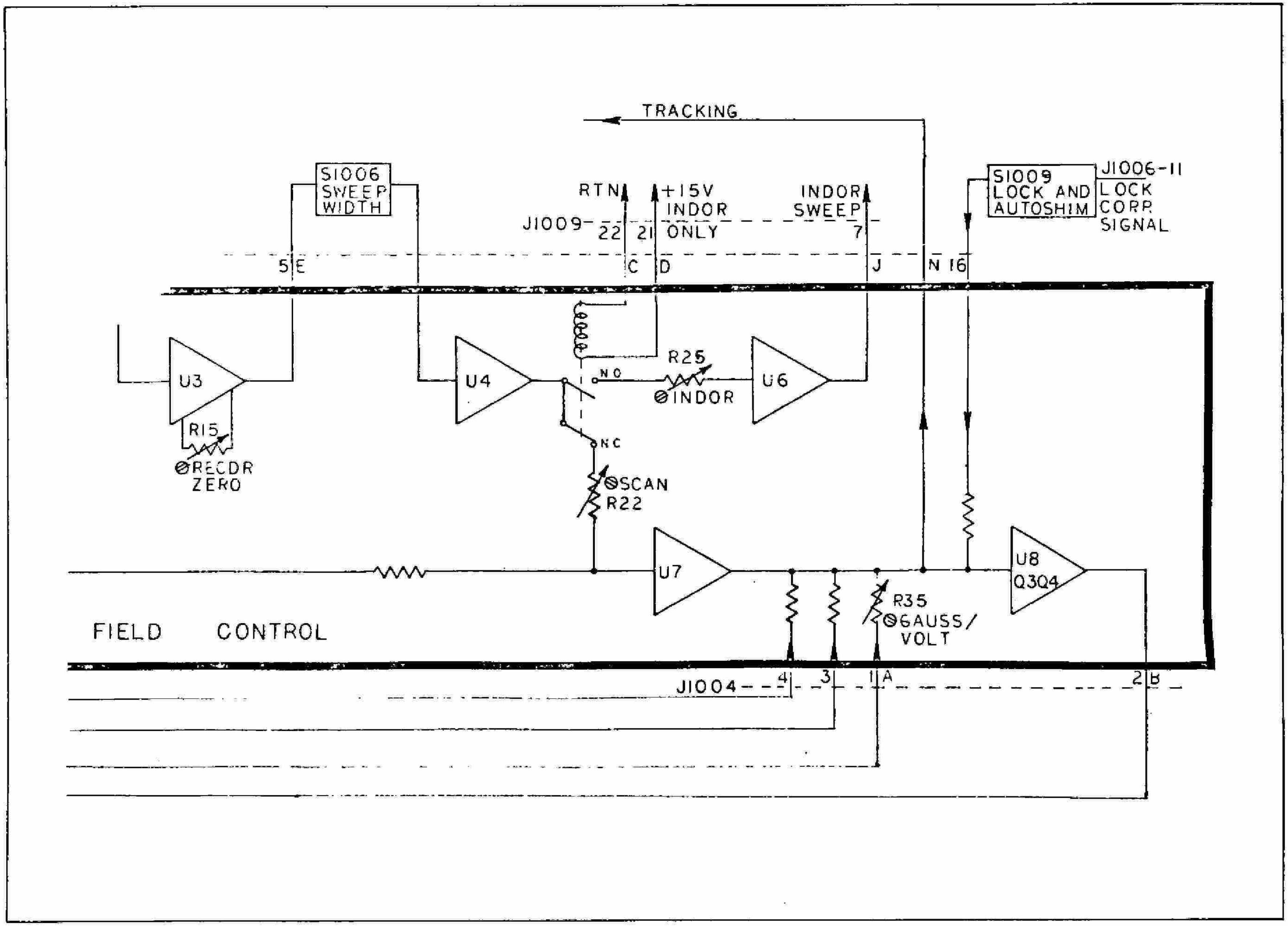

FIGURE 1-7. P/O FIELD CONTROL PCB

1.2.4 FIELD MODULATOR (Figures 8-11)

a. Observe Channel Reference

U1 and crystal Y1 make up a 25 KHz oscillator. The crystal frequency is the output frequency and the amplitude is stabilized by a feedback thermistor. This 25 KHz sine-wave is applied to buffer amplifier U6 and to squaring circuits Q4, Q21, and CR4. This circuit delivers a 5 volt square wave to delay circuit U2 and U3. Here the signal is delayed by the amount prescribed by the OBSERVE PHASE control setting. This delay is variable in this control from 0 through more than 400°. The output is an unbalanced rectangular waveform to the circuits of U4 where it is converted to a balanced waveform. This balanced output in Q and Q-bar TTL Logic signal is applied to the Observe Channel PCB as reference.

b. Lock VCO Generation

U24 is a voltage regulator which regulates the ±26 volts to a precise ±15 volts used throughout the PCB. The -15 volts is further regulated to -10 volts which is the reference for the VCO Frequency Controls as well as the Field Control PCB. U12 inverts and regulates this -10 volts to +12 volts.

The voltage from the LOCK FREQUENCY COARSE and FINE controls is applied to summing amplifier U13. A fixed offset is applied through K2 and a resistive network to the summing amplifier U13. The Field Control VCO TRACKING signal is summed with the other signals and amplified in U13. The combined signal is the VCO CONTROL to U14, Lock VCO.

The Lock VCO oscillates from 40 KHz to 60 KHz which is divided by 2 in U11 to 20 to 30 KHz. The Q output of U11 is applied to buffer amplifier Q10 which resets the sawtooth generator U8, U9, and Q9. This reset frequency determines the frequency of the triangular wave output. The amplitude is proportional to the VCO control voltage which is applied through buffer U12A. A portion of the lock signal is taken across the LOCK POWER control to be summed with the Observe and Spin Decoupler signals.

c. Temperature Regulator

There is an oven mounted on the Field Modulator PCB to house the temperature sensitive frequency generation components. An inner oven houses the Lock VCO. Temperature control between +42°C and 48°C is accomplished with continuous control U25, Q19, and Q20. A temperature sensor balances the circuit to maintain proportional control.

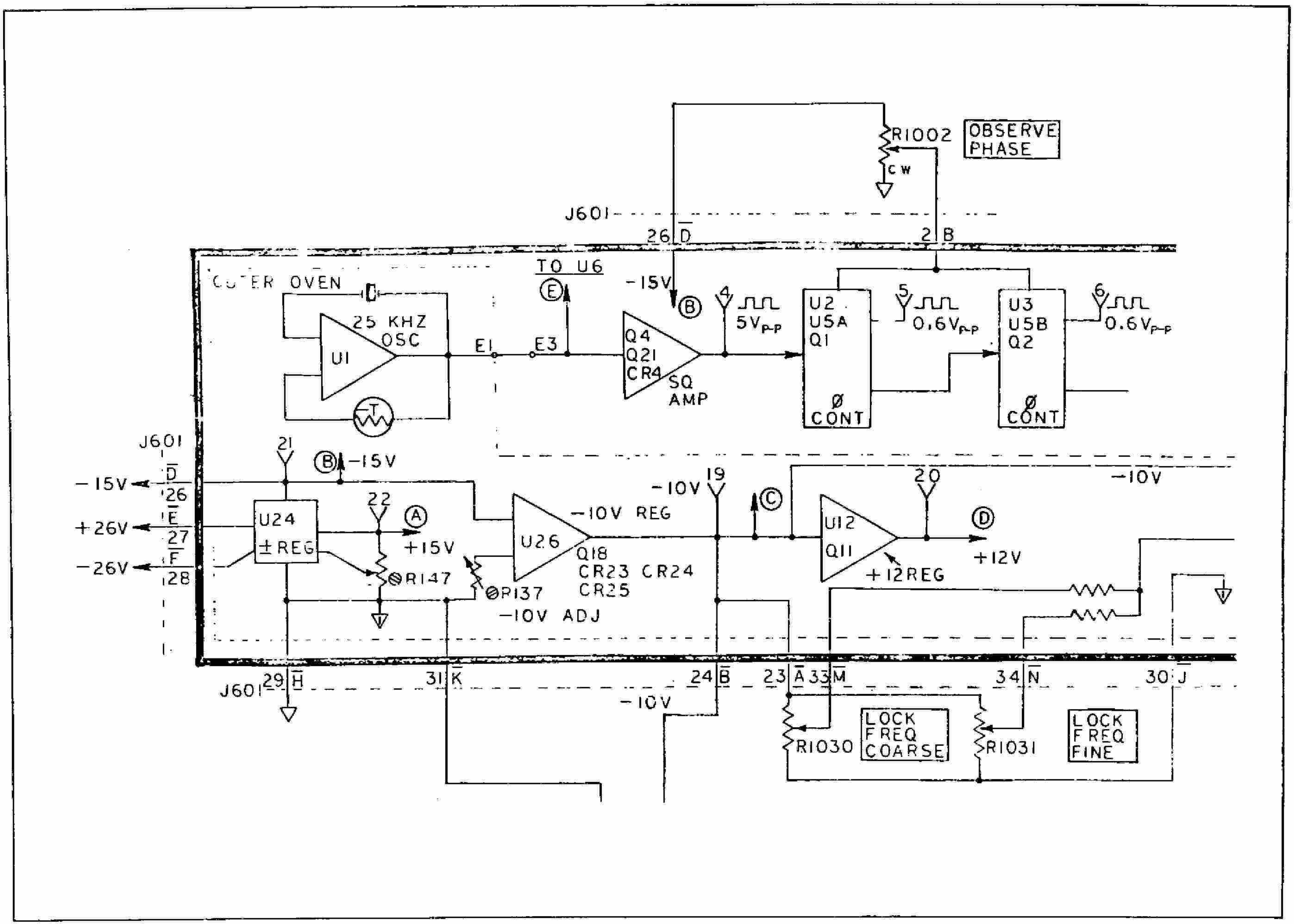

FIGURE 1-8. P/O FIELD MODULATOR PCB

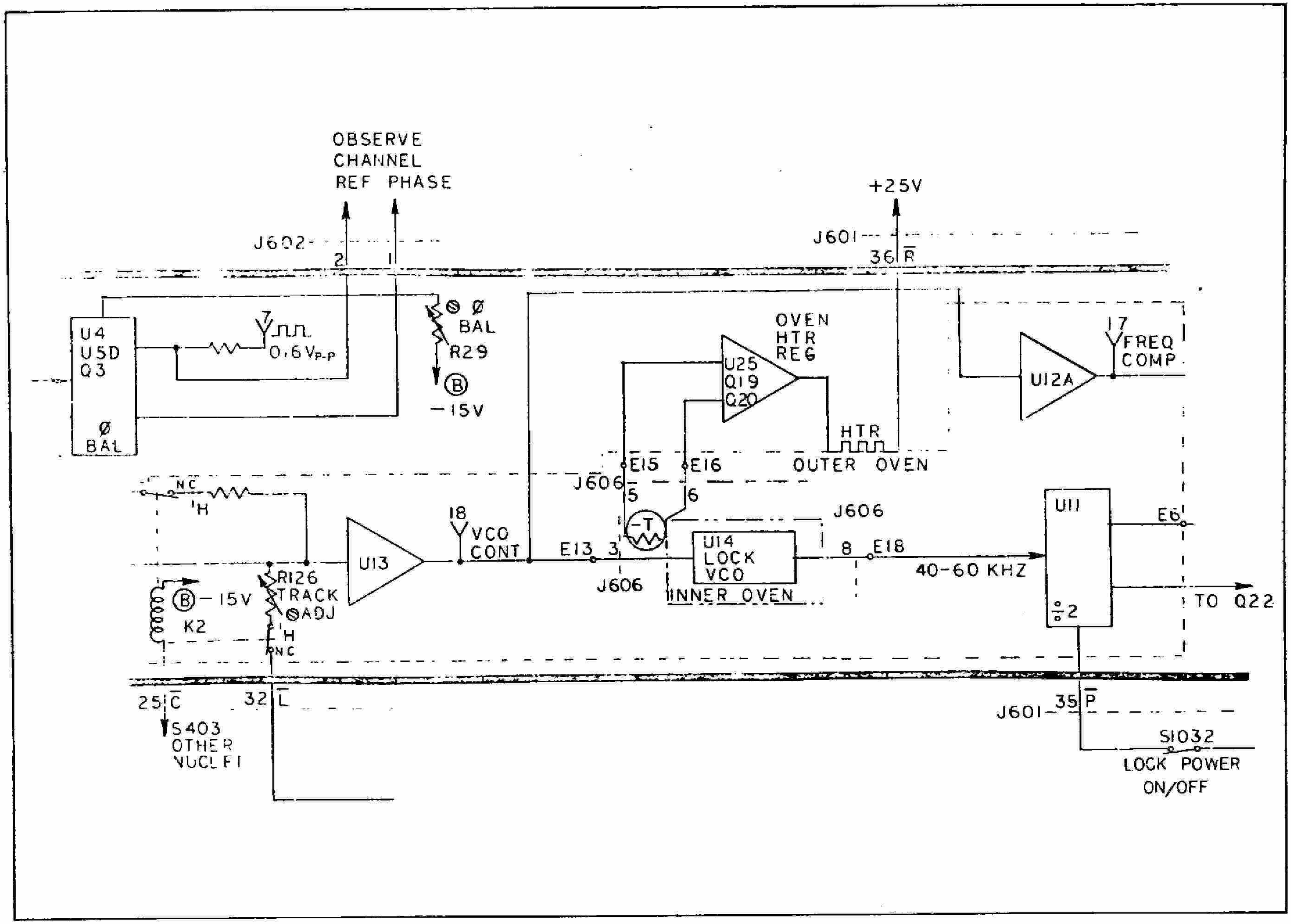

FIGURE 1-9. P/O FIELD MODULATOR PCB

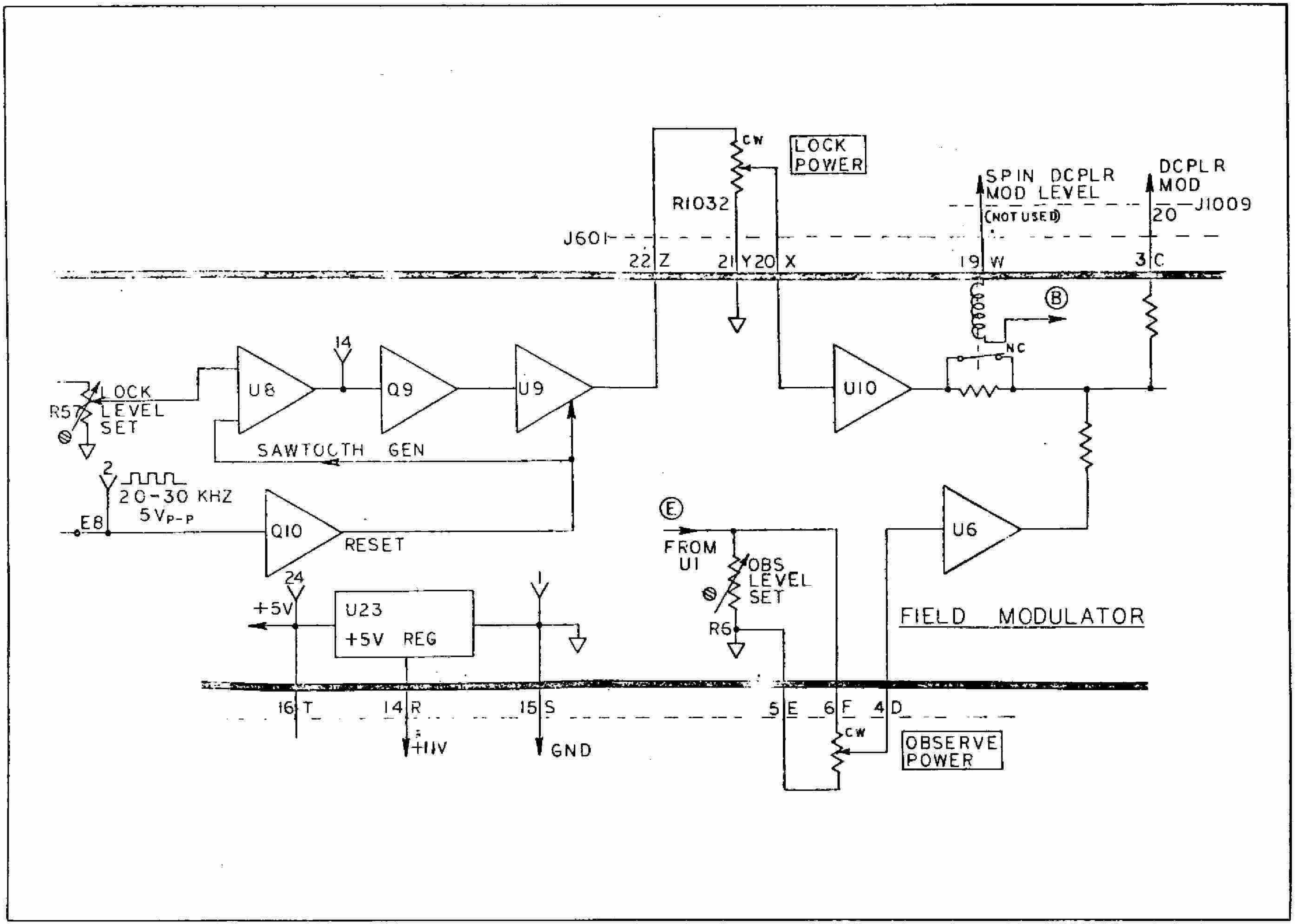

FIGURE 1-10. P/O FIELD MODULATOR PCB

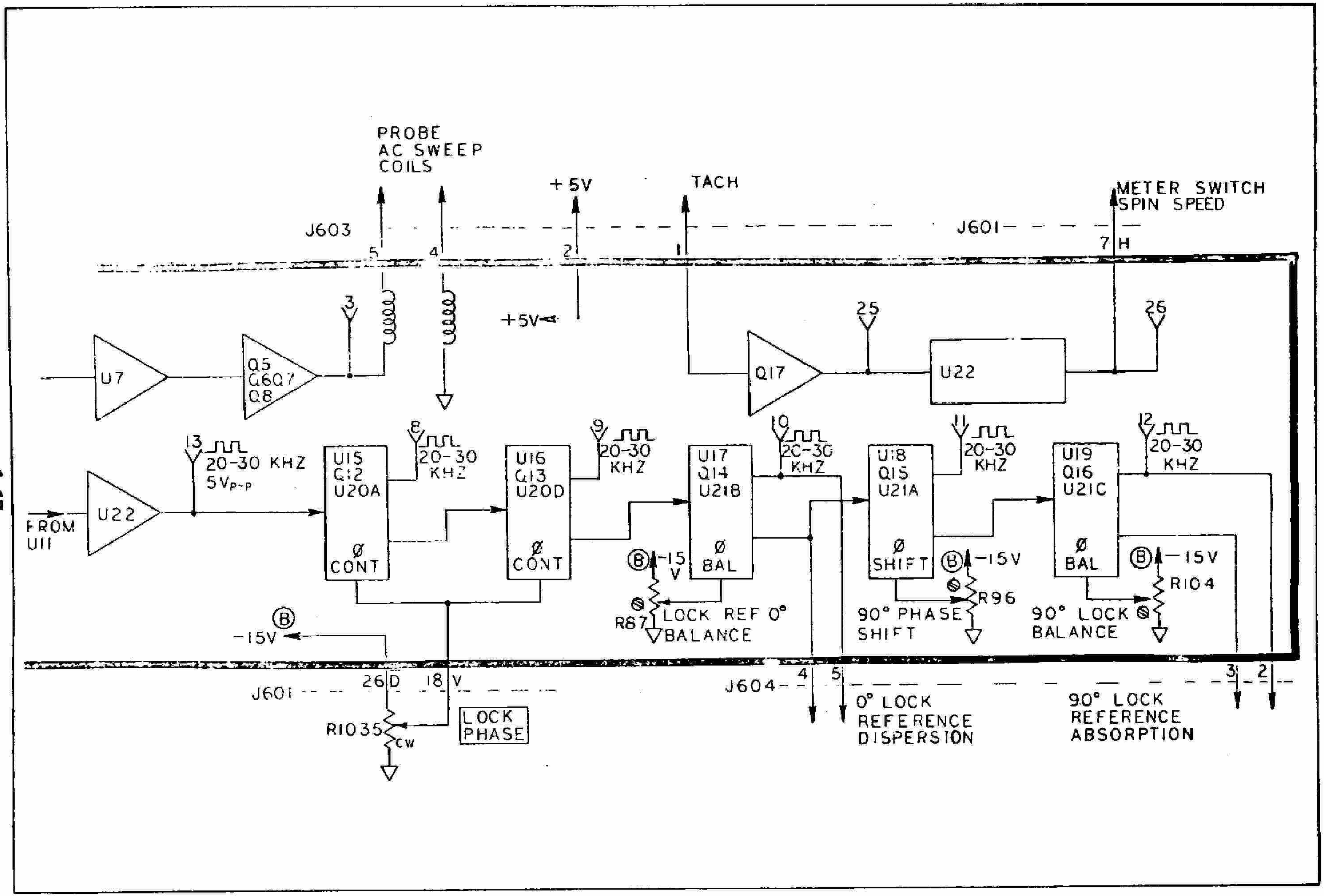

FIGURE 1-11. P/O FIELD MODULATOR PCB

d. Modulation Output Amplifier

The Observe 25 KHz signal is level set and adjusted by the OBSERVE POWER control and applied through U6 to the summing amplifier U7. In the input of U7, the Observe, Spin Decoupler, and Lock signals are combined, the composite signal is amplified and applied to the Probe AC Sweep Coils.

e. Lock Channel Reference

The 20 to 30 KHz square wave from the Q-bar output of U11 is buffered by U22 and applied to the phase delay circuits U15 and U16. Here the signal may be delayed by the LOCK PHASE control for an effective phase shift of from 0 to more than 400°. The unbalanced waveform from U16 is balanced in U17 and applied out J604 pins 4 and 5 to the Lock Channel Dispersion Mode phase detector. The signal from U17 is also applied to U18 for a 90° phase shift and then balanced by the U19 circuits. The output is applied to the Lock Channel Absorption Mode phase detector as reference.

f. Spinner Speed Tachometer

A tachometer on the probe delivers a square wave to J603 pin 1 which is twice the frequency of the spinner rotation. The amplifier Q17 drives a monostable multi-vibrator U22 whose output average DC level is taken to the SPINNER SPEED position of the METER switch.

1.2.5 CONSOLE POWER SUPPLY

The input power is applied through an ON/OFF Switch to fuses F1 and F2 on the Console Power PCB to the transformer T201. The value of the fuses F1 and F2 and the input pin numbers of T201 vary depending on whether the voltage input is 115 volts, 208 volts, or 230 volts. The platen fan, B201, comes on with the power application.

Pins 11 and 12 of T201 output 19 VAC to a diode bridge CR201 which produces +25 volts to the Magnet Heaters. Q204 regulates this +25 volts to +11 volts for use in the logic circuits and the Variable Temperature Controller.

T201 output pins 16, 17, and 18 supply 38 VAC to a diode bridge of CR1, CR2, CR3, and CR4. The output +24V and -24V is switched on when the recorder is turned on for use as recorder Vcc.

T201 output pins 19, 20, and 21 supply 38 VAC to a diode bridge CR6, CR7, CR8, and CR9. The output is a +26V and -26V for use as the system unregulated supply. These voltages are zener regulated to +15 and -15 volts for use in the regulators. A +15 volt regulator and a -15 volt regulator provide regulated system voltages to all circuits.

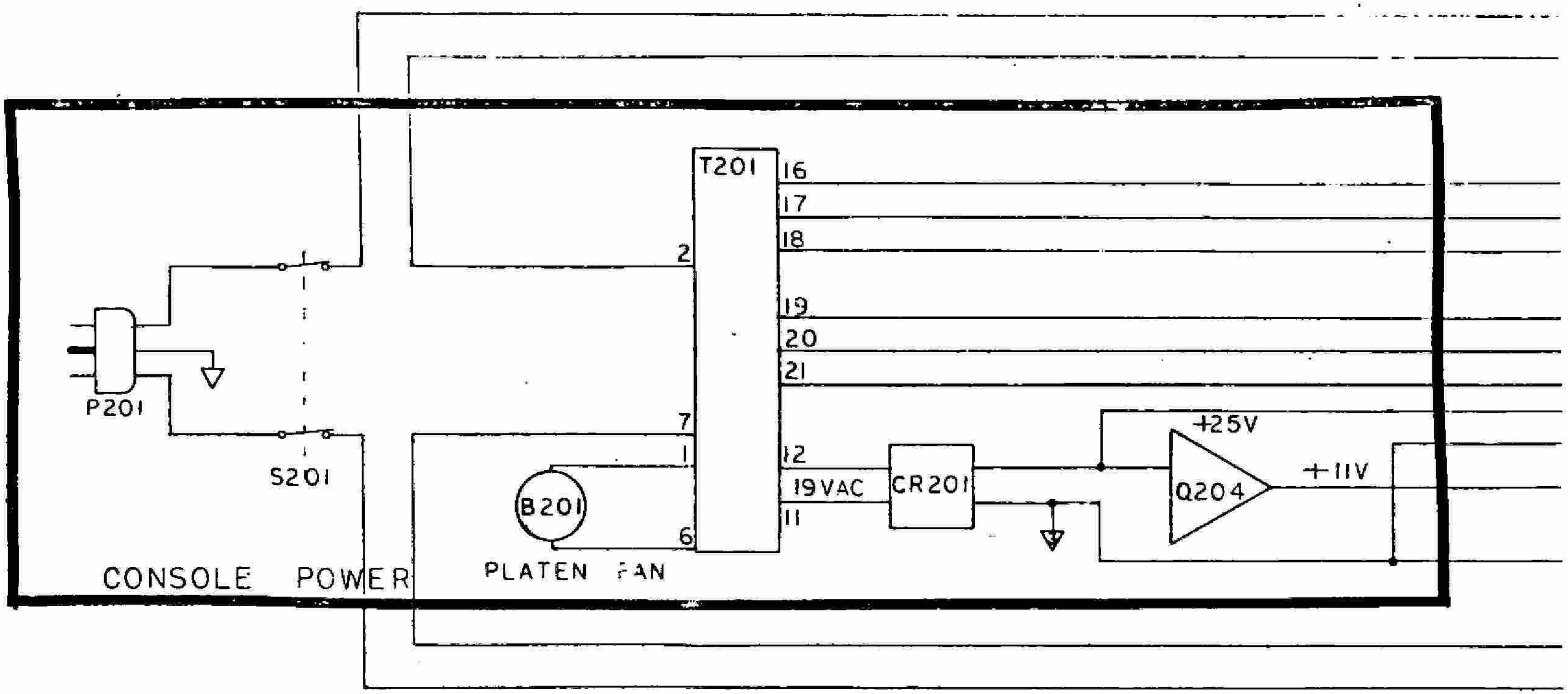

FIGURE 1-12. CONSOLE POWER SUPPLY – CHASSIS COMPONENTS

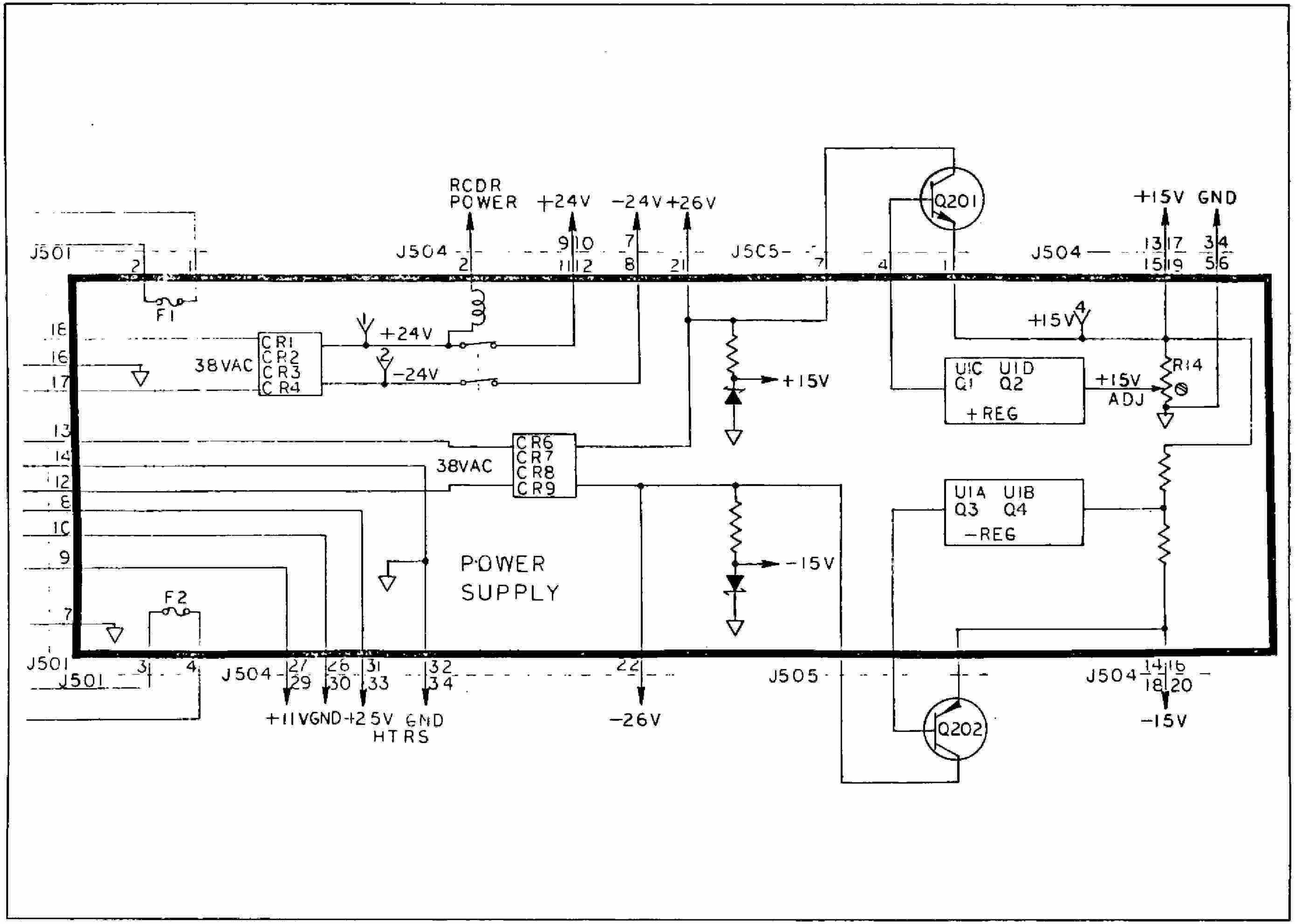

FIGURE 1-13. CONSOLE POWER SUPPLY PCB

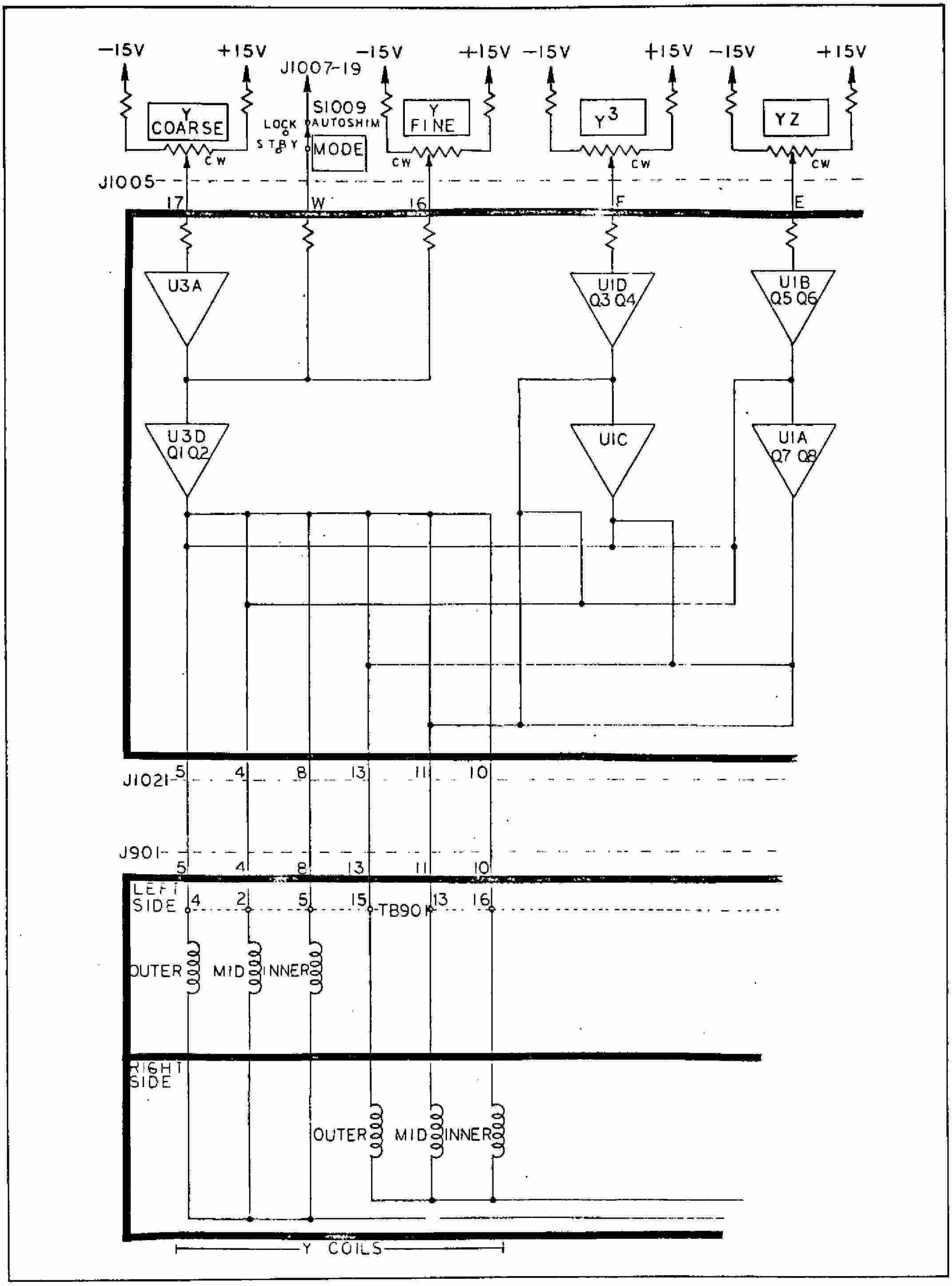

FIGURE 1-14. Y-SHIM COILS AND CONTROL

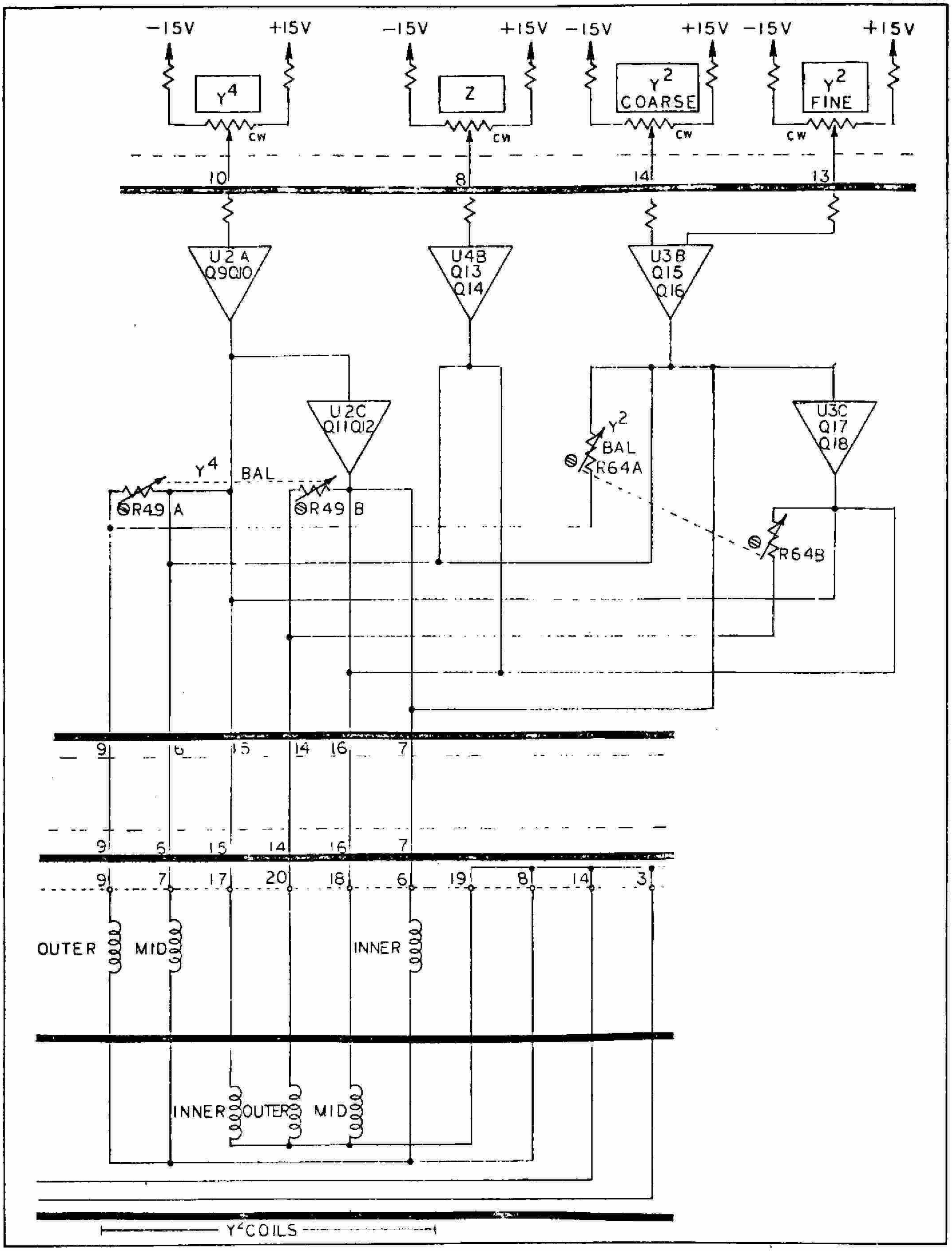

FIGURE 1-15. Y^2 SHIM COILS AND CONTROL

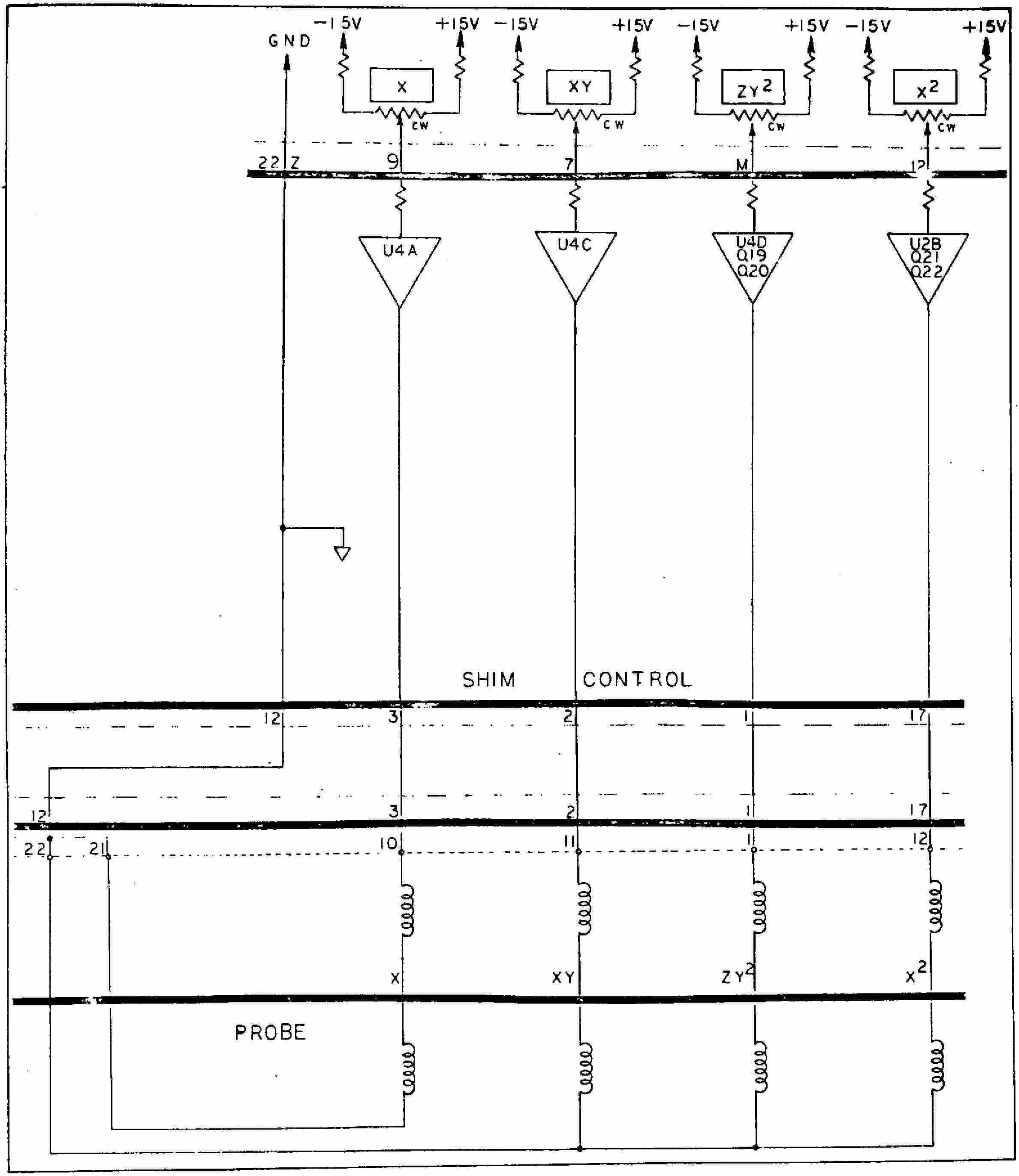

FIGURE 1-16. X, XY, ZY^2, X^2 SHIM COILS AND CONTROL

Starting with Serial 138, a crowbar which toggles at 17 volts protects the load in case the +15 or -15 volt supply loses regulation. The + crowbar is placed at TP4 to ground and the - crowbar is placed from TP5 to ground.

1.2.6 SHIM CONTROL

The shim control circuits supply the various currents required to homogenize the magnets with various shim coils. The circuits are controlled by 12 front panel controls. Operational amplifiers with transistor drivers are used to supply the shim currents. These circuits are shown in Figures 14-16.

1.2.7 PROBE

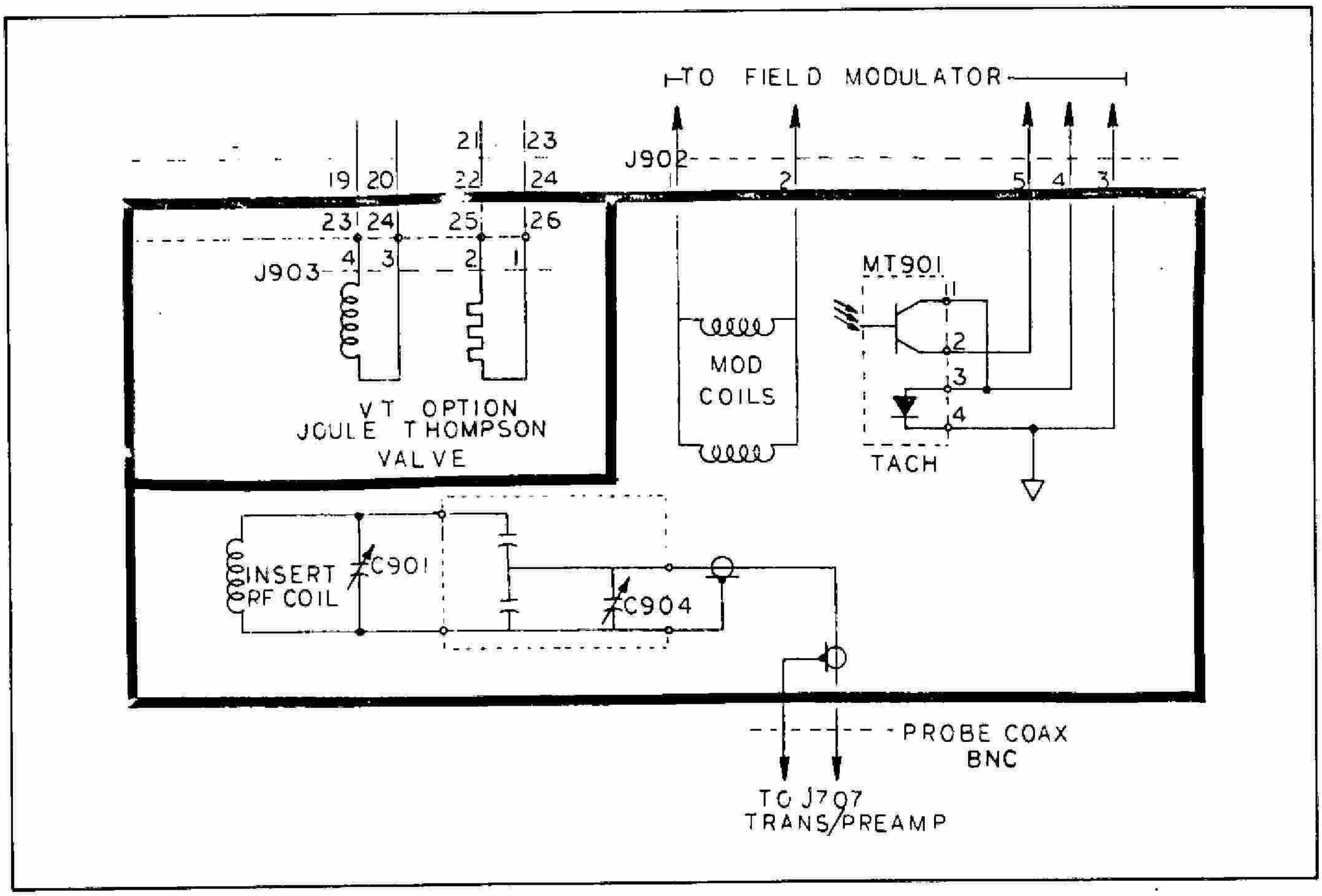

FIGURE 1-17. PROBE

This is a single coil variable temperature probe with the following characteristics:

a. The shim coils are mounted within the side plates.

b. The modulation coils are of the current sheet type using bobbin construction.

c. The cooling for variable temperature work uses a Joule-Thompson valve where high pressure gas is throttled through a small opening and cooling occurs.

d. A heater-sensor is used to control the temperature of the sample.

e. A tachometer is used to monitor the turbine speed.

f. A matching network is used to step the insert impedance down to the 93 ohm transmission line.

g. An eject system is used to retrieve the sample from the probe.

1.2.8 TRANSMITTER/RF PREAMPLIFIER

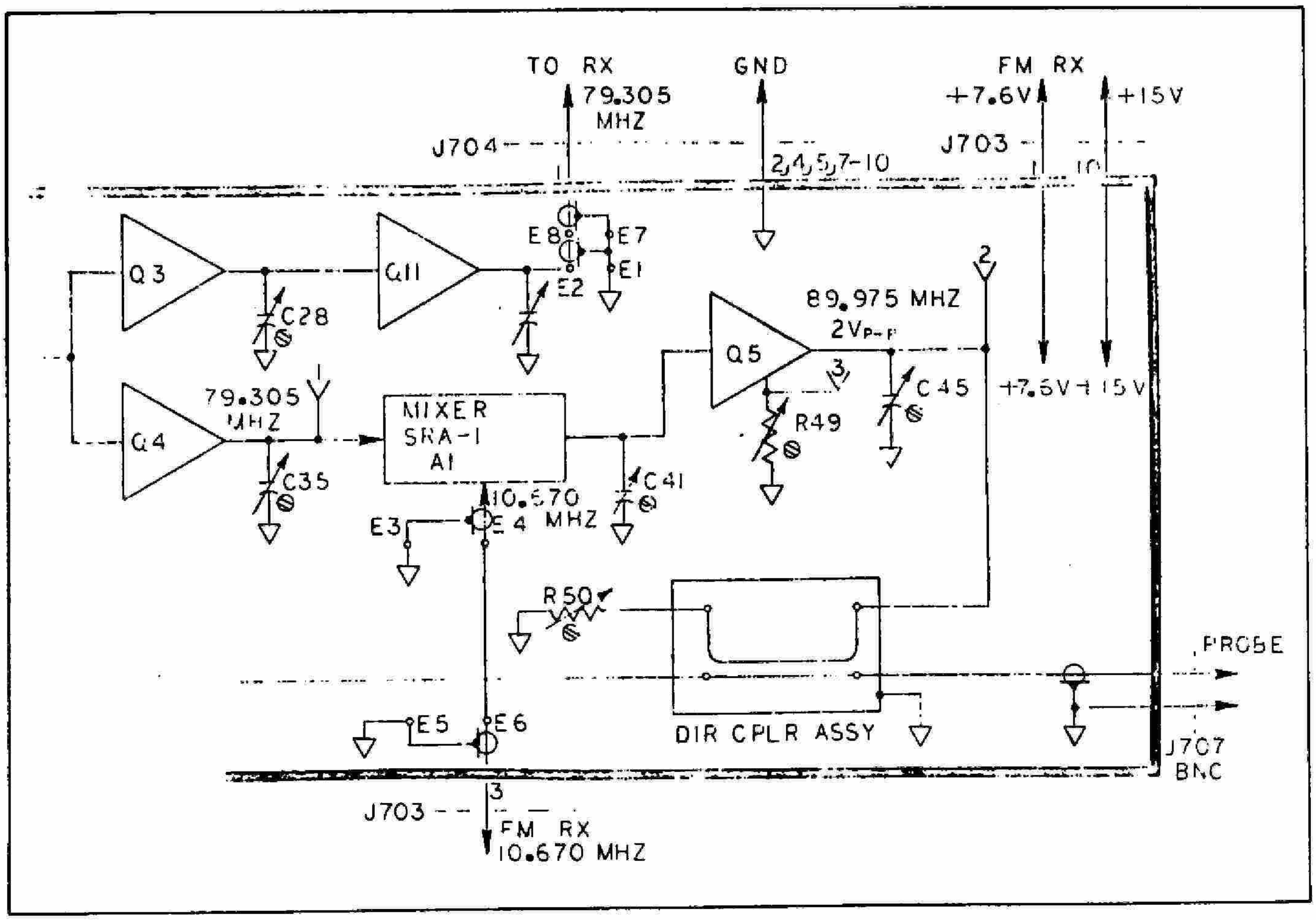

FIGURE 1-19. P/O TRANSMITTER/RF PREAMP

Each nucleus has its own Transmitter/RF Preamplifier PCB and are identical except for tuning and frequency sensitive components. Only the proton unit is outlined here but the Theory of Operation Section treats each nuclei transmitter as a separate entity.

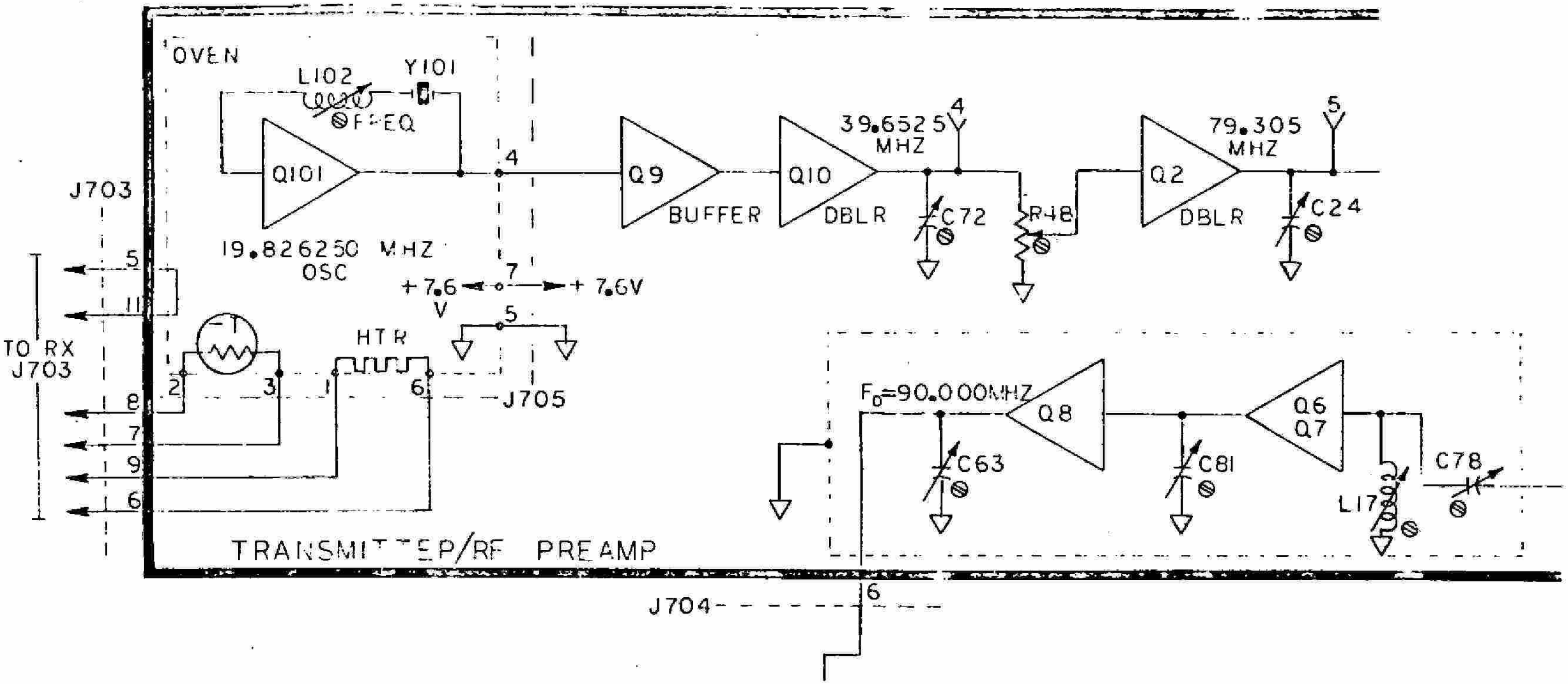

FIGURE 1-18. P/O TRANSMITTER/RF PREAMP

The Y101 and Q101 with tuned circuit L102 make up a 19.826250 MHz oscillator which is placed in a temperature controlled oven. This oven also contains the heat sensor RT1 which is the input to the Temperature Controller on the Receiver Card.

Two doublers, Q10 and Q2, multiply this frequency to 79.305 MHz. A high-level amplifier produces the receiver local oscillator signal to the First Mixer at this frequency (Q3 and Q11). The 79.305 MHz is applied to Mixer A1 to be added to 10.67 MHz to produce the 89.975 MHz transmitter output signal to the directional coupler.

The directional coupler is used to prevent the saturation of the RF preamp by the transmitter carrier which shares the common probe coaxial cable with the preamplifier.

The excited resonance is amplified in cascode amplifier Q6 and Q7 and given further amplification in Q8 before being applied to the receiver.

1.2.9 RECEIVER

This circuit board receives the preamplified Transmitter and NMR signals. The Transmitter signal is rejected and the NMR signal is further amplified. The desired NMR signals are converted to a nominal 25 KHz for the lock and observe channels.

A temperature controller stabilizes the crystal oscillators in the receiver and transmitter/preamplifier boards. U3 is used as a bridge amplifier with a thermistor located in the first transmitter oven. Q7 drives Q8 which is the pass transistor in series with the heating elements located in the first transmitter oven, receiver oven, and second transmitter oven. Q9 is a pass transistor which is turned on if the second transmitter board is removed from its socket. A jumper mounted on the second transmitter board determines whether current passes through Q9 or the second transmitter oven heater.

The 10.670 MHz Local Oscillator is generated with Q101 and Y1. Q3 is an oscillator buffer. Q2 is a driver which provides a 10.670 MHz signal at J703A-3 to the transmitter/preamplifier board in order to synthesize the transmitter signal. Q1 and Q11 are used to drive the second mixer A2. These driver output levels are controlled by R14.

The 90 MHz (proton) NMR signal and the 89.975 MHz (proton) transmitter signal come into the circuit board at J704A-6. The First Local Oscillator signal at 79.305 MHz (proton) enters the receiver at J704A-1 from the transmitter/preamplifier. These signal frequencies are unique for ^{1}H or proton operation but when these signals are mixed in A1 the output or difference frequency is the same no matter which nuclei transmitter/preamplifier board is used.

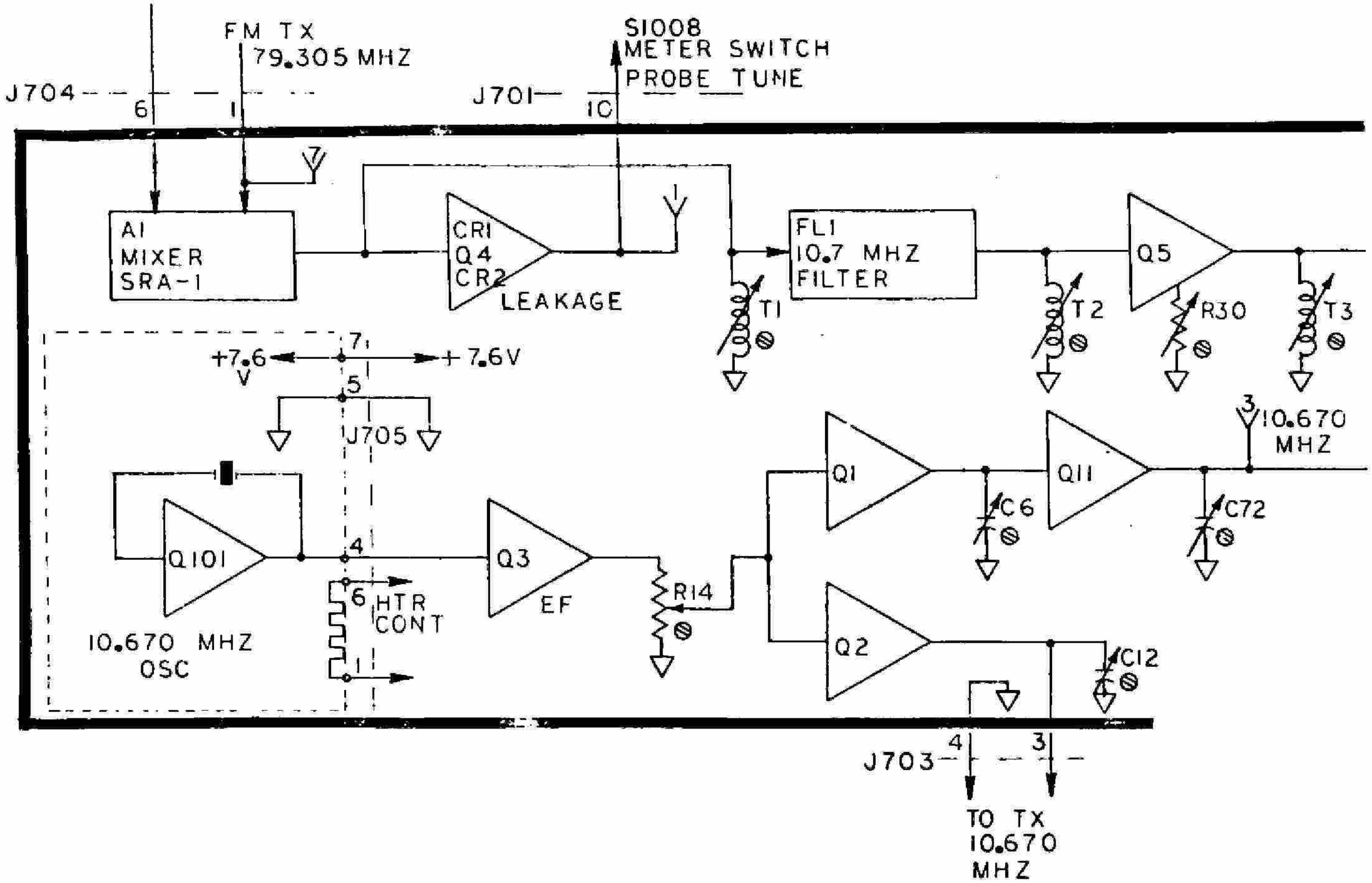

FIGURE 1-20. P/O RECEIVER

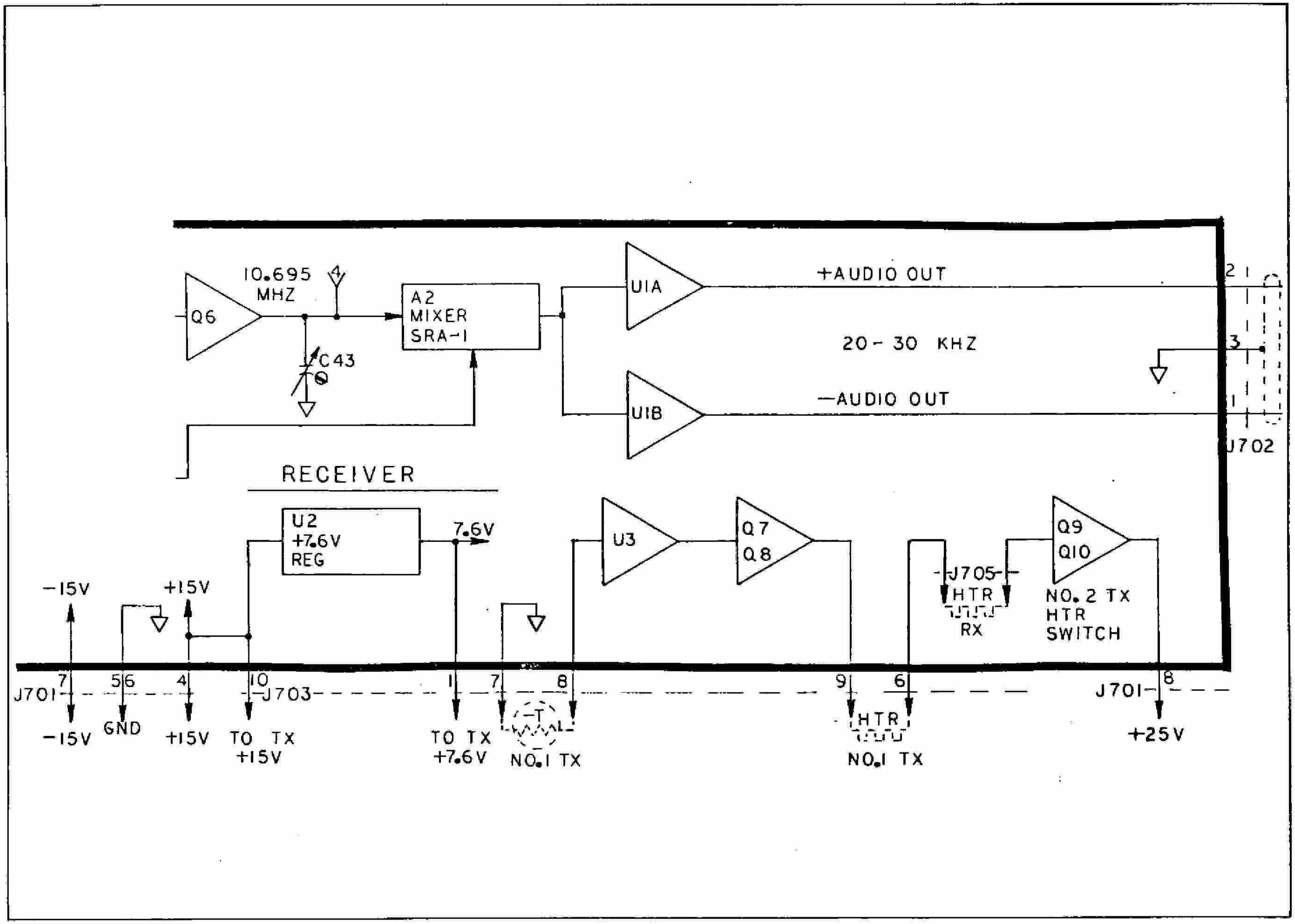

FIGURE 1-21. P/O RECEIVER

The NMR frequency produces 10.695 MHz and the transmitter frequency produces 10.67 MHz after the first conversion. A crystal filter with adjustable input and output transformers is used to reject the 10.67 MHz signal as the bandpass is 10.7 MHz ± 0.015 MHz (15 KHz). The NMR signal is further amplified in Q5 and Q6. The IF amplifier gain may be controlled by R30. The output of Q6 is applied to A2, the second mixer.

The output of A2 is filtered and only the nominal 25 MHz difference frequency is passed. This signal is applied to a pair of operational amplifiers in order to drive a balanced line.

1.2.10 OBSERVE CHANNEL

The audio signal from the receiver is applied to the balanced input pins 1 and 2 of J1022 to IC U1. It is amplified and applied to the COARSE GAIN control and to the Lock Channel PCB. The signal is there applied to IC amplifier U2, a 40 dB non-inverting amplifier. The amplified audio signal is then phase detected.

The phase-detected signal is applied to difference amplifier U3 then it is either filtered and applied to the recorder or integrated and then applied to the recorder.

1.2.11 LOCK CHANNEL

The Lock Channel circuit board receives an audio signal from a buffer amplifier on the Observe Channel card and amplifies it by 40 dB. The 20 KHz to 30 KHz amplified audio signal is fed into two phase detectors, one with 0° phase and the other with 90° phase reference signals.

The signal detected with 90° phase reference (called the "Absorption Mode") is fed into METER SELECT Switch LOCK AMPLITUDE position and to the Autoshim circuits after 20 dB of amplification.

The signal detected with the 0° phase reference (called the "Dispersion Mode") is fed into integrator U2. The integrated output is the field lock error signal to the Field Control. This is the major function of the Lock Channel card.

1.2.12 AUTOSHIM

This board contains a 50 Hz astable multivibrator U3A whose output is shaped by Schmitt Trigger U5. ICs U1 and U2 divide this frequency by 100 to generate the 0.5 Hz modulation signal to the Y-Axis Shim coils. The resulting signal modulation is detected from the lock NMR signal and returned to the DC Amplifier U4.

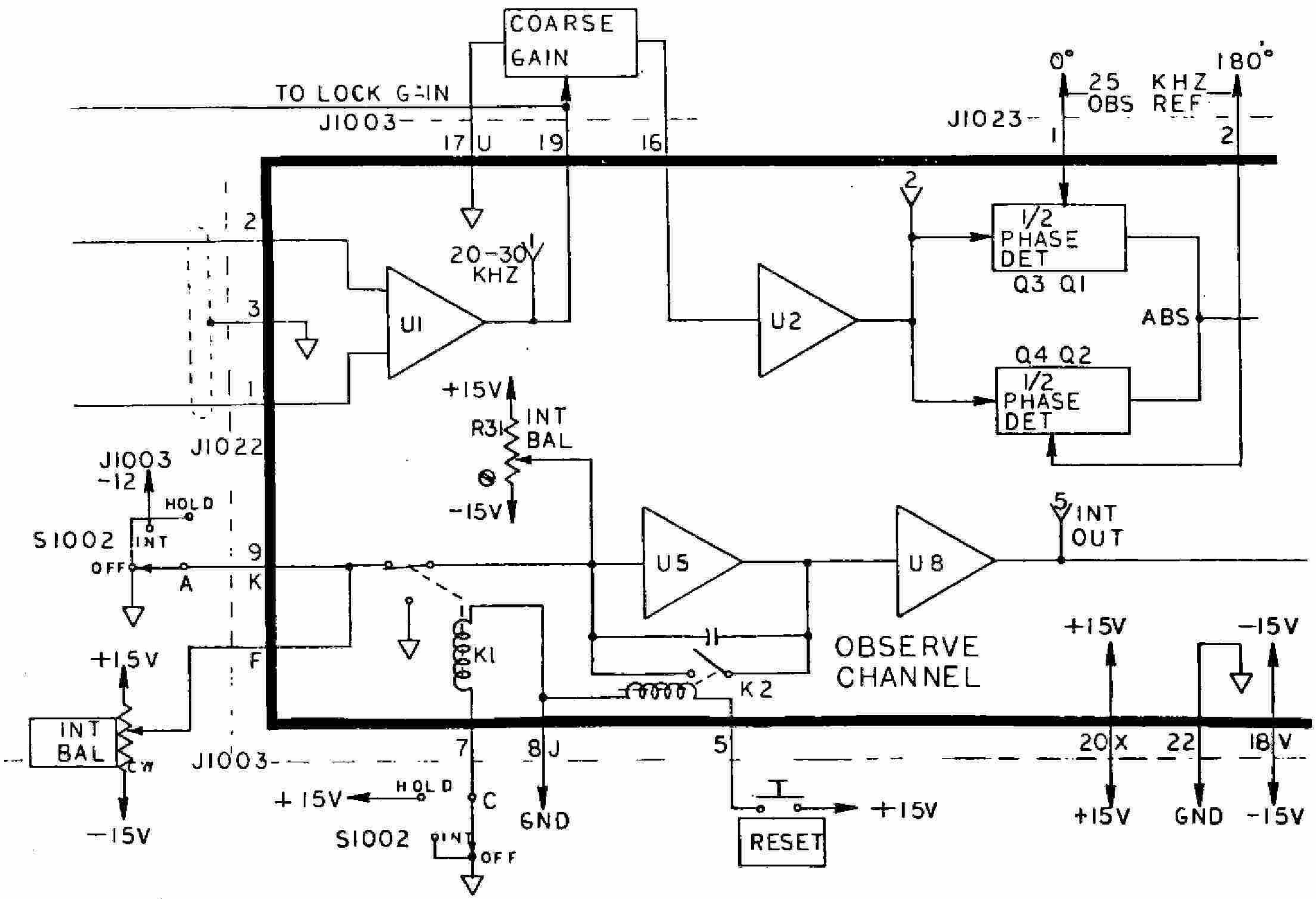

FIGURE 1-22. P/O OBSERVE CHANNEL

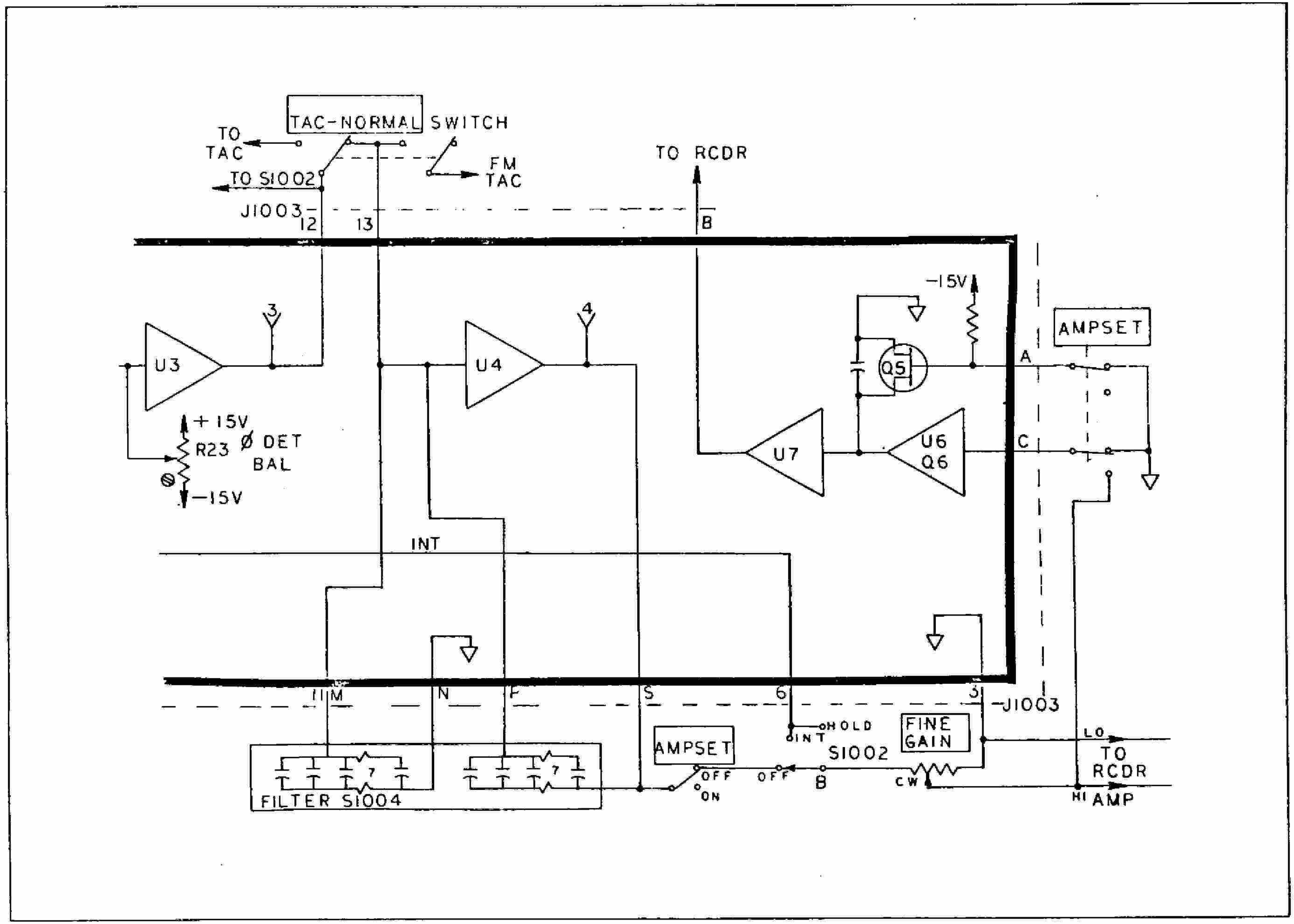

FIGURE 1-23. P/ O OBSERVE CHANNEL

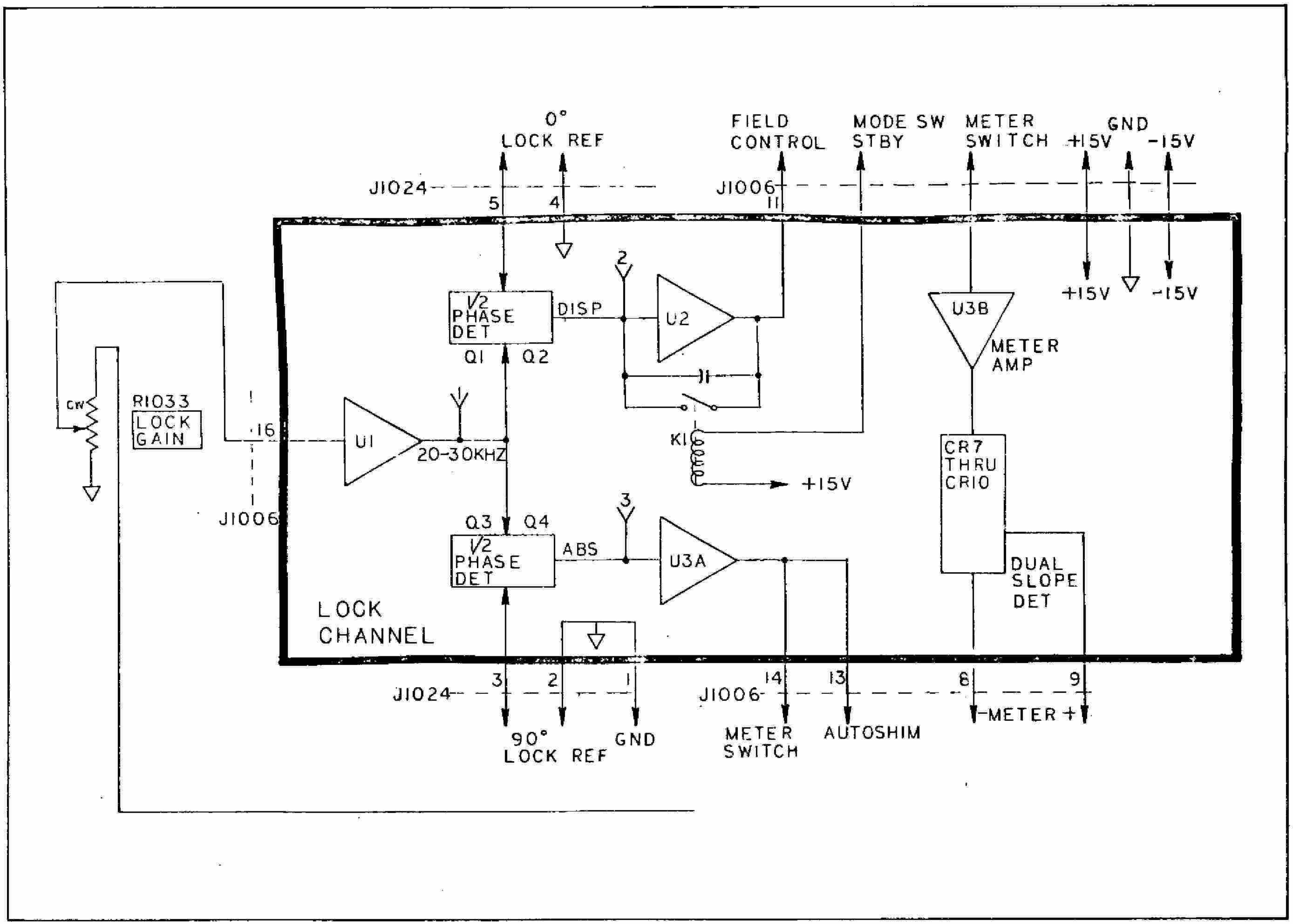

FIGURE 1-24. LOCK CHANNEL

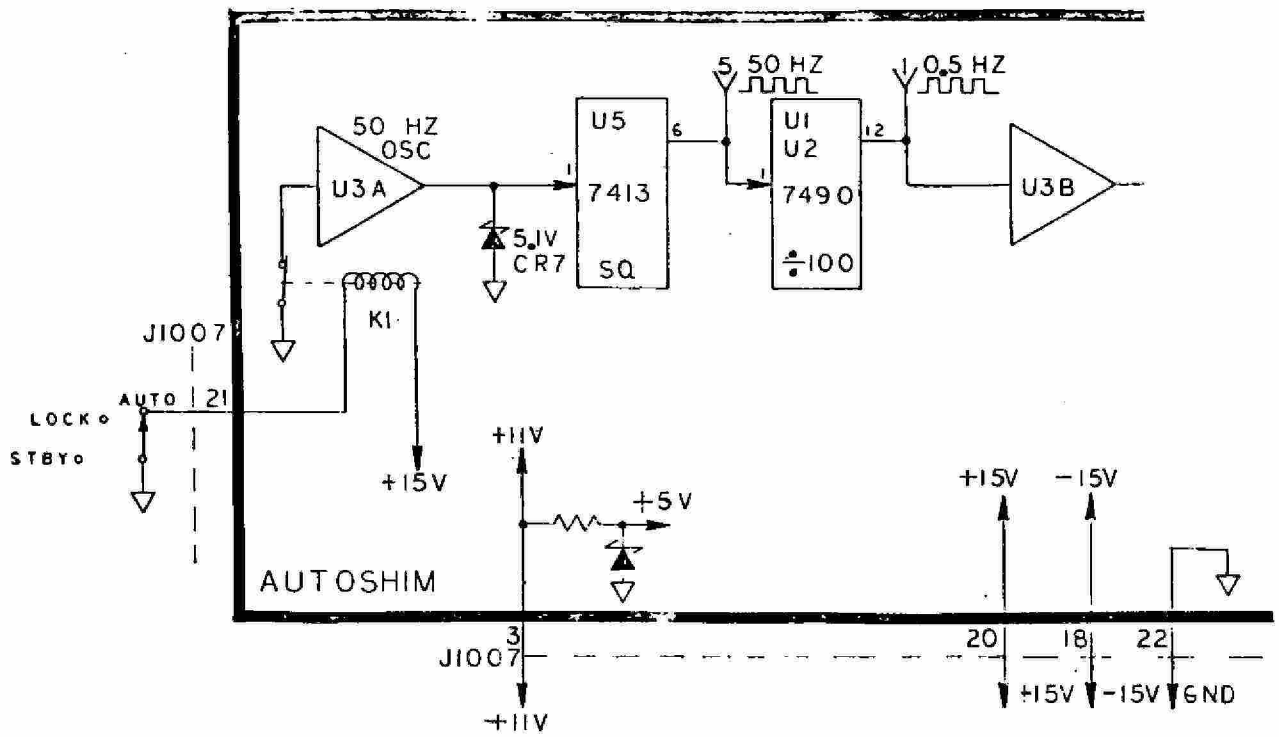

FIGURE 1-25. P/O AUTOSHIM

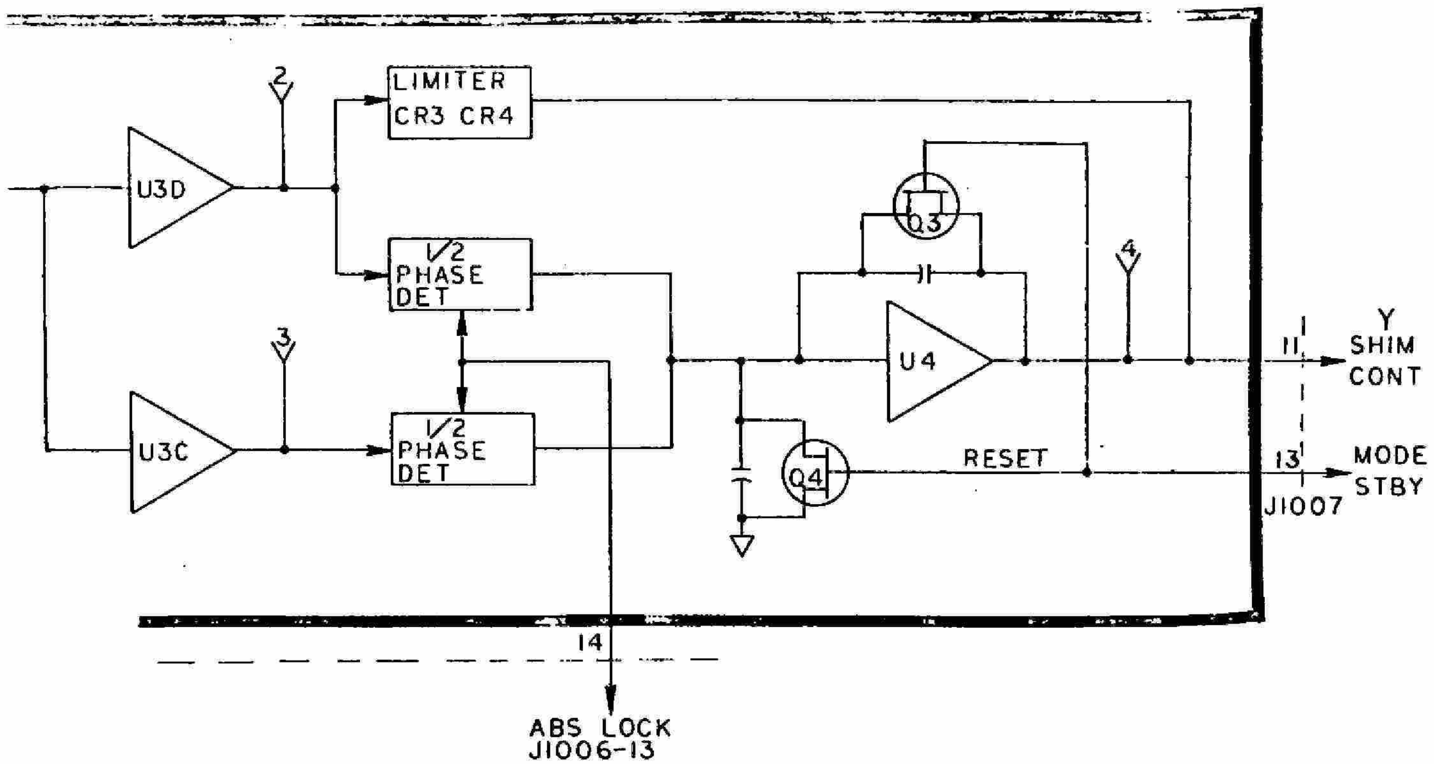

FIGURE 1-26. P/O AUTOSHIM

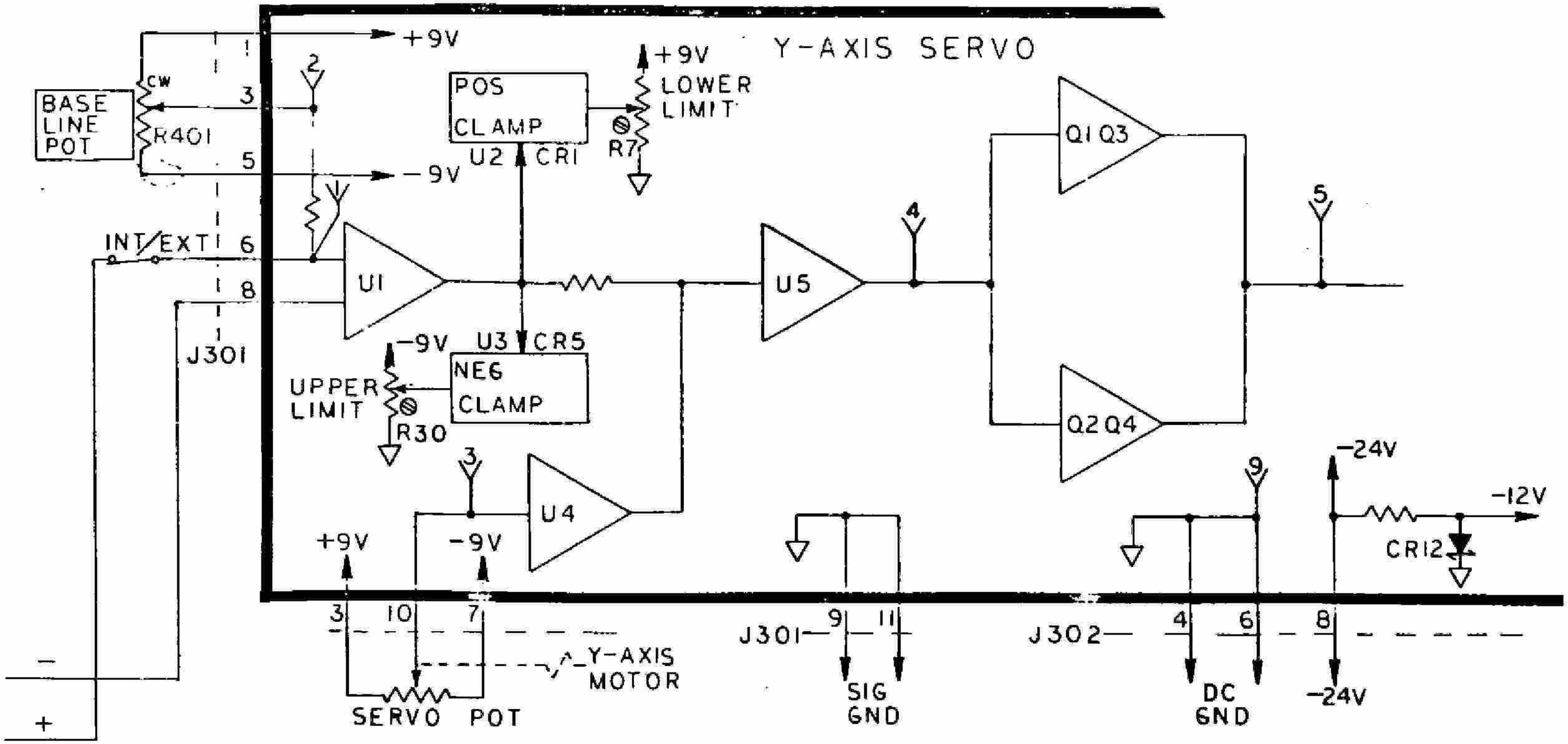

FIGURE 1-27. P/O Y-AXIS SERVO

The demodulated 0.5 Hz signal is compared with the original signal in a type of phase detector and the resulting DC, after amplification and integration, is fed to the Y shim coils as a correcting current. By this means the magnetic field homogeneity will be automatically held at the optimum point.

1.2.13 Y-AXIS SERVO

A +9 and -9 volt supply (Figure 1-28) provides the reference potentials for this circuit.

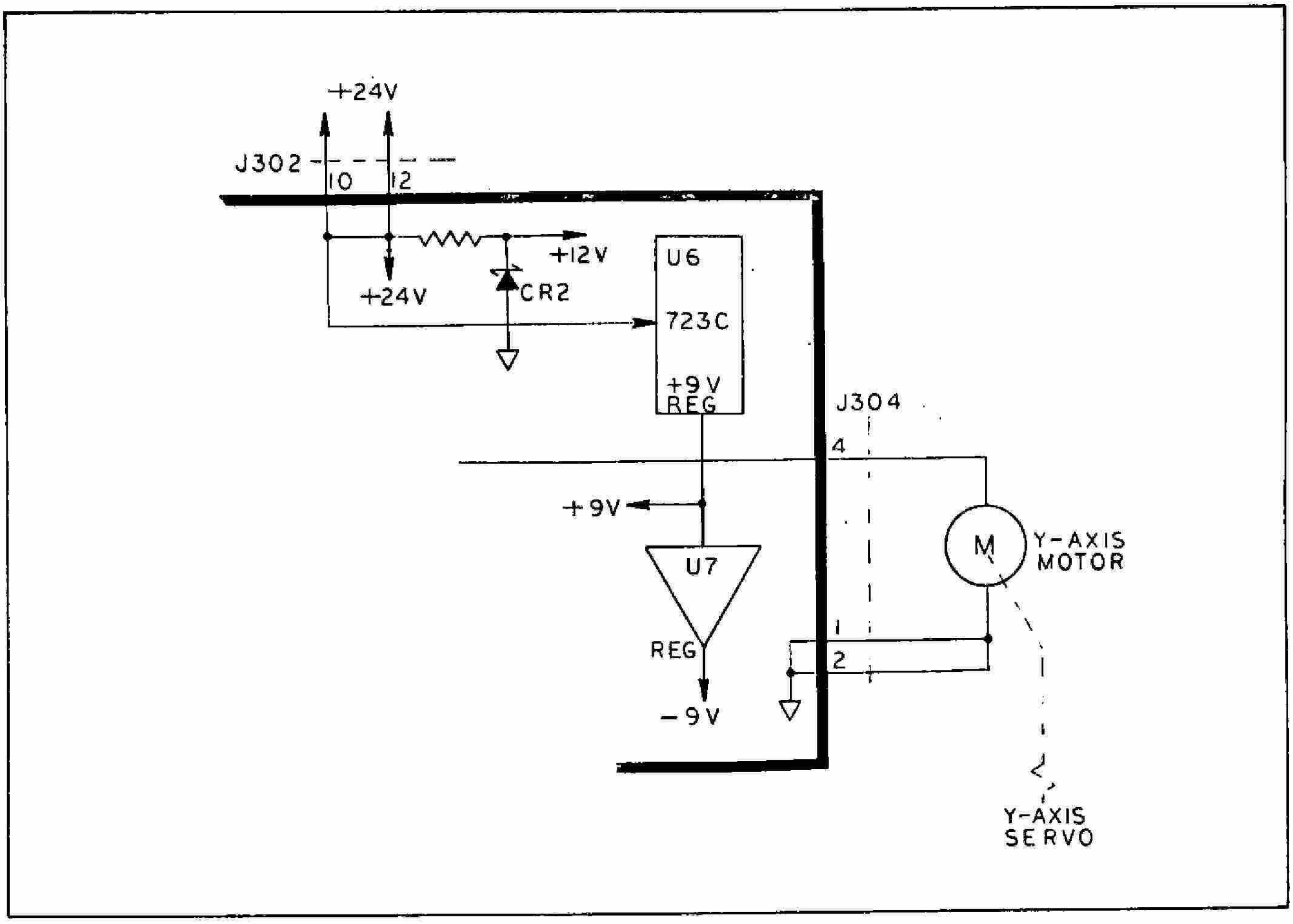

FIGURE 1-28. P/O Y-AXIS SERVO

The signal from the Observe Channel is applied to U1 differential amplifier. The DC level of the signal is set by the BASELINE control on the Recorder Panel. The output of U1 is clamped in both the positive and negative limits before being applied to U5.

Also applied to U5 is the output of a potentiometer which is gauged to the Y-Axis Servo Motor. This provides the nulling signal of the servo loop.

The resulting signal is applied to the Y-Axis Servo Motor after amplification in Q103 and Q104.

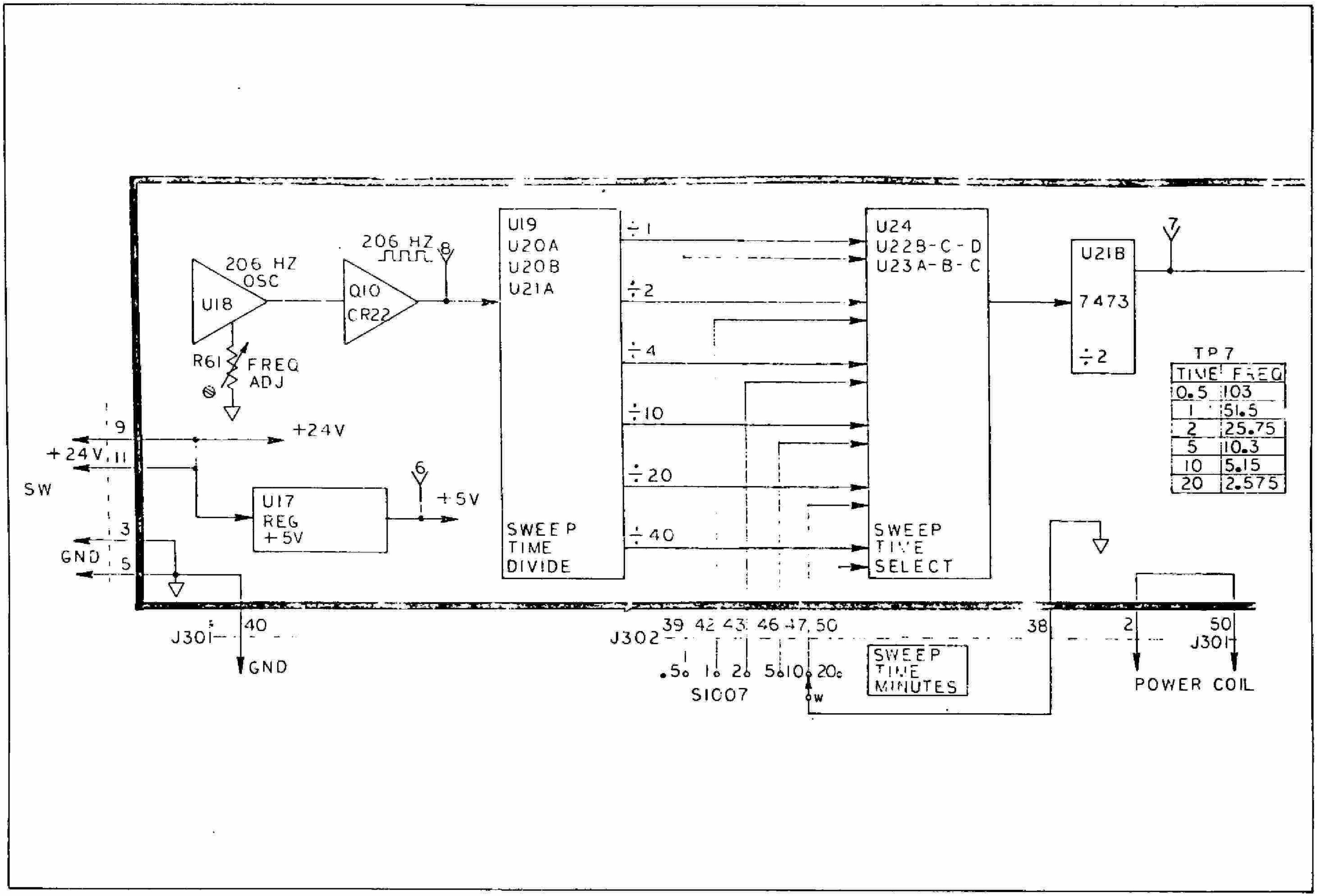

FIGURE 1-29. P/O X-AXIS SERVO

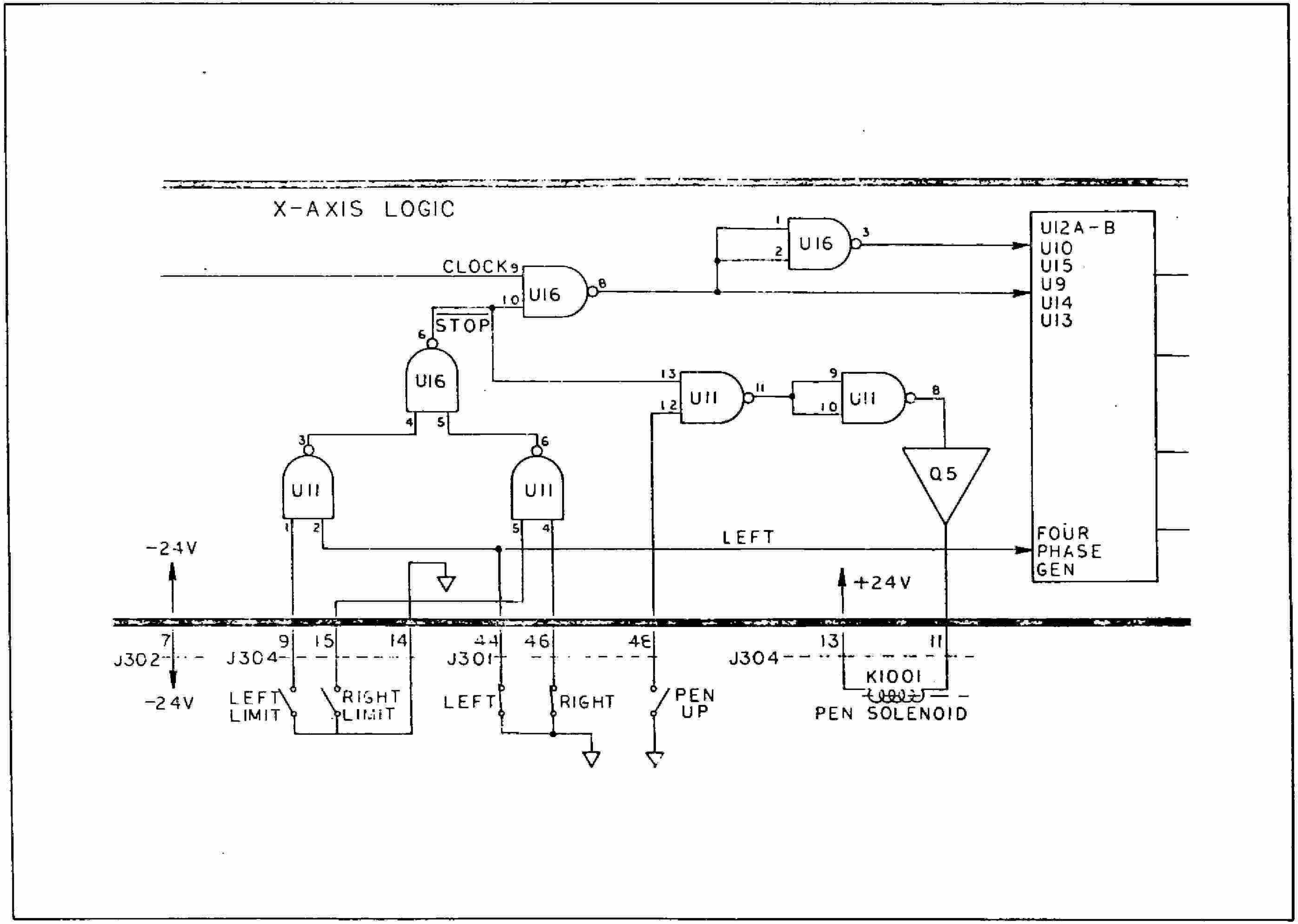

FIGURE 1-30. P/O X-AXIS SERVO

1.2.14 X-AXIS SERVO

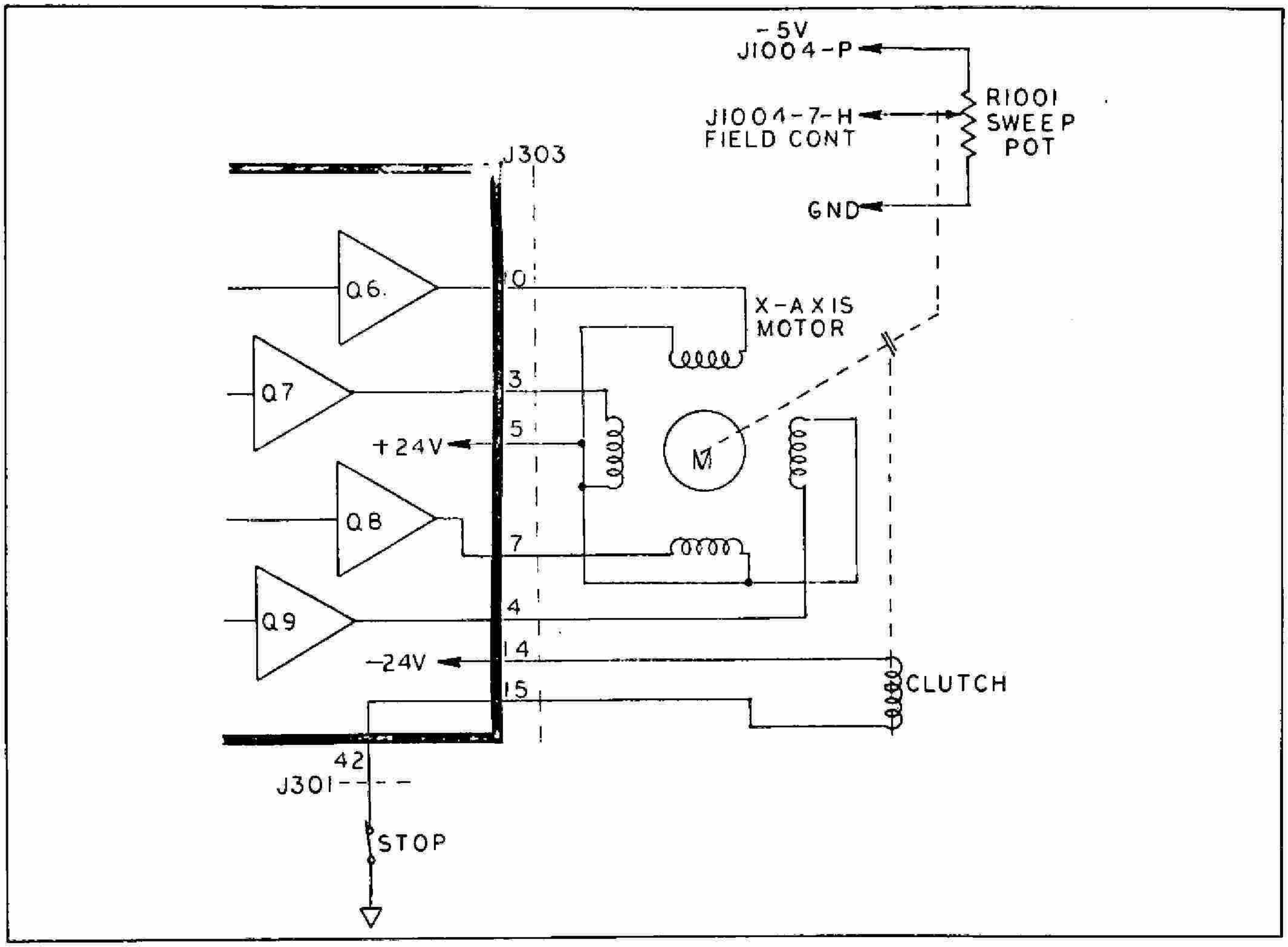

FIGURE 1-31. P/O X-AXIS SERVO

A 206 Hz signal is generated in an oscillator U18 and squared in Q10 to be applied to a divider chain. The output of the divider is the 206 Hz divided-by-1, divided-by-2, divided-by-4, divided-by-10, divided-by-20, and divided-by-40. All these frequencies are applied to the Sweep Time Select gates.

A low (ground or 0 volts) is applied to one of these gates to select only one of these frequencies. This frequency is divided-by-two in U21B and applied to the Scan Control circuits. These circuits are controlled by front panel switches which select direction and mode of operation. The circuits will regulate the phase rotation of the four-phase signal applied to the stepper motor to control direction and speed.

The motor moves the wiper of the sweep potentiometer varying the voltage to the Field Control Sweep Input.

1.2.15 VARIABLE TEMPERATURE CONTROL

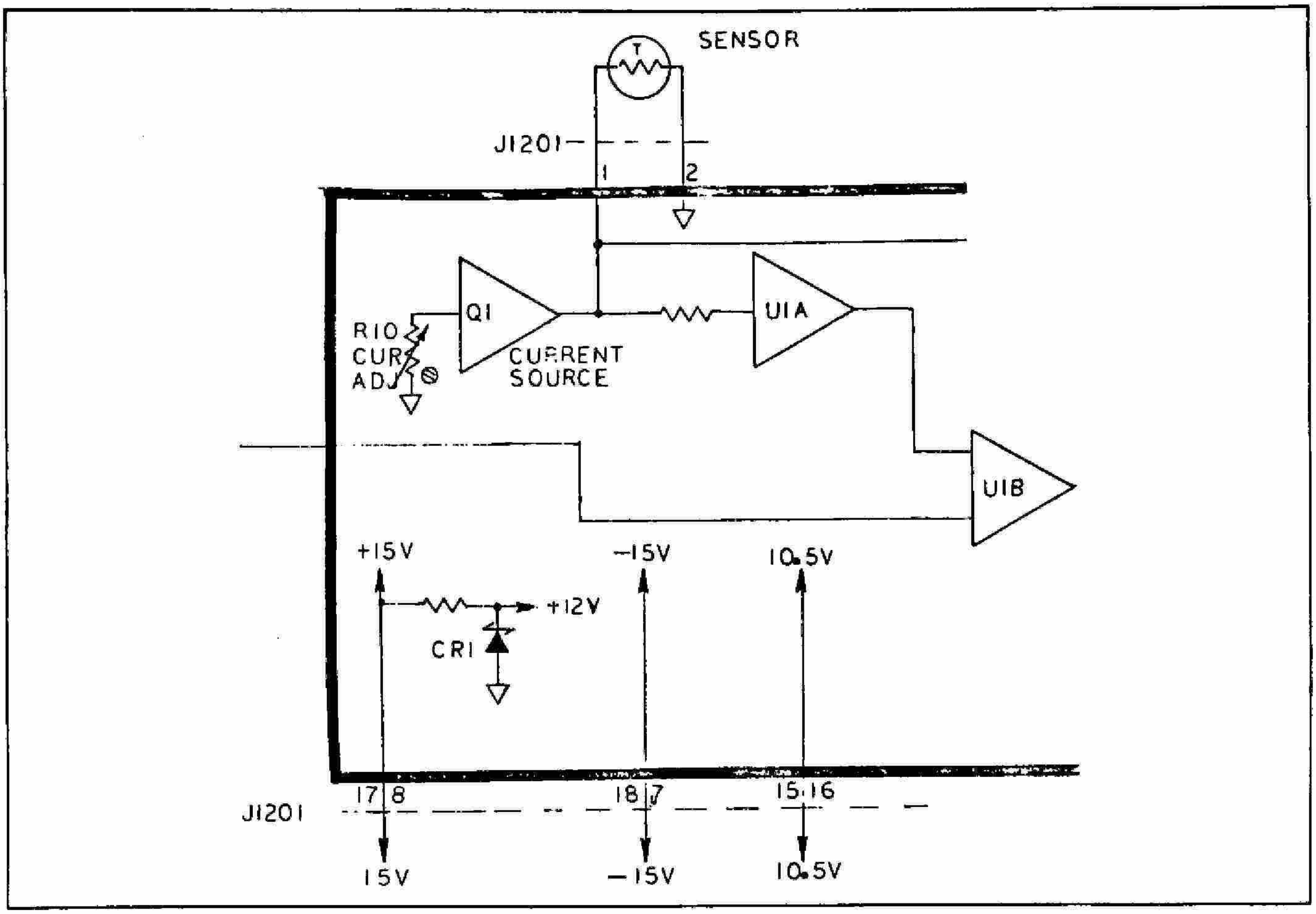

FIGURE 1-32. P/O VARIABLE TEMPERATURE

A current source supplies the current to the sensor and to U1A. The resistance of the sensor determines the drive to U1A which in turn drives U1B. The other input of U1B is the thumbwheel switch TEMPERATURE SET input. U1B is a differential amplifier which drives the power circuits U1D and Q2 and Q3 to produce the current flow in the heater.

The high temperature cut-off is +200°C and this is set by U1C and Q4.

U2B controls the INCREASING lamp and U2A controls the DECREASING lamp. At the proper temperature (that set in by the thumbwheel switch), both lamps are on.

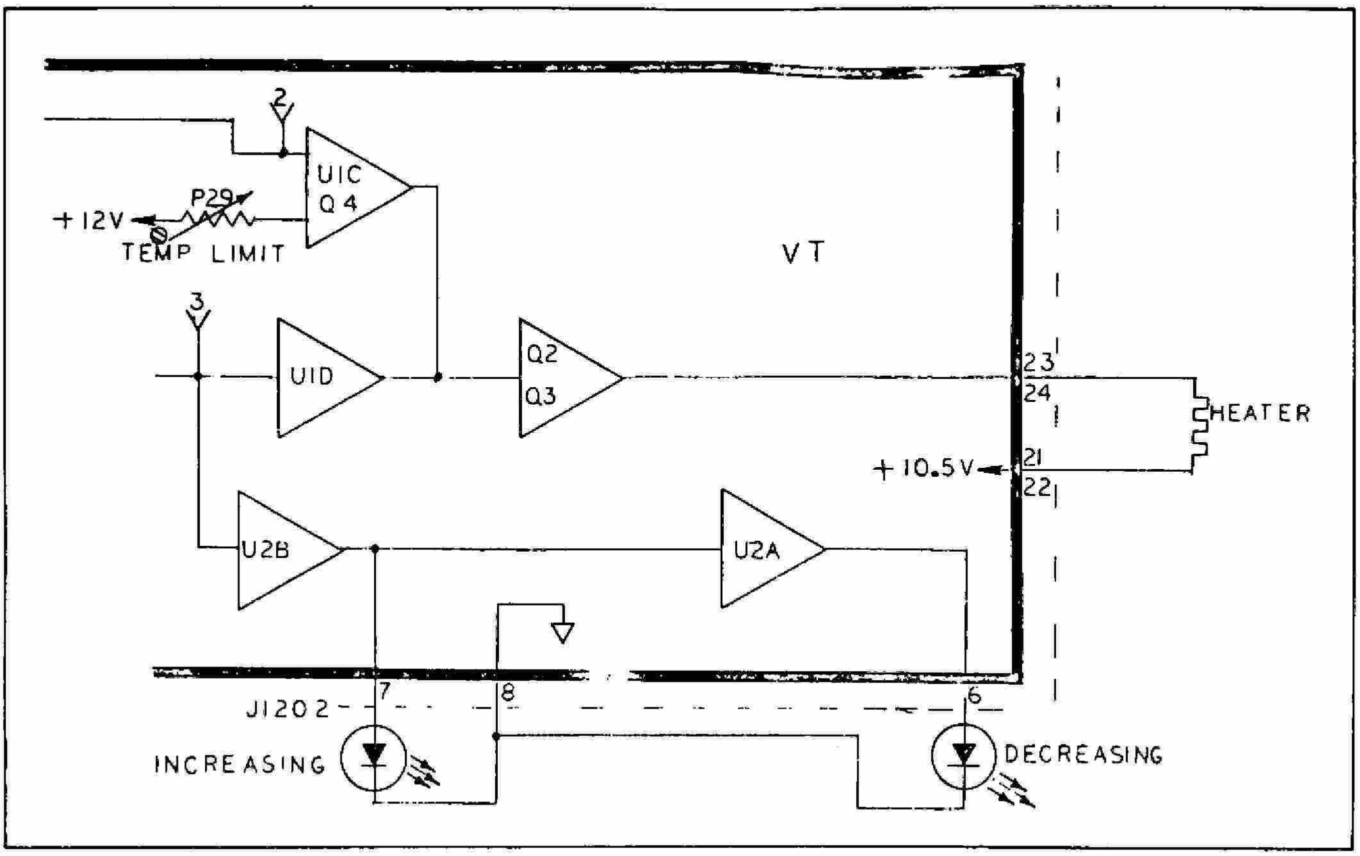

FIGURE 1-33. P/O VARIABLE TEMPERATURE

1.2.16 SPIN DECOUPLER

This unit generates a sine wave signal with a frequency of 20 KHz to 30 KHz. The frequency is swept with the system recorder X-AXIS signal. Also it can be set with a thumbwheel switch calibrated in PPM. A variable fine frequency control potentiometer is also provided. The output signal of this unit is applied to the EM-390 console to the Field Modulator amplifier and out to the modulation coils in the probe.

IC U1, CR2, Q1 and associated components make up a stable -10 volt reference voltage source which supplies the fixed frequency offset components, the FINE FREQUENCY control, and the thumbwheel switch divider.

IC U2 regulator provides a stable ±15 volt source for the sensitive operational amplifiers and the VCO U5.

U3 is the sweep and offset summing amplifier and controls the VCO U5.

IC U4, Q2, and Q3 make up an oven temperature control circuit.

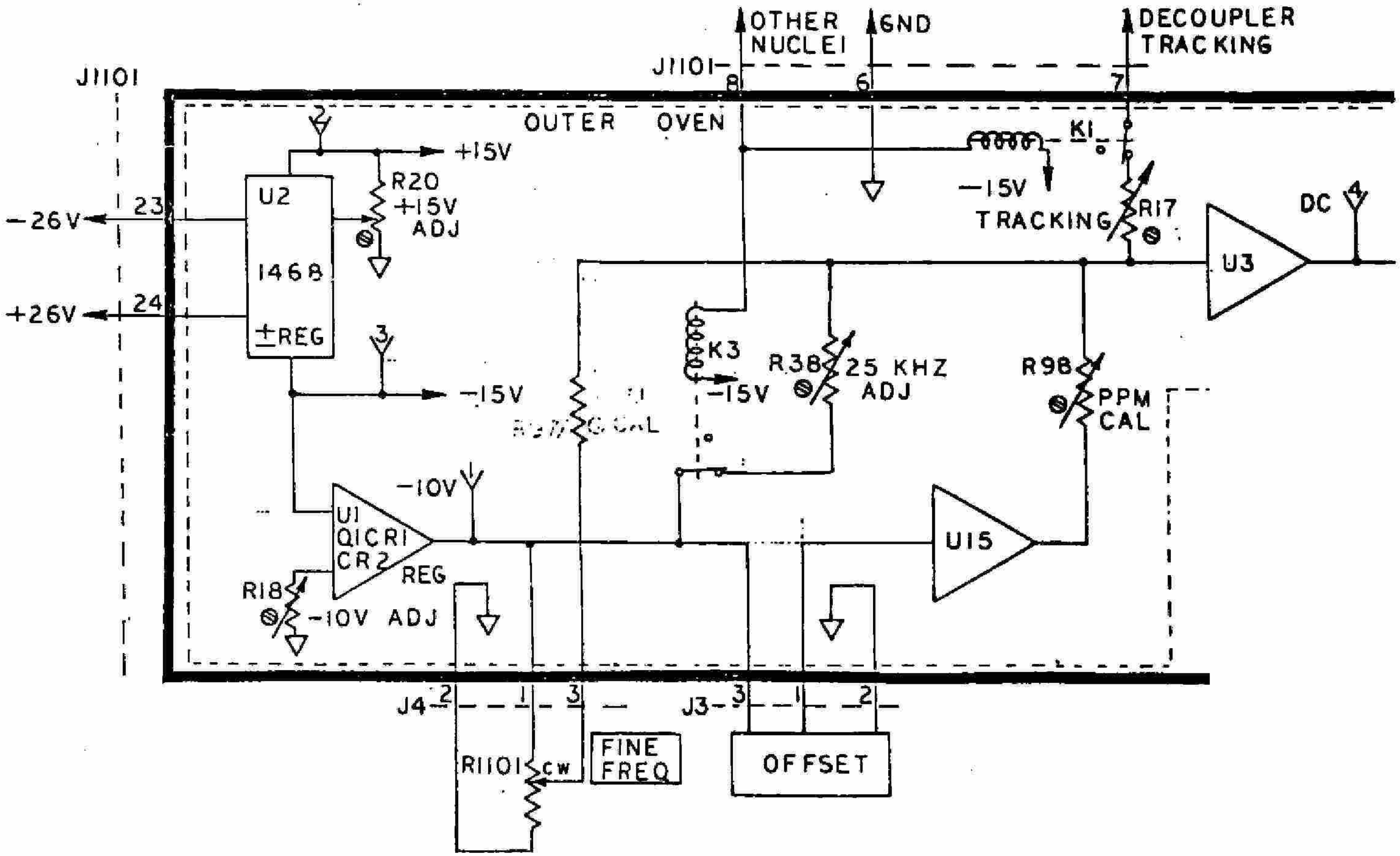

FIGURE 1-34. P/O SPIN DECOUPLER

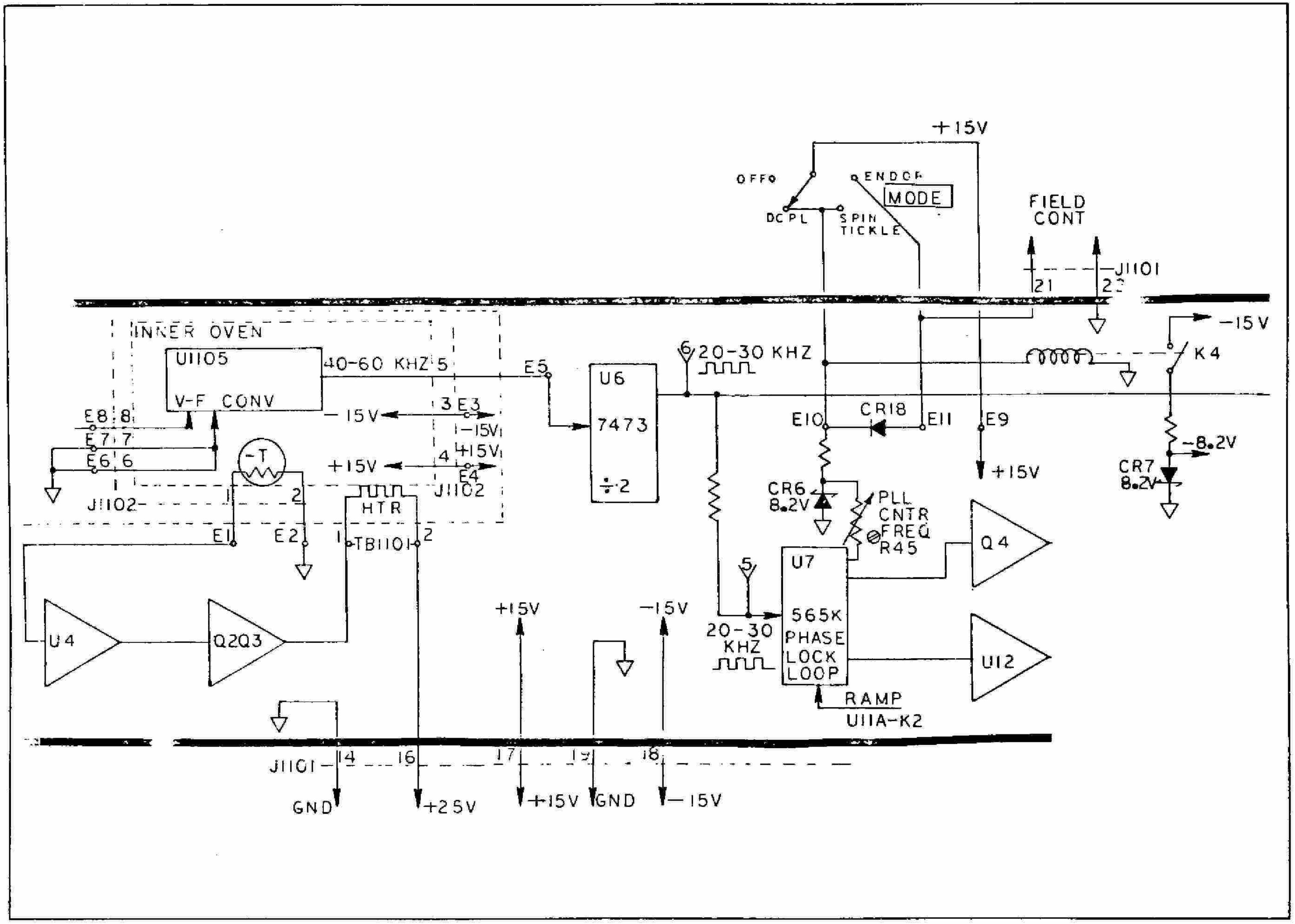

FIGURE 1-35. P/O SPIN DECOUPLER

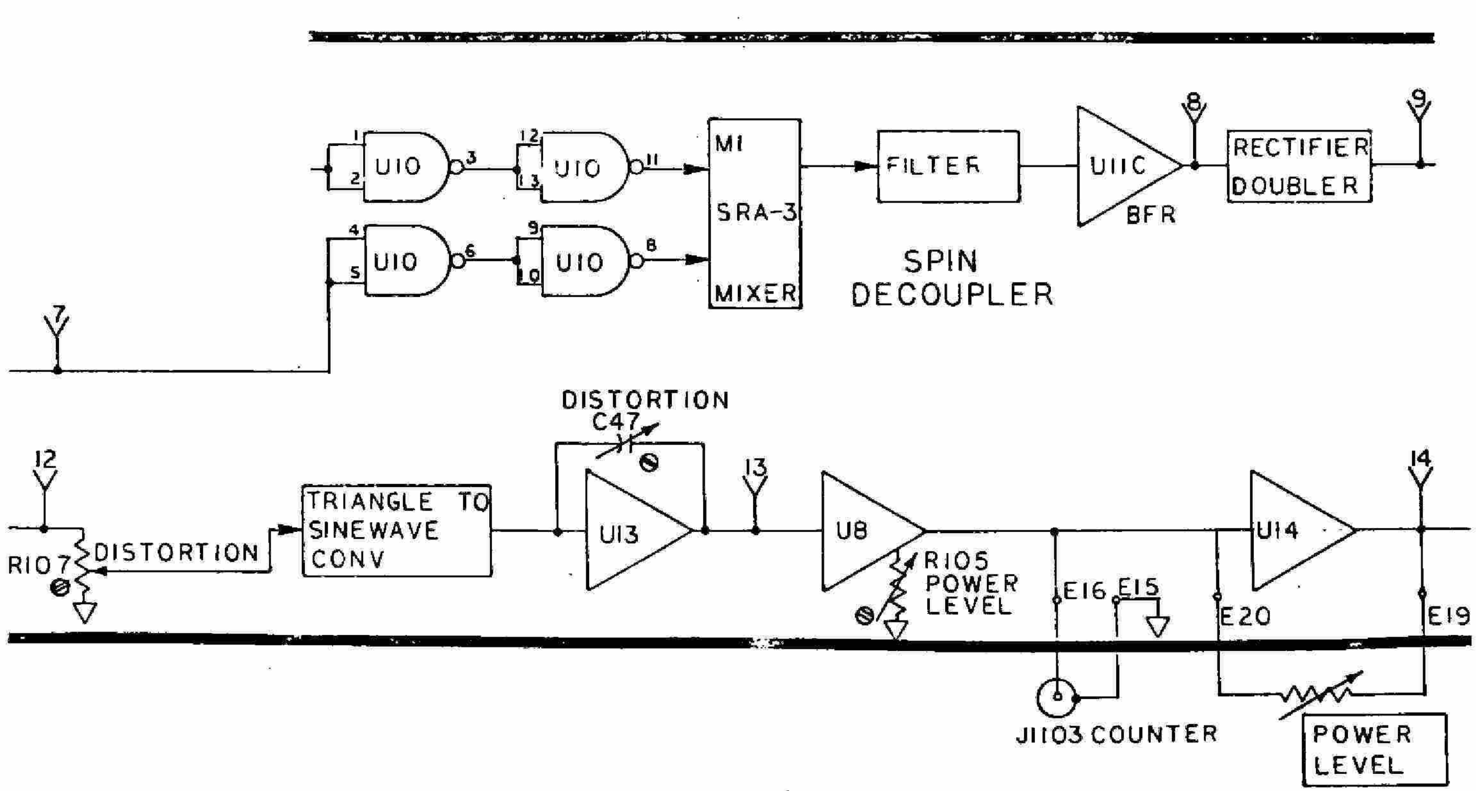

FIGURE 1-36. P/O SPIN DECOUPLER

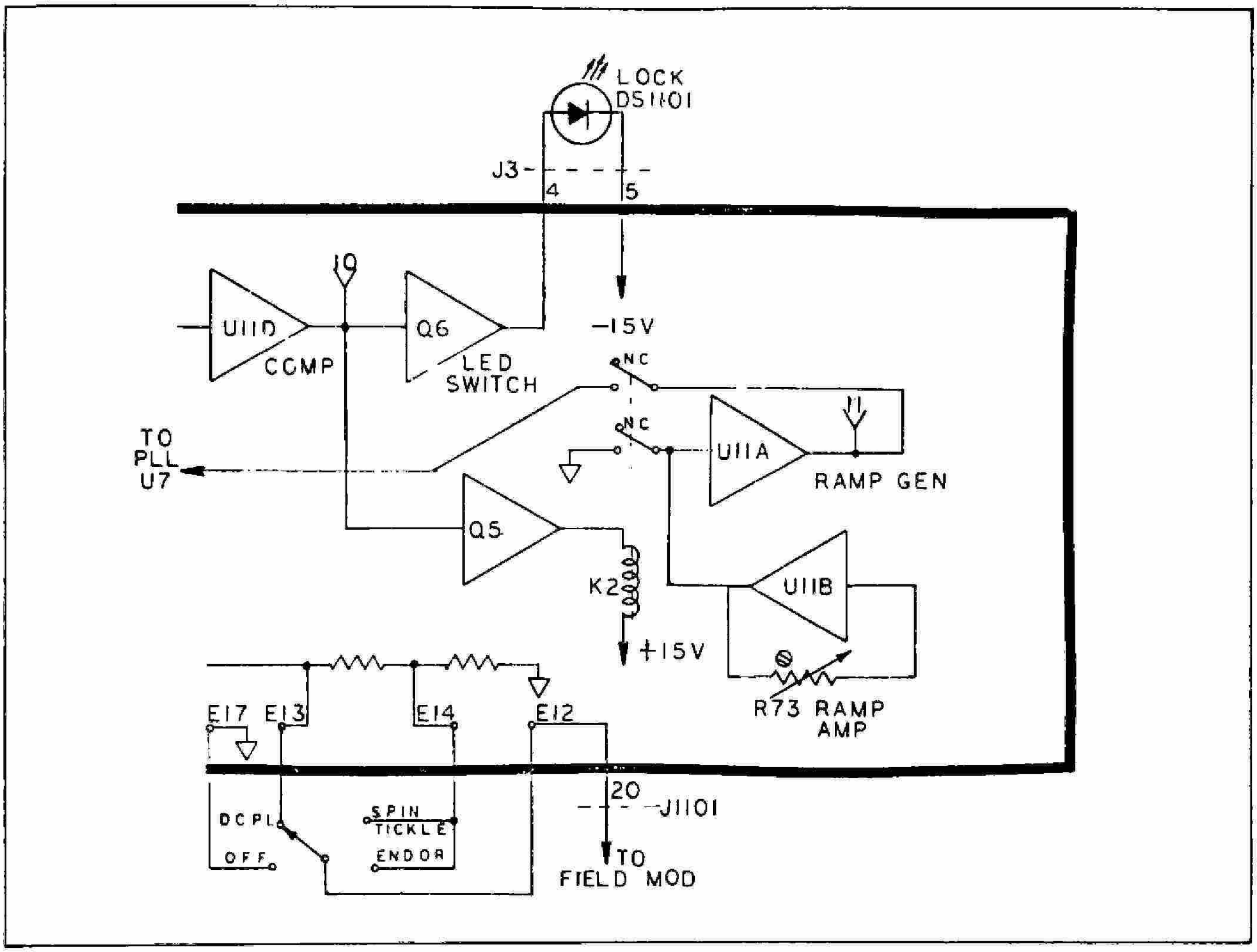

FIGURE 1-37. P/O SPIN DECOUPLER

The signal out of the VCO U5 is divided by 2 with U6 which generates a square wave signal at TP6 at a frequency of 20 KHz to 30 KHz. This signal is applied to buffer gates U10 to the Mixer M1 and to the reference input of the phase lock loop IC (PLL) U7.

The VCO output of the PLL U7 is also fed to the mixer M1 through buffer gates U10. When the PLL U7 is not locked to the TP6 signal its free running frequency is approximately 25 KHz set by R45. The difference frequency signal at the output of M1 is applied through a bandpass filter U11-10.

The CR12, CR11, C43, and R70 make up a voltage doubler rectifier. IC U11-12 is used as a voltage comparator with 0.3 volt hysteresis. Its output at pin 12 controls Q6 and Q5 which consequently control the LED and the relay K2.

In the unlocked mode of PLL U7 the output signal at U11-12 is +12 volts and the relay K2 is energized and the LED is off. The energized relay K2 enables the triangle wave generator made up with U11-3 and U11-4 and the associated components. The triangular signal sweeps the VCO of the PLL U7 pin 7 from 18 KHz to 32 KHz. When the VCO frequency of the PLL U7 is approximately within 200 Hz of the signal frequency at TP6, the DC voltage at TP9 drops to zero, the relay is de-energized, the LED is on, and lock is achieved by disabling the triangle wave generator.

The signal at pin 9 of U7 is a triangle wave buffered with U12. The IC U13 and associated components make up a triangle to sine wave converter. R147 and C47 are set for minimum distortions of the sine wave signal at TP13. A high pass filter in this circuit produces a +6 dB per octave slope in the output to compensate for the frequency dependent modulation index of the spectrometer. IC U8 buffers the high pass filter and sets the required full scale signal amplitude at TP14.

IC U14 is a variable gain amplifier of approximately 0 to 2X and is controlled by a front panel potentiometer.

When the decoupler is OFF, the supply voltages for U6, U10, and PLL U7 are turned off such that no 20 KHz to 30 KHz signal present within the decoupler.

In the DECOUPLE mode, the 20 KHz to 30 KHz signal is fed through C52, R93, and J1101-20 to the Field Modulator circuit board in the console.

In the SPIN TICKLE Mode the modulation signal amplitude is reduced by a factor of 10.

In the INDOR mode the low level of the signal is maintained and in addition, a relay control line at J1101-21 is energized which activates the INDOR circuit in the Field Control circuit board in the console.

In the NORMAL or ^{1}H operation K1 and K2 are de-energized as shown and the recorder tracking is set with R17, the PPM calibration with R97, and the 25 KHz fixed offset with R38.

In the OTHER NUCLEI (^{19}F) mode of operation K1 and K2 are energized. The recorder tracking is set with R15, the PPM calibration with R19, and the 25 KHz fixed offset with R100.

1.3 SYSTEM TESTS AND OPERATION

1.3.1 BASIC SYSTEM

A. PRELIMINARY TESTS

On installation, perform these tests prior to applying power to the system. If power has been previously applied, allow the system to remain under power while these tests are performed.

> CAUTION:
> DO NOT PULL OR REPLACE ANY PCB OR CONNECTOR IN THE SYSTEM WITH POWER APPLIED.

1. Measure the AC Line Voltage available for the system.

2. Check that the transformer jumpers are set for the proper line voltage.

   a. For 115 volt operation, the AC input is through 3 amp fuses to pins 2 and 7 of the transformer with jumpers between pins 10 and 8 and between pins 3 and 4.

   b. For 208 volt operation, the AC input is through 1.5 amp fuses to pins 2 and 9 of the transformer with a jumper between pins 4 and 8.

   c. For 220/230 volt operation, the AC input is through 1.5 amp fuses to pins 2 and 10 of the transformer with a jumper between pins 4 and 8.

3. Check that the probe is inserted and properly seated and fastened down.

   a. The coaxial cable, the ribbon connector, and the five conductor plug are connected.

   b. Air hoses should be connected.

      1) Spinner

      2) Bearing

      3) Eject

4) Body Exhaust (VT only)

5) Chimney Cap Exhaust (VT only)

4. Ensure the air source is properly connected to the external air supply of 10 PSI.

   a. The clean, dry building air or nitrogen may be used if properly filtered by the air filter/regulator assembly provided.

   b. For low temperature operation, a closed cycle pump is required for use as the air source. This source must also be filtered by the air filter/regulator assembly.

5. Check that the following PC cards are properly installed.

a.	Interconnect Assembly	950106
b.	Observe PCB	950096
c.	Field Control	950098
d.	Shim Control	950100
e.	Lock PCB	950090
f.	Autoshim	950102
g.	Field Modulator	950092
h.	Recorder Amplifier	950110
i.	Magnet Temperature	950070
j.	Receiver	950118
k.	Transmitter No. 1	950074
l.	Transmitter No. 2	OPTION
m.	Power Supply PCB	950104

n. Module Switch Assy 950089

o. Accessory Panel 950270

6. Check that the plugs and cables in the console are connected properly.

   a. Power Supply J501

   b. Power Supply J504 (Ribbon Cable)

   c. Power Supply J505

   d. Power Supply J506

   e. Recorder J303

   f. Recorder J304

   g. Recorder J301 (Ribbon Cable)

   h. Recorder J302 (Ribbon Cable)

   i. Recorder J305

   j. Observe Channel J1022

   k. Observe Channel J1023

   l. Shim Control J1021

   m. Lock Channel J1024

   n. Field Modulator J604

   o. Field Modulator J603

   p. Field Modulator J602

   q. Receiver J706 (Coaxial)

   r. Receiver J702

s. Receiver J705

t. Interconnect PCB J1013 (Meter)

u. Interconnect PCB J1012 (Thumbwheel Switch)

v. Interconnect PCB J1011 (Accessory Panel)

w. Interconnect PCB J1009 (Spin Decoupler)

x. Interconnect PCB J1010 (Variable Temperature)

y. Pushbutton Switches J402

z. Pushbutton Switches J401

7. Check that proper fuses are installed under the cover on the Power Supply PCB.

   a. 1.5A at 208/230 VAC.

   b. 3A at 115 VAC.

8. Check that the front panel switches have stops set as indicated on the front panel.

9. Check that the control knobs turn freely without binding.

10. Check that pushbuttons all change without sticking or binding when cover is installed.

11. Check for completeness of covers, panels, and trim.

B. OPERATIONAL ADJUSTMENTS

1. Apply power and turn on POWER switch if not already on. Recorder blower should come on.

2. Measure the current to the Magnet Oven Heaters with a clip-on DC Ammeter at pin 2 of J505. If a clip-on meter is not available, pull pin 2 of J505 and place a conventional DC Ammeter in series.

a. Warmup current 2.5 to 3.5 A.

b. Stabilized current 1.5 to 3 A depending on room temperature.

The current will normally stabilize after operating for 2½ hours.

If the oven current has been off for five minutes or more and is then turned on, the current will start above the stabilized value and then slowly decline to the stabilized value. If the current does not show any sign of declining, it is not regulating.

Heater resistance is about 7 ohms.

3. Measure the voltage at TP4 of the Power Supply. Set this voltage to +15±0.1V with R14 on the power supply. TP4 is labeled and R14 is the only potentiometer on the PCB.

4. Measure the following voltages on the power supply between the test points indicated.

TP1-TP3	+24.5 VDC ± 1.5 V
TP2-TP3	-24.5 VDC ± 1.5 V
TP5-TP6	-15 VDC ± 0.4 V
TP7-TP6	+11.5 VDC ± 1.2 V
TP8-TP6	25 VDC ± 1.5 V

5. Connect the input air hose to the regulated supply of clean dry air and set the input pressure to 10 PSI.

Place a sample with spinner in the probe.

The sample should rotate freely up to 50 revolutions per second.

Adjust eject value regulator for smooth ejection of the sample.

6. **Magnet Shunt Adjustment**

This adjustment should be made only on installation and when the signal has moved outside the range of the OFFSET controls. If the signal is suddenly lost during normal operation it is most probably due to a malfunction of the spectrometer circuits. DO NOT ADJUST the Magnet Shunt until you are certain the spectrometer is operational in all respects.

a. Set END OF SWEEP Switch to zero.

b. Set FINE FIELD ADJUST to mid-range.

c. Set COARSE FIELD ADJUST two turns from maximum clockwise position. This is eight turns from counter-clockwise end.

   Counter-clockwise rotation increases field and moves spectra plot to the left.

   Total range is approximately 250 PPM.

d. Insert the 8-Hz water sample in the probe (943346-03).

e. Turn OBSERVE POWER to MAXIMUM.

f. Set METER SWITCH to LOCK LEVEL.

g. Set LOCK POWER to MINIMUM but not OFF.

h. Set LOCK GAIN for convenient reading on the meter.

i. Adjust the Magnet Shunt until a response is observed on the meter. Readjust OBSERVE POWER as necessary to prevent saturation after a response is found.

   A signal may also be observed on an oscilloscope connected to TP1 (near J1022) on the Observe Channel card.

   Two resonances may be observed separated by about 20 turns of the shunt. This will vary from magnet to magnet and varies greatly with the position of the shunt.

The outermost resonance (most CCW) is correct for the EM-390 spectrometer.

It may be that only one resonance can be found. If this is the proper resonance as described in j. below and the shunts are between 5 and 50 turns from the innermost position the magnet is satisfactory.

If a resonance cannot be found by adjusting the shunts, the search may be continued by feeding an adjustable current up to 2 amps into the DC Sweep Coil and looking for resonance as the current is varied. A high field can be corrected with additional shunts. A low field must be remagnetized at the factory.

j. The following notes may be helpful to establish the correct field adjustment.

   1) Movement of the recorder arm from left to right causes the magnetic field to increase.

   2) Clockwise rotation of the FINE FIELD ADJUST or COARSE FIELD ADJUST causes a decrease of magnetic field.

   3) Clockwise rotation of the magnet shunt screw causes the field to decrease.

   4) Increasing in a positive direction on END OF SWEEP control causes a decrease in magnetic field.

7. Lock Procedure

   a. Turn LOCK MODE Switch to STANDBY.

   b. Turn LOCK POWER to MINIMUM but not OFF.

   c. Turn METER SWITCH to LOCK LEVEL.

   d. Turn LOCK GAIN to MIDRANGE.

   e. Turn RF OBSERVE POWER to 3/4 FULL.

   f. Set END OF SWEEP to ZERO.

g. Set Recorder Pen to chart zero on the chart paper.

h. Slowly rotate the COARSE FIELD control until a response is noted on the meter. Adjust LOCK GAIN and OBSERVE POWER so that the meter reading can be observed to go through a peak.

i. Increase LOCK POWER to 3/4 of full power and reduce OBSERVE POWER to about 0.01 mG.

j. Set LOCK FREQUENCY FINE to MIDRANGE and then rotate LOCK FREQUENCY COARSE control to find a response on the meter. Adjust LOCK GAIN and LOCK POWER for convenient reading on the meter.

k. Adjust the LOCK FREQUENCY FINE control to produce a zero beat with the Observe Frequency. This can be observed on the meter or by a pen movement on the recorder.

   The above procedure produces a zero beat of the lock signal at this position of the recorder arm.

l. Move the recorder arm to eliminate the zero beat.

m. Select SWEEP WIDTH of 1 PPM.

n. Reduce OBSERVE RF POWER to a minimum and then adjust FINE FIELD ADJUST to see a peak on the LOCK METER.

o. Turn LOCK MODE Switch to LOCK.

   If the meter reading stays, reduces slightly, or increases, the system is locked and LOCK PHASE should be adjusted slightly for a peak.

   If the meter reading goes to zero the system is not locked. Go to LOCK STANDBY, rotate LOCK PHASE to a new position and try again. Ten turns of the LOCK PHASE control is about 400 degrees adjustment.

8. Homogeneity Adjustment

   a. Place water sample in the probe and sweep through the line to observe the line shape on the recorder. Place the pen at the maximum pen deflection.

b. With the sample spinning from 40 to 50 rps, adjust Y for maximum upward pen deflection. Move the pen back and forth to remain on the maximum point of the line.

c. Repeat this step using Y^2. Adjust Y^2 for maximum pen deflection while spinning.

d. Repeat steps b. and c. until no further improvement is evident.

e. Turn the spinner OFF.

f. Using the same procedure, maximize the response from the non-spinning controls X, Z, XY, YZ, ZY^2 ensuring that the pen is maintained on the peak of the line by moving the pen continuously back and forth.

g. Turn the spinner ON.

h. Readjust Y and Y^2 as before.

i. Turn the spinner OFF and readjust X, Z, XY, YZ, and ZY^2 for maximum. Continue this alternation between spinning and non-spinning adjustments until no further improvement is evident.

j. Place the REFERENCE Sample (TMS and $CHCl_3$) in the probe, spin at 40-50 rps, and lock to the TMS.

k. Maximize the LOCK LEVEL indication with the Y control.

l. Turn on the AUTOSHIM and adjust Y^2 for maximum allowing the AUTOSHIM to keep Y peaked.

m. Turn off the AUTOSHIM, peak Y, and turn the AUTOSHIM back ON.

n. Adjust Y^3 for maximum allowing the AUTOSHIM to keep Y peaked.

o. Turn off the AUTOSHIM, peak Y and turn the AUTOSHIM back ON.

p. Adjust Y^2 and Y^4 alternately for maximum allowing the AUTOSHIM to keep Y peaked.

q. Turn off the AUTOSHIM, peak Y, and turn the AUTOSHIM back ON.

r. Set up the following parameters on the spectrometer with END OF SWEEP PPM as required.

SPINNER SPEED	40 rps
RF POWER	0.006 mG
FILTER	0.1 Seconds
SWEEP WIDTH	1 PPM
SWEEP TIME	5 Minutes
SPECTRUM AMPLITUDE	As Necessary to Observe First and Second Order spinning sidebands.

s. Slowly sweep through the First Order sidebands adjusting first X, then Z, then XY, the YZ for minimum first order sidebands allowing the AUTO-SHIM to keep Y peaked on the LOCK METER. Adjust each control for minimum sidebands before proceeding to the next.

t. Turn the AUTOSHIM OFF, peak Y, and turn the AUTOSHIM ON.

u. Slowly sweep through the Second Order sidebands adjusting ZY^2 and X^2 for minimum second order sidebands allowing the AUTOSHIM to keep Y peaked on the LOCK METER. Adjust each control for minimum side-bands before proceeding to the next.

v. Turn the AUTOSHIM OFF, peak Y, and turn the AUTOSHIM ON.

w. Repeat steps s through v until the spinning sidebands are less than five times the height of the Carbon-13 satellites. With a badly tuned instrument, several repetitions of this procedure are necessary.

C. OPERATIONAL PERFORMANCE TESTS

1. Magnet Temperature Determination

The magnet should operate at 34°C after proper stabilization. This temperature is determined by measuring the resistance of thermistors placed in the magnet and accessible through test points on the Magnet Regulator Card.

a. The Alnico thermistor is TP1 to TP2.

b. The Yoke thermistor is TP3 to TP4.

c. The Magnet Oven thermistors may be read between P801-8 and P801-9.

Yoke and Alnico Resistance vs Temperature

Temperature (°C)	Resistance (Ohms)
19	3930
21	3592
23	3282
25	3000
27	2742
29	2506
31	2290
33	2093
34	2000
35	1912
37	1748

Magnet Thermistors Resistance vs Temperature

Temperature (°C)	Resistance (Ohms)
24	2092
25	2000
26	1912
27	1828
28	1747
29	1670
30	1597
31	1527
32	1460
33	1395
34	1334
35	1275
36	1219
37	1166
38	1114

It is normally not necessary to measure the magnet thermistors as they are theoretically the same temperature as the Yoke and Alnico thermistors. Measure them only if a malfunction is suspected.

Do not proceed with this section if the temperature is not 34°C.

2. Room Temperature Specification

The room temperature must be within 18°C (64.4°F) to 32°C (89.6°F) with a maximum variation of ±3°C (5.4°F) over a 24 hour period.

3. Sensitivity Performance

The sensitivity shall be greater than 50 to 1 signal-to-average noise ratio on the largest peak in the methylene quartet of a 1% (V/V) ethylbenzene solution (943346-09).

Use the following instrument parameters.

SPINNER SPEED	40 rps
RF POWER	Set for maximum signal just under saturation (0.16 mG typically)
FILTER	0.5 Second
SWEEP WIDTH	5 PPM
END OF SWEEP	As required
SPECTRUM AMPLITUDE	As required to provide for ethylbenzene quartet 80% of chart height
PROCEDURE	Take the average of three runs with no change in settings between runs as in Figure 1-38.

The signal-to-noise ratio is determined by taking the peak-to-peak value of 8 centimeters of noise and comparing it to the signal amplitude with the following formula.

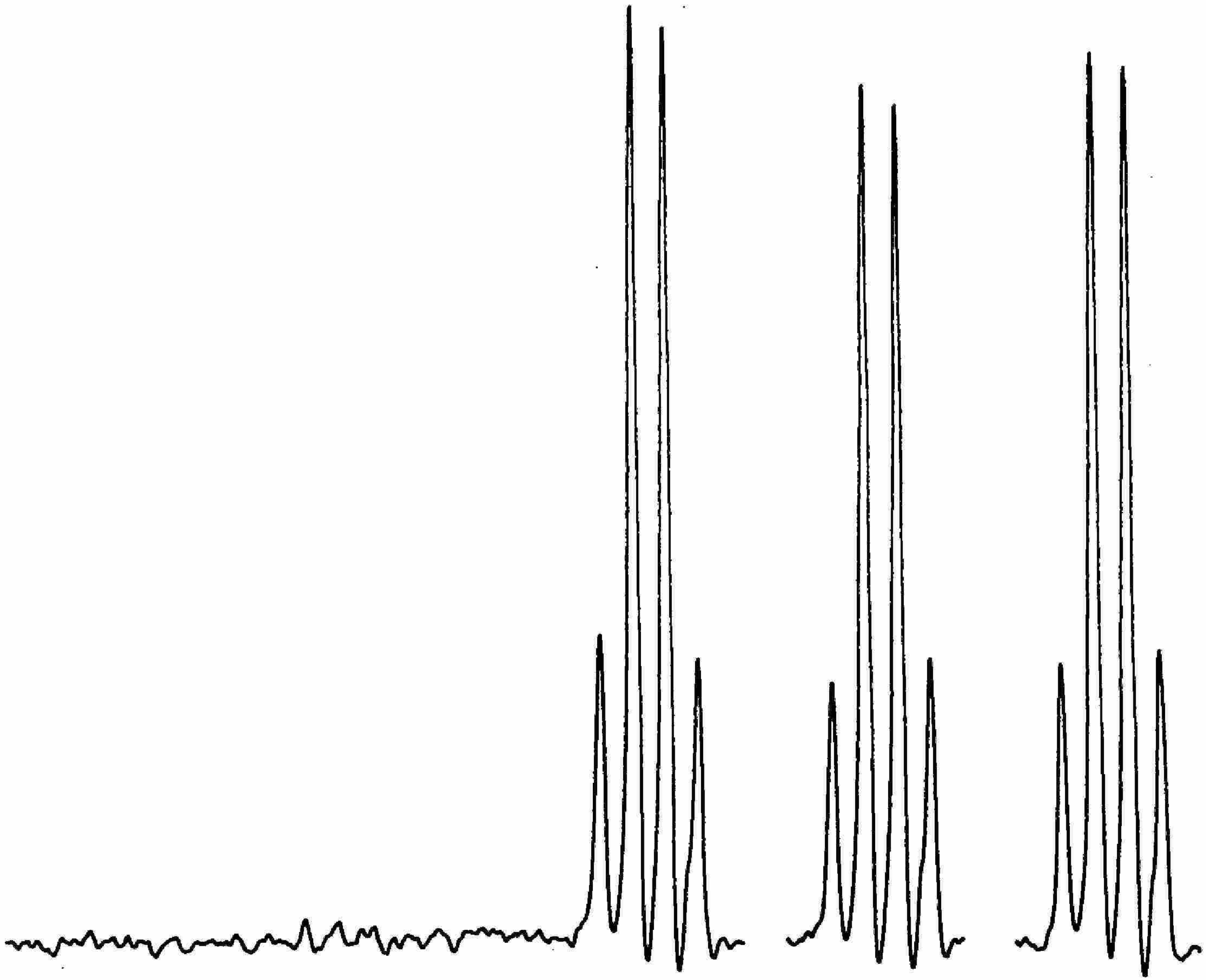

FIGURE 1-38. SENSITIVITY TEST

$$S/N = \frac{\text{Signal Height}}{\text{Peak-to-Peak Noise}} \times 2.5$$

Noise is normally recorded by offsetting the spectra 10 PPM to eliminate any peaks due to sample impurities or spinning sidebands.

4. Resolution Test

The resolution shall be less than ½ (0.5) Hz full linewidth at half-maximum amplitude of the seventh or fourteenth peak of 30% ortho-dichlorobenzene (943346-26). See Figure 1-39. This corresponds to better than one part in 5×10^{-8}.

Use the following instrument parameters.

SPINNER SPEED	40 rps
RF POWER	0.004 mG
FILTER	0.05 Second
SWEEP WIDTH	0.5 PPM
SWEEP TIME	10 Minutes
SPECTRUM AMPLITUDE	As necessary
END OF SWEEP	As necessary
PROCEDURE	Run the trace and record the half-amplitude linewidth of the seventh or fourteenth peak.

5. Integration Test

The integral reproducibility shall have an average deviation of less than 2 percent for five consecutive scans of a 5% (V/V) ethylbenzene solution (943346-27). See Figure 1-40.

Use the following instrument parameters.

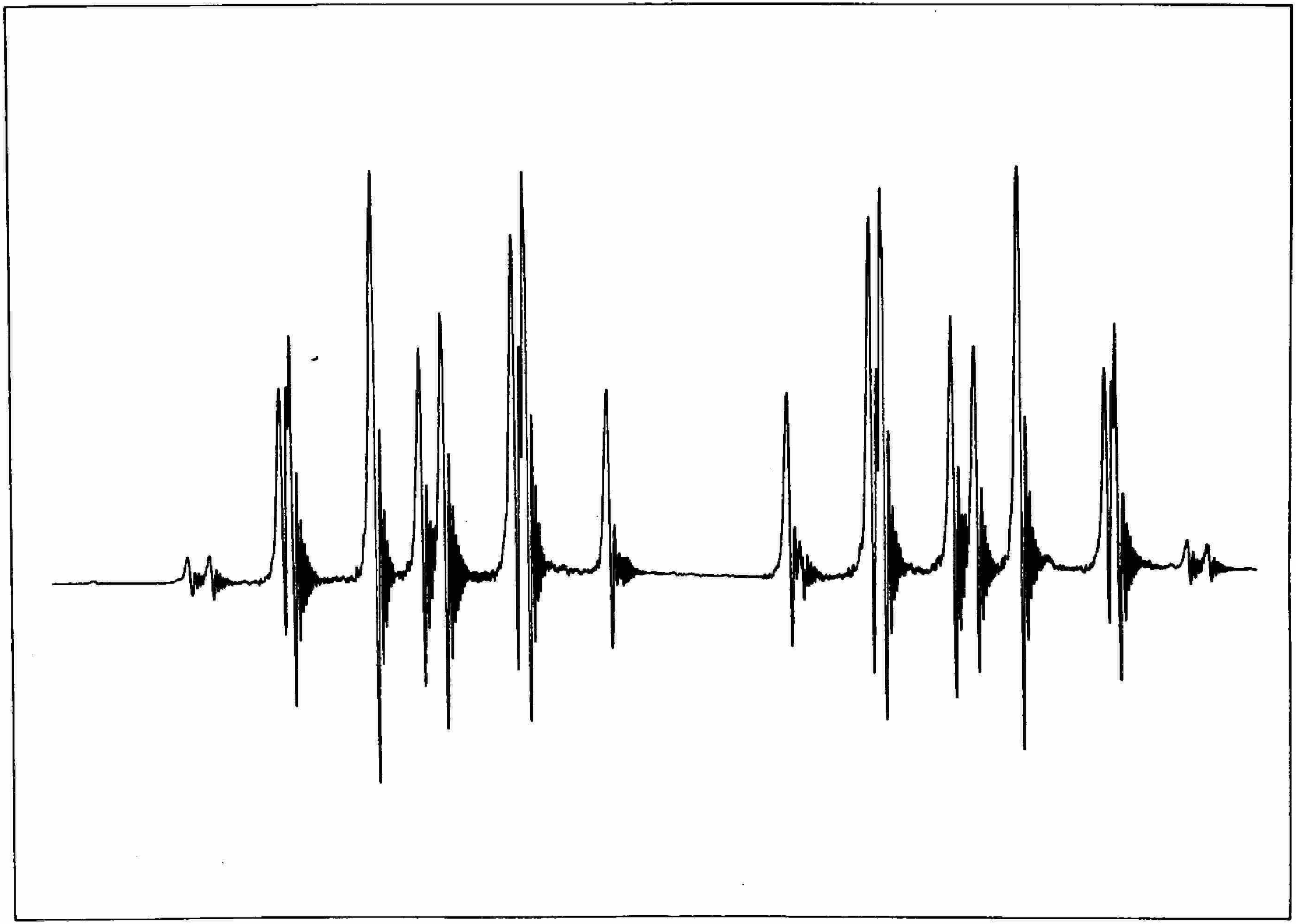

FIGURE 1-39. RESOLUTION TEST

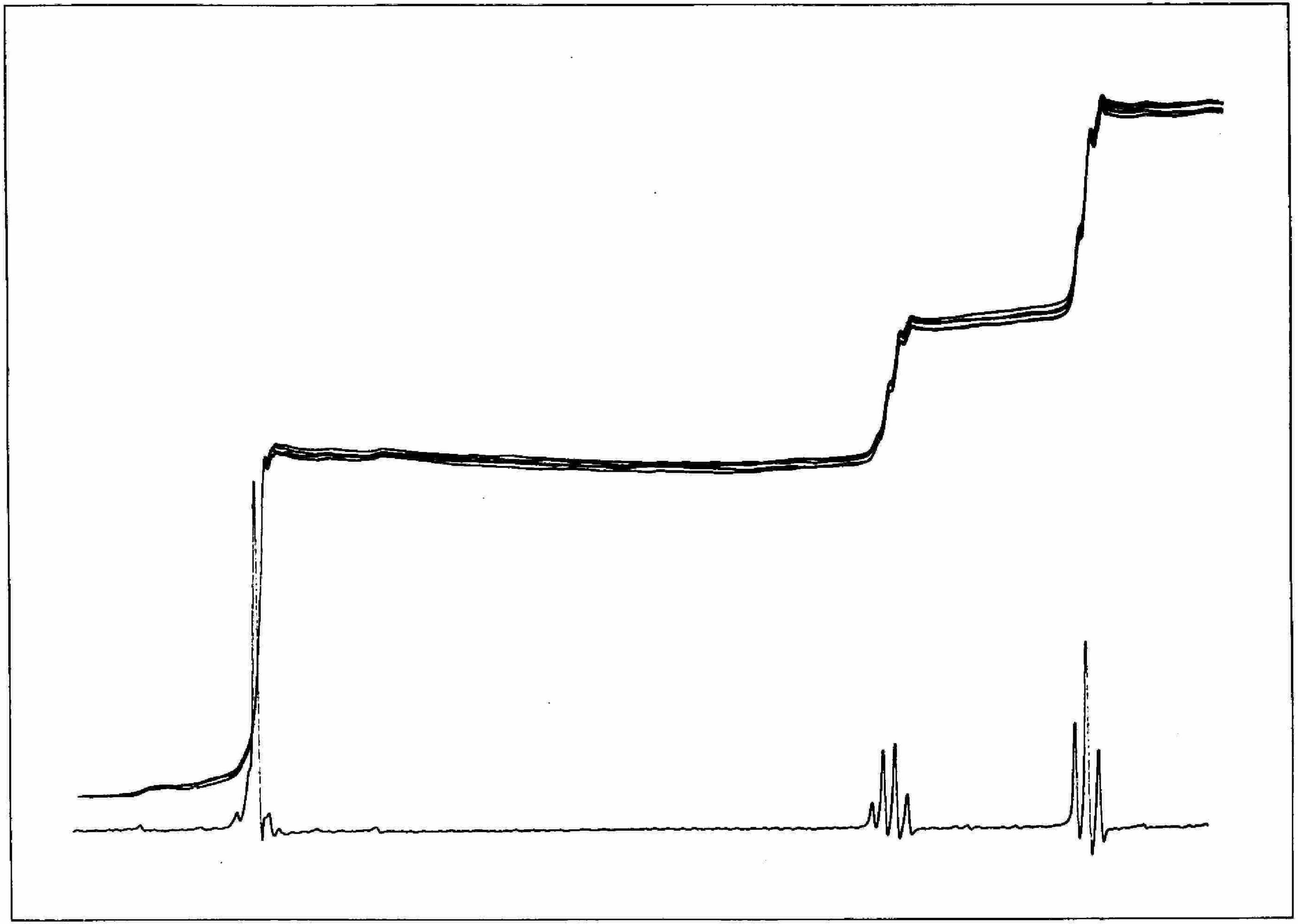

FIGURE 1-40. INTEGRATION TEST

SPINNER SPEED	40 rps
RF POWER	0.15 mG
FILTER	OPEN
SWEEP WIDTH	10 PPM
SWEEP TIME	1 Minute
END OF SWEEP	As required
SPECTRUM AMPLITUDE	As necessary to fill 80% of chart
PROCEDURE	Run five traces and determine % average deviation.

LOCK GAIN must be set low enough so there is no disturbance of the LOCK LEVEL METER as the recorder passes through a peak.

Calculate the average deviation as follows :

a. Determine average height of the five integrals.

b. Measure the average deviation from this average height.

$$\% \text{ Average Deviation} = \frac{\text{Avg. Deviation}}{\text{Avg. Height}}$$

6. Spinning Sideband Test

The spinning sidebands shall be less than 2.5% of the main signal amplitude at a sample spin rate of 50 Hz. Use the Reference Sample 943346-07 and position as shown in Figure 1-41 at the Chloroform line.

Use the following instrument parameters.

SPINNER SPEED	40 Hz
RF POWER	0.006 mG
FILTER	0.1 Second

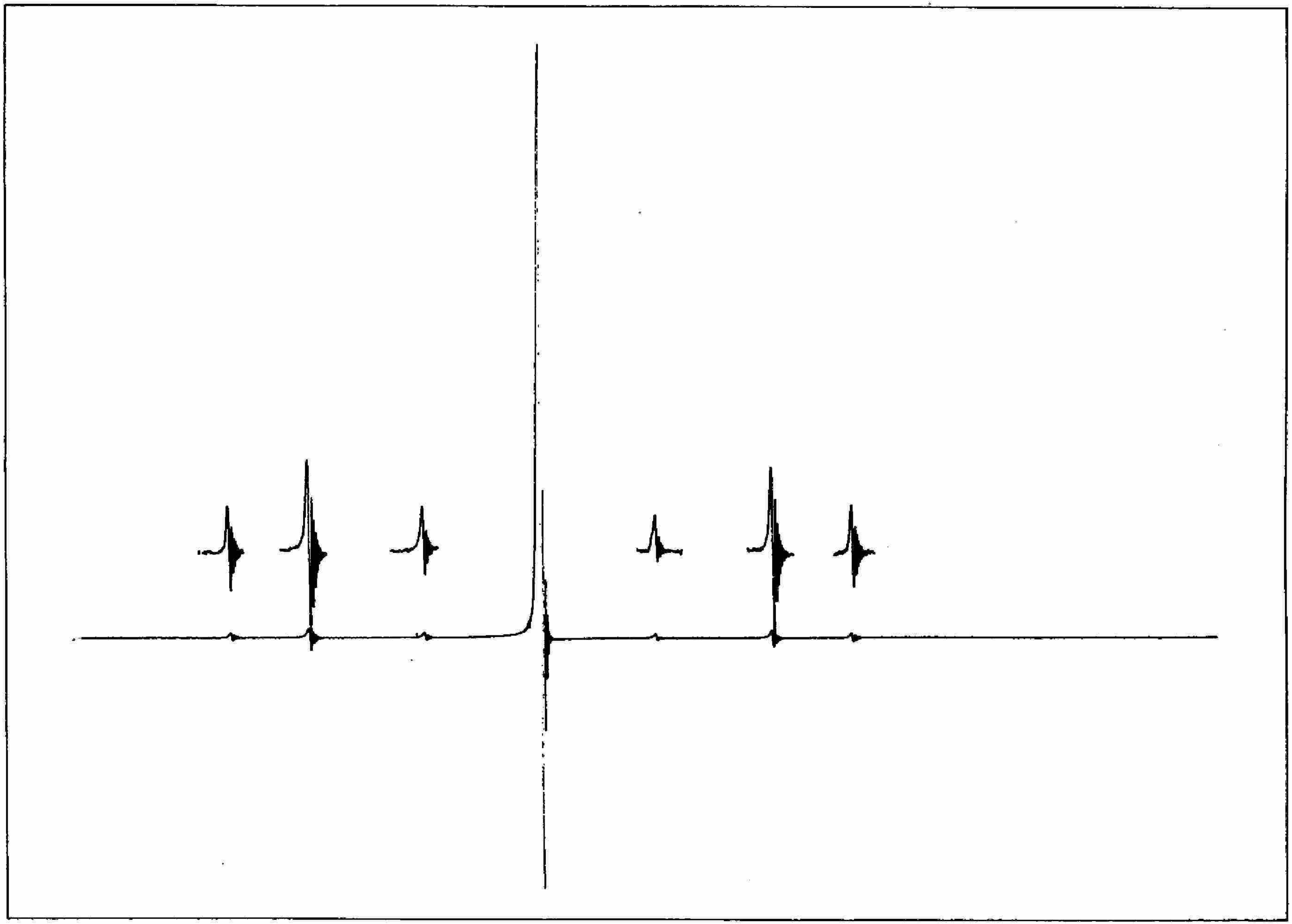

FIGURE 1-41. SPINNING SIDEBANDS

SWEEP WIDTH	5 PPM
SWEEP TIME	5 Minutes
END OF SWEEP	As required
SPECTRUM AMPLITUDE	As required

The Carbon-13 satellites occur at 105 Hz from the chloroform line and are 0.55% of the chloroform amplitude. Use these satellite peaks to determine the amplitude of the spinning sidebands.

7. Line Shape Test

The lineshape must meet two criteria.

a. The chloroform line width at the height of the Carbon-13 satellites (0.55%) must be less than 10 Hz.

b. The chloroform line width at 1/5 the height of the Carbon-13 satellites (0.11%) must be less than 35 Hz.

Use the REFERENCE Sample 943346-07 (Figure 1-42).

Use the following instrument parameters.

SPINNER SPEED	40 rps
RF POWER	0.006 mG
FILTER	0.1 Second
SWEEP WIDTH	2 PPM
SWEEP TIME	5 Minutes
SPECTRUM AMPLITUDE	As required

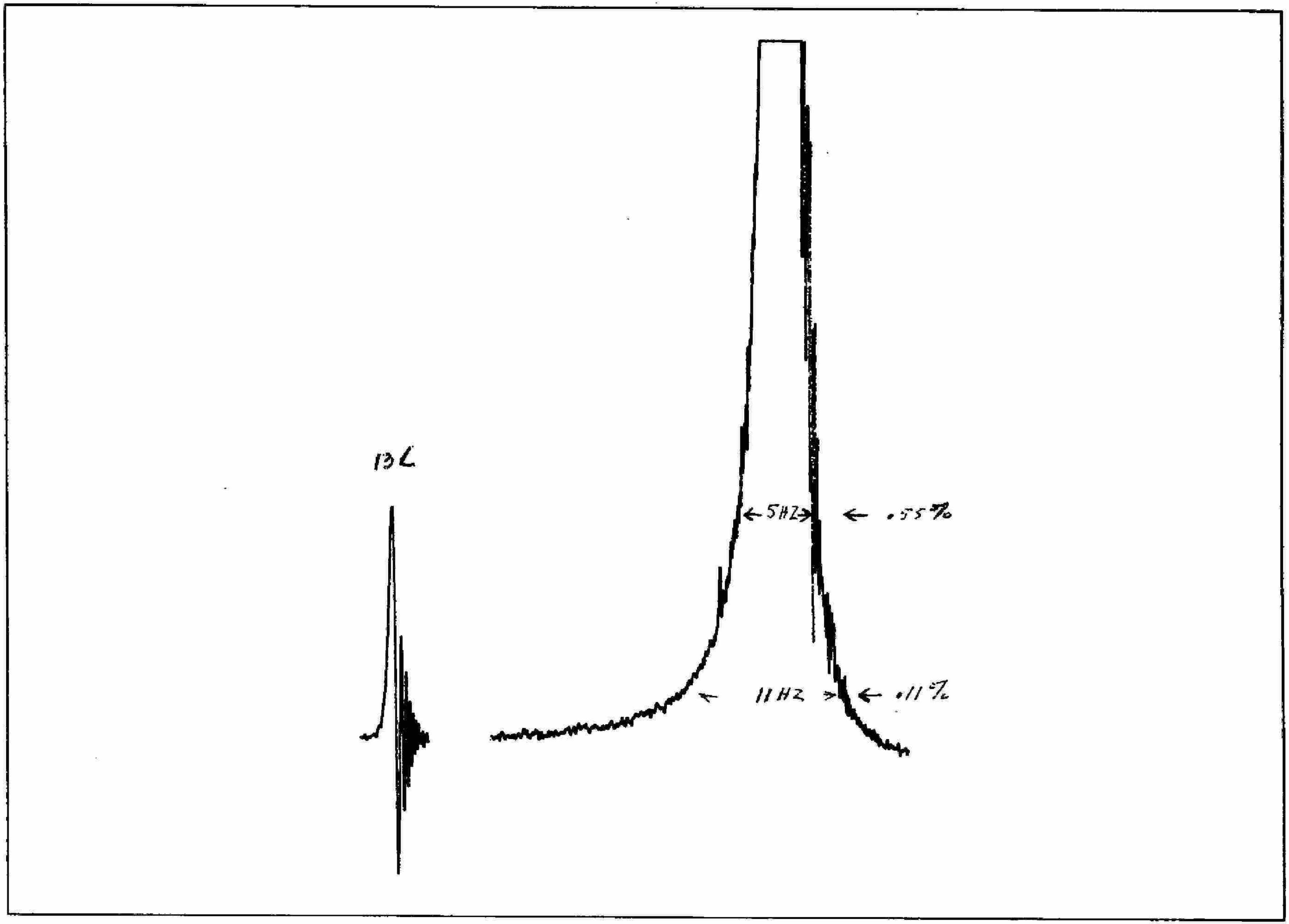

FIGURE 1-42. LINE SHAPE

8. Lock Range

The range of the internal lock system (as the recorder arm is moved or END OF SWEEP is adjusted) is 20 PPM on the original EM-390 with adjustment of LOCK PHASE. On Fluorine equipped instruments and all instruments produced after 1 January 1976, the Lock Range is 50 PPM with LOCK PHASE Adjustment (Serial No. 147).

The range must be greater than ±10 PPM with no adjustment of LOCK PHASE for a 1% TMS Lock. This lock must be maintained at the maximum sweep rate with a SWEEP WIDTH of 10 PPM.

Rapid manual movement of the recorder arm will cause loss of NMR lock.

9. Lock Stability

The LOCK VCO and magnetic field strength must dynamically track for step changes in the END OF SWEEP Control as described below.

a. Lock on 1% TMS (943346-27).

b. Adjust Homogeneity.

c. Set LOCK POWER below saturation.

d. Set LOCK GAIN for a reading of 40 on the LOCK LEVEL METER.

e. Peak the LOCK PHASE.

f. Make a 1 PPM change in END OF SWEEP control and the meter reading should not drop below 15 for a change in either the + or - direction.

10. AUTOSHIM Stability

The AUTOSHIM should compensate for changes in the Y-Gradient. To check its operation, perform the following:

a. Lock on a TMS line, any sample.

b. Adjust Homogeneity.

c. Turn the Y-FINE Control clockwise until the LOCK LEVEL METER reading decreases to 50% of the peak reading.

d. Turn on the AUTOSHIM and the meter reading should return within 5 minutes to greater than 90% of the peak reading.

e. Turn off the AUTOSHIM and turn the Y-FINE control counterclockwise until the LOCK LEVEL METER reading decreases to 50% of the peak reading.

f. Turn on the AUTOSHIM and the meter reading should return within 5 minutes to greater than 90% of the peak reading.

11. System Stability

The specification for stability is two-fold:

a. When locked, the peak position deviation will be less than 0.2 Hz in a 5 minute interval.

b. When unlocked, the peak position deviation will be less than 2 Hz in a 5 minute interval.

Set up the spectrometer to run the chloroform line of the reference sample (943346-07) using a 5 minute scan.

Run two traces with the system locked and record the peak position deviation.

Run two traces with the system unlocked and record the peak posotion deviation.

1.3.2 SPIN DECOUPLER TESTS

A. PRELIMINARY TESTS

1. System Connection

Ensure that P1009 is connected into the EM-390 Interconnect board at J1009. Place the EM-390 Spin Decoupler on top of the EM-390 console. Turn the Decoupler MODE SWITCH to DECOUPLE and the DECOUPLE POWER Switch full counterclockwise. Allow the decoupler to warm up at least 20 minutes before proceeding.

2. Proton Tracking

NOTE: Frequency Counter required!

a. Set the DECOUPLER OFFSET thumbwheel switch to +000.0 PPM.

b. Set the DECOUPLER FINE OFFSET control to MIDRANGE.

c. Set the EM-390 END OF SWEEP thumbwheel to +000.0 PPM.

d. Position the chart paper at the "hash mark".

e. Place the recorder pen on chart zero.

f. Connect a high resolution counter to J1103 on the back panel of the Spin Decoupler module.

g. Increase the DECOUPLER POWER until a beat note appears on the recorder.

h. The frequency on the counter should read 25,000 Hz ± 1 Hz.

i. Adjust the DECOUPLER FINE OFFSET control until this condition is met and record the exact frequency within 0.2 Hz.

j. Set the END OF SWEEP thumbwheel to +10.0 PPM.

k. The frequency <u>change</u> should be +900 Hz ± 1 Hz.

l. If this condition is not met refer to the Spin Decoupler Calibration Adjustment in the rear of this publication and perform the Tracking Adjustment. Do not proceed with this test until the Tracking Adjustment is made.

3. Other Nuclei Tracking – ^{19}F

NOTE: Frequency Counter required!

a. Set the DECOUPLER OFFSET thumbwheel switch to +000.0 PPM.

b. Select the OTHER NUCLEI button on the Recorder.

c. Set the DECOUPLER FINE OFFSET control to MIDRANGE.

d. Set the EM-390 END OF SWEEP thumbwheel to -000.0 PPM.

e. Position the chart paper at the "hash mark".

f. Place the recorder pen on chart zero.

g. Connect a high resolution counter to J1103 on the back panel of the Spin Decoupler Module.

h. Increase the DECOUPLER POWER until a beat note appears on the recorder.

i. The frequency on the counter should read 25,000 Hz ± 1 Hz.

j. Adjust the DECOUPLER FINE OFFSET control until this condition is met and record the exact frequency within 0.2 Hz.

k. Set the END OF SWEEP thumbwheel to -10.0 PPM.

l. The frequency change should be +846 Hz ± 1 Hz.

m. If this condition is not met refer to the Spin Decoupler Calibration Adjustment in the rear of this publication and perform the Tracking Adjustment -^{19}F.

n. Do not proceed with this test until the Tracking Adjustment -^{19}F is made.

B. PERFORMANCE TESTS

1. Spin Decoupling

The Spin Decoupler Accessory will decouple the quartet and triplet in the INTEG TEST Sample (943346-27) from each other as shown in Figure 1-43.

a. Set up the spectrometer as follows:

SPINNER SPEED	40 rps
RF POWER	0.15 mG

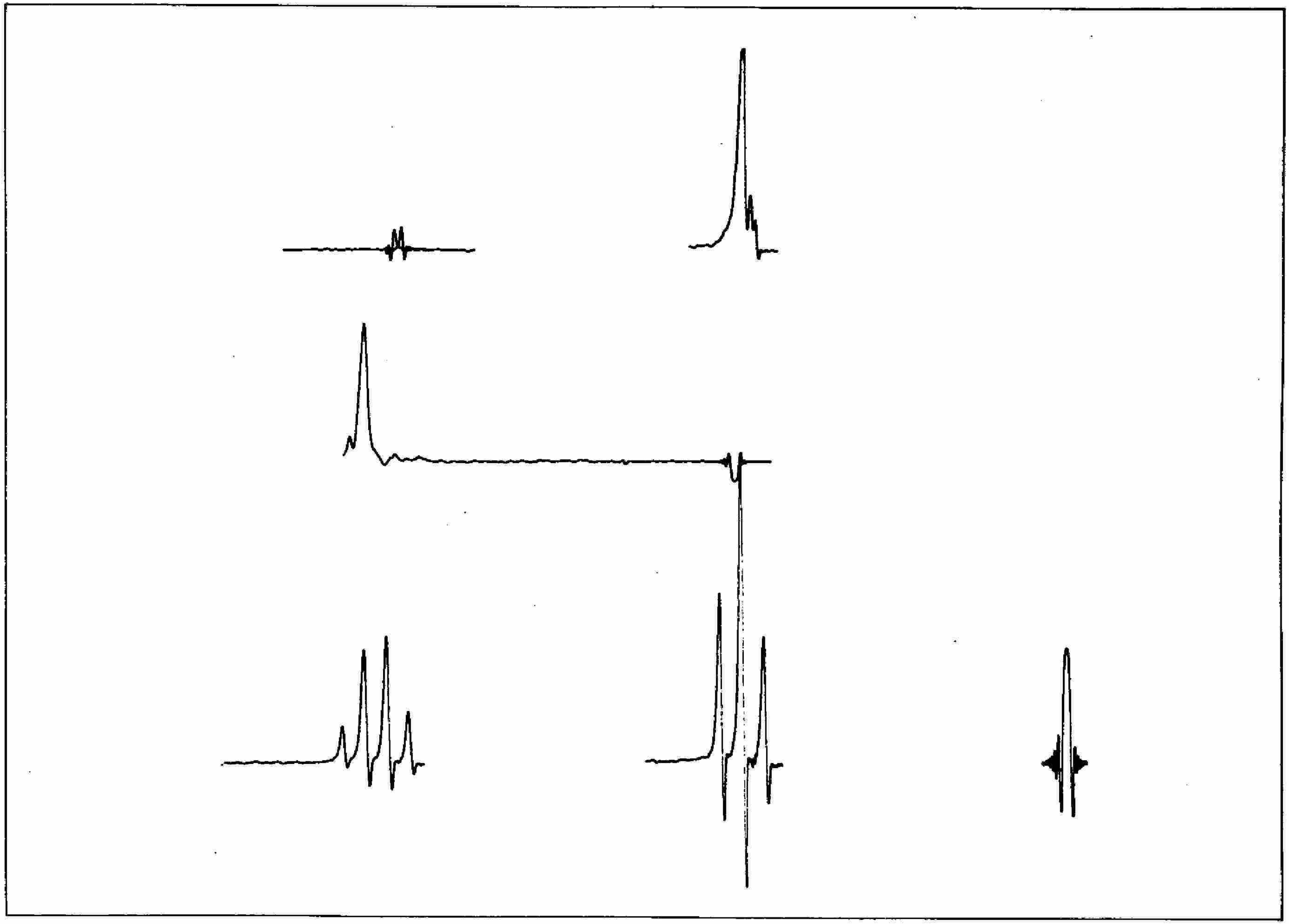

FIGURE 1-43. DECOUPLED ETB

FILTER	0.05 Second
SWEEP WIDTH	5 PPM
SWEEP TIME	5 Minutes
SPECTRUM AMPLITUDE	As necessary to provide triplet height at 30% of chart height
SPIN DECOUPLER	OFF

Run a trace showing the quartet and triplet of ethylbenzene on the lower 1/3 of the chart paper.

b. Place the pen in the middle of the group to be irradiated for decoupling.

c. Turn the Spin Decoupler to DECOUPLE.

d. Set DECOUPLER POWER to minimum (CCW).

e. Adjust the frequency of the decoupler using DECOUPLER OFFSET thumbwheel using either a counter or observing a beat note on the pen.

f. Gradually increase the DECOUPLER POWER while observing the group that is coupled to the one being irradiated. Make very slight adjustments of the decoupler frequency for optimum decoupling.

g. LOCK GAIN may have to be reduced to minimize saturation in the Lock Channel when the decoupler frequency is close to the lock frequency.

2. Spin Tickling

a. Use the 19% dibromopropionic acid (DBPA 943346-19) sample and set up the spectrometer as follows.

SPINNER SPEED	40 rps
RF POWER	0.15 mG
FILTER	0.5 Second

SWEEP WIDTH	2 PPM
SWEEP TIME	5 Minutes
SPECTRUM AMPLITUDE	500

b. Run a normal trace with the Spin Decoupler OFF.

c. Position the pen precisely over the line in the multiplet desired to be irradiated (See Figure 1-44).

d. Turn on the Spin Decoupler in the SPIN TICKLE mode.

e. Adjust the frequency of the Spin Decoupler for a zero beat on the pen and accurately set the frequency to null the beat.

f. Turn SPIN DECOUPLE POWER to about 0.1 mG and sweep through the full spectrum.

   1) A zero beat occurs on the line being irradiated.

   2) Line splittings should occur in the multiplets coupled to this line.

g. Adjust Spin Decoupler POWER to optimize these splittings.

3. INDOR Test

   a. With the decoupler off, trace out the normal spectrum in the desired expansion of dibromopropionic acid as shown in Figure 1-45.

   b. Place the recorder arm at chart zero.

   c. Shift the spectrum to the right using END OF SWEEP controls to place the line desired to be irradiated at the zero position.

   d. The pen should now be on top of this line.

   e. Reduce OBSERVE POWER to prevent saturation of this line (about 0.1 mG).

   f. Set DECOUPLER POWER to 0.1 mG and switch to INDOR.

FIGURE 1-44. SPIN TICKLING

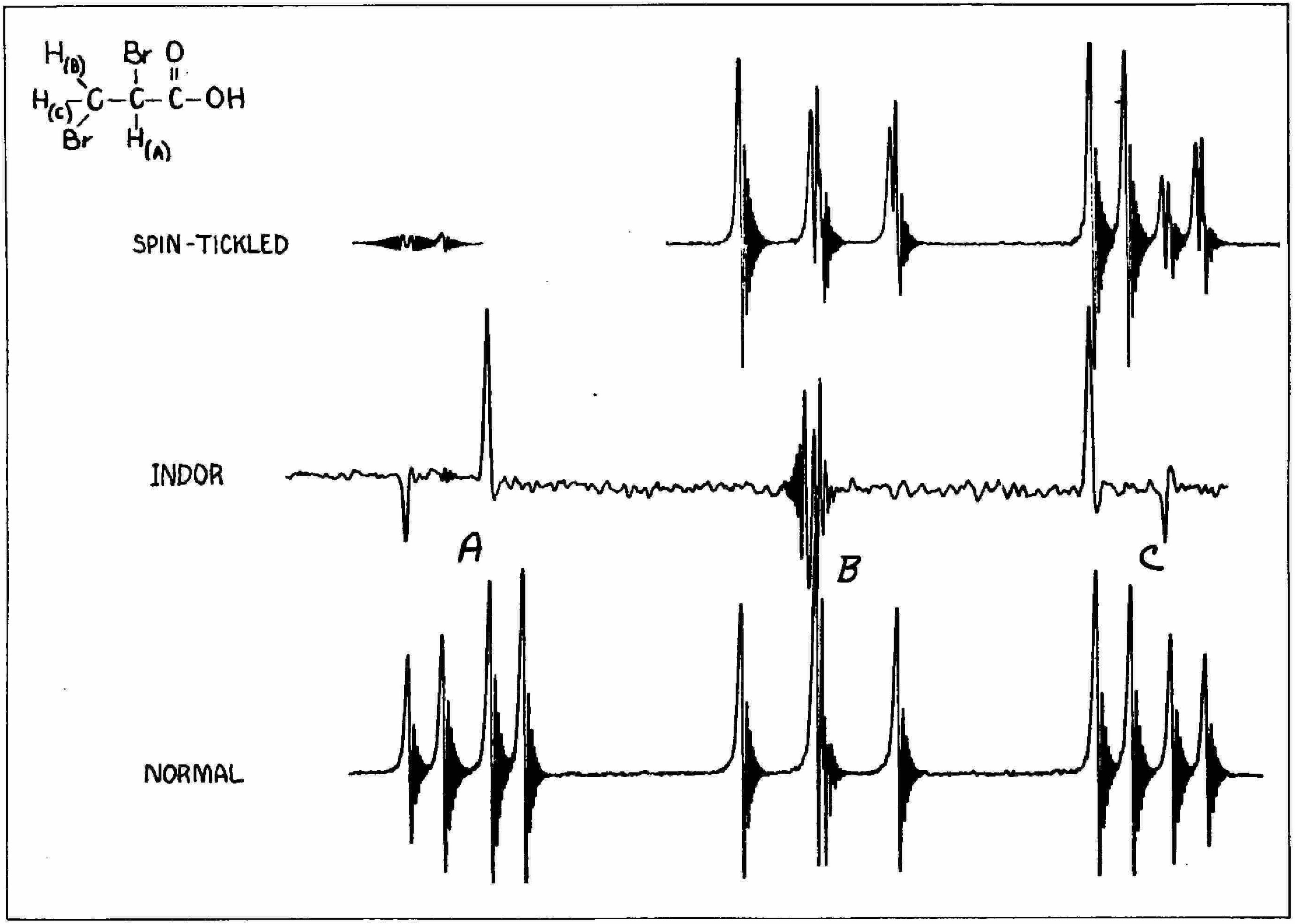

FIGURE 1-45. INDOR

g. The pen should remain on top of the line to be irradiated.

h. If the pen moves off the line, readjust either END OF SWEEP VERNIER or LOCK FREQUENCY FINE for maximum upward pen deflection.

i. The pen is now disconnected from the field sweep control and may be moved freely back and forth without pen moving from the amplitude of the monitor line.

j. Move the recorder arm so the pen is at the original position of the monitor line in the normal spectrum.

k. Adjust the decoupler frequency until a beat note is obtained.

l. Move the recorder arm to the left end and record the INDOR spectrum.

   1) Ensure INDOR scan speed is such that the sweep width over sweep time is about 0.5 Hz/sec.

      Example: 2 PPM is 180 Hz. Sweep time then must be 5 minutes or 300 seconds to fit this criterion.

   2) The Filter time constant can be fairly long, typically 0.5 Second.

m. Adjust Spin Decoupler POWER for the optimum display.

1.3.3 VARIABLE TEMPERATURE

A. SAFETY PRECAUTIONS – PRELIMINARY

> **WARNING:**
>
> High pressure gas is used. Pressures up to 2500 psi at the gas bottle and up to 1400 psi from the regulator through the gas lines can cause severe injury if mishandled. A small airleak at 1400 psi can cut skin and cause serious hazards to the unwary.
>
> Never look for gas leaks in high pressure lines using fingers or hands. Use a soap or bubble solution with a remote applicator to keep hands away from lines.

> WARNING (continued):
>
> Use only Nitrogen or Argon – Do not use any other gas.
>
> Do not exceed 2500 psi tank pressure.

1. Perform the following:

   a. Double check all fittings for tightness. Do not overtighten.

   b. See Figures 1, 2, and 3 for proper use of Swage Lock fittings. Fittings that have been properly tightened may be remade many times.

   c. If a fitting is cross-threaded, it must be replaced.

   d. Use only approved regulators, gas lines, and hardware that Varian has supplied or recommended.

   e. Do not block, even momentarily, the exhaust hose barb on the top of the probe as internal pressure may build up within the probe with disastrous results to the insert.

   f. If a flow-meter is connected to the exhaust barb, it should not have a shut-off valve with it.

   g. When changing gas bottles, the valve on the gas bottle must be off and the pressure gauges on the regulator should be at 0.

   h. Do not leave the adsorber open-ended to air longer than absolutely necessary as moisture will be adsorbed.

   i. Use extreme care when handling the tubing to avoid nicking or scratching the tubing surface. The Swage Lock fittings require a perfectly smooth tubing surface to seal.

   j. For future operating safety by the customer, ensure the warning labels that warn of gas pressure to 2500 psi are installed.

B. HIGH TEMPERATURE TEST

1. Ensure all conditions and connections for Variable Temperature operation are made.

   a. Pneumatic connections are made per Figure 5 of the Manual 87-145-601.

   b. The VT plug P1010 is mated with J1010 in the console.

   c. The pressure cap thumbscrew is adjusted for spinner speed of 40 rps.

2. The High Temperature Control range is from +10°C to +175°C and the high temperature sample, ethylene glycol, explodes at +190°C. Do not approach 190°C with the controller.

Table 1
Ethylene Glycol Shift vs Temperature (90 MHz)

Degrees Centigrade	Frequency Shift in Hz
+10	159.3
+20	150.3
+30	141.3
+40	132.3
+50	123.3
+60	114.3
+70	105.3
+80	96.3
+90	87.3
+100	78.3
+110	69.3
+120	60.3
+130	51.3
+140	42.3
+150	33.3
+160	24.3
+170	15.3
+180	6.3

3. Install the ethylene glycol sample, neat solution, into the probe (943346-05).

a. Set the RANGE switch on the Temperature Controller to HIGH.

b. Set the gas pressure from the regulator to 800 psi.

c. Set the Temperature Controller TEMPERATURE SET to +35°C.

d. Turn the POWER SWITCH ON.

e. Adjust the thumbscrew on the pressure cap until the sample begins to spin. Spinner speed is then set to 40 rps.

f. Run a trace of the ethylene glycol and position the spectrometer controls to place the right hand peak on chart zero as shown in Figure 1-46.

g. Lock to this peak and turn on the AUTOSHIM.

h. Turn the Temperature Controller to +120°C and observe that

   1) only the TEMPERATURE INCREASING Lamp comes on.

   2) the separation of the peaks in the spectra starts to decrease.

i. The temperature should stabilize in 7 to 10 minutes with the following states evident.

   1) Both INCREASING and DECREASING lamps are ON.

   2) The spacing between the lines is 60.3 ± 1.8 Hz.

j. Turn the Temperature Controller to +60°C and observe that

   1) Only the TEMPERATURE DECREASING lamp comes ON.

   2) The separation of the peaks starts to increase.

k. The temperature should stabilize in 7 to 10 minutes with the following states evident.

   1) Both INCREASING and DECREASING lamps are on.

   2) The spacing between the lines is 114.3 ± 1.8 Hz.

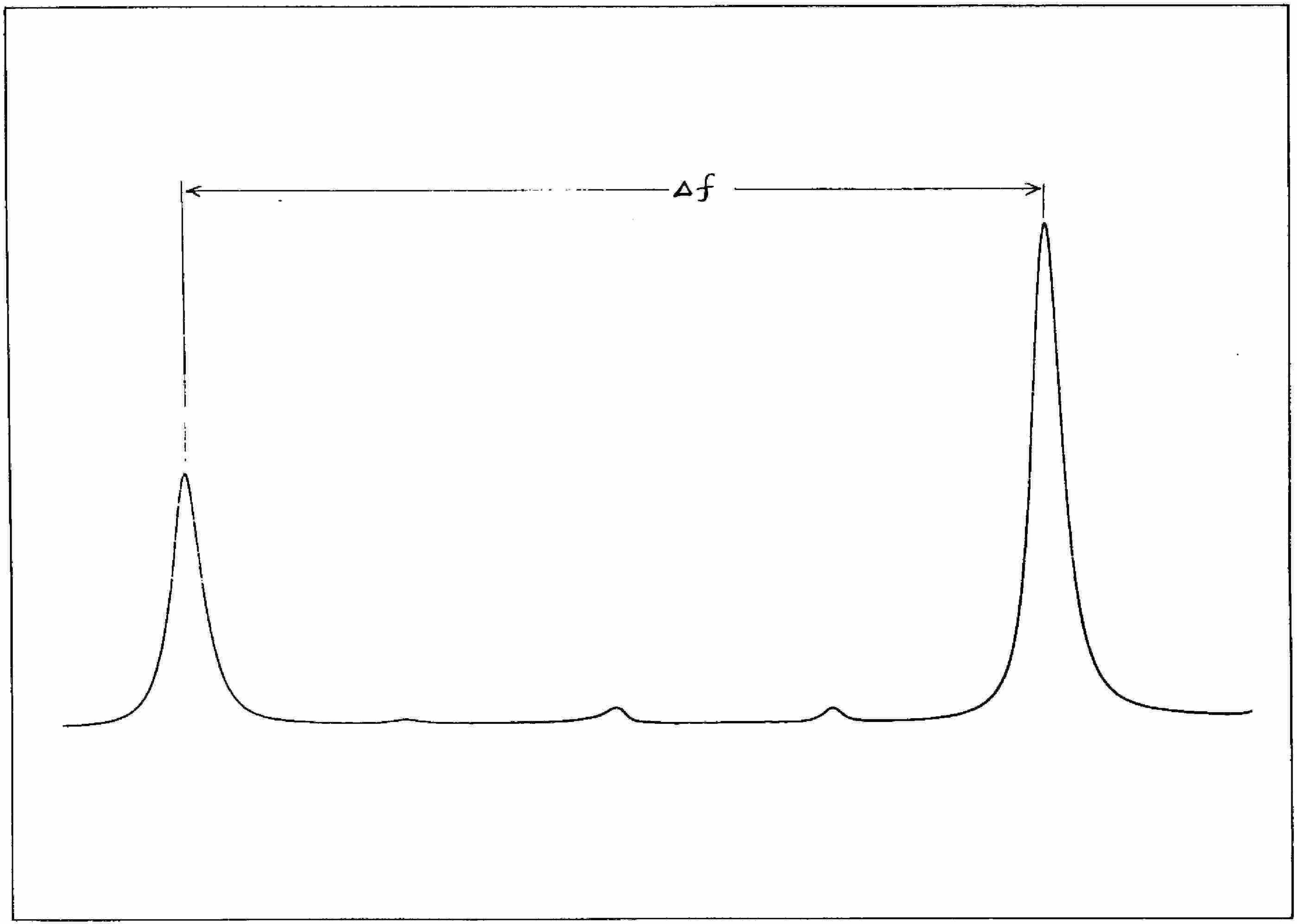

FIGURE 1-46. HIGH TEMPERATURE SAMPLE

l. If the conditions at +120°C and +60°C are not met, perform the calibration procedures for VT in a later section of this Handbook.

> NOTE
>
> It may be necessary to adjust the phase of the spectra with a change in temperature.

m. Turn the temperature Controller to +34°C and await stabilization before proceeding.

C. LOW TEMPERATURE TEST

1. Ensure all conditions and connections for Variable Temperature operation are made.

   a. Pneumatic connections are made per Figure 1-4 of Section 1.2.1.

   b. The VT plug P1010 is mated with J1010 in the console.

   c. The pressure cap thumbscrew is adjusted for spinner speed of 40 rps.

2. The Low Temperature Control range is from +10°C to -100°C but the low temperature sample, methanol, freezes and breaks the tube at -90°C. Do not approach -90° with the controller using this sample. If it is necessary to calibrate at -90 or below, use a thermometer or remote reading thermocouple.

Table 2
Methanol Shift vs Temperature (90 MHz)

Degrees Centigrade	Frequency Shift in Hz
+10	152.1
0	159.8
-10	167.4
-20	175.1
-30	182.7
-40	190.4
-50	198.0
-60	205.7
-70	213.3

Table 2 (continued)

Degrees Centigrade	Frequency Shift in Hz	
-80	221.0	
-90	228.6	SAMPLE FREEZES
-100	236.3	

3. Install the methanol sample with TMS into the probe (943346-33).

   a. Set the RANGE switch on the Temperature Controller to LOW.

   b. Set the gas pressure from the regulator to 1400 psi.

   c. Set the Temperature Controller TEMPERATURE SET to +10°C.

   d. Turn the POWER SWITCH ON.

   e. Adjust the thumbscrew on the pressure cap until the sample begins to spin. Spinner speed is set to 40 rps.

   f. Run a trace of methanol and position the spectrometer controls to place TMS, the right hand peak, on chart zero as shown in Figure 1-47.

   g. Lock to TMS and turn on the AUTOSHIM.

   h. Turn the Temperature Controller to -35°C and observe that

      1) Only the TEMPERATURE DECREASING Lamp comes on.

      2) The separation of the reference peak in the spectra starts to increase.

   i. The temperature should stabilize in 7 to 10 minutes with the following states evident.

      1) Both INCREASING and DECREASING Lamps are ON.

      2) The spacing between the lines is 186.6 Hz ± 1.6 Hz.

   j. Turn the Temperature Controller to -65°C and observe that

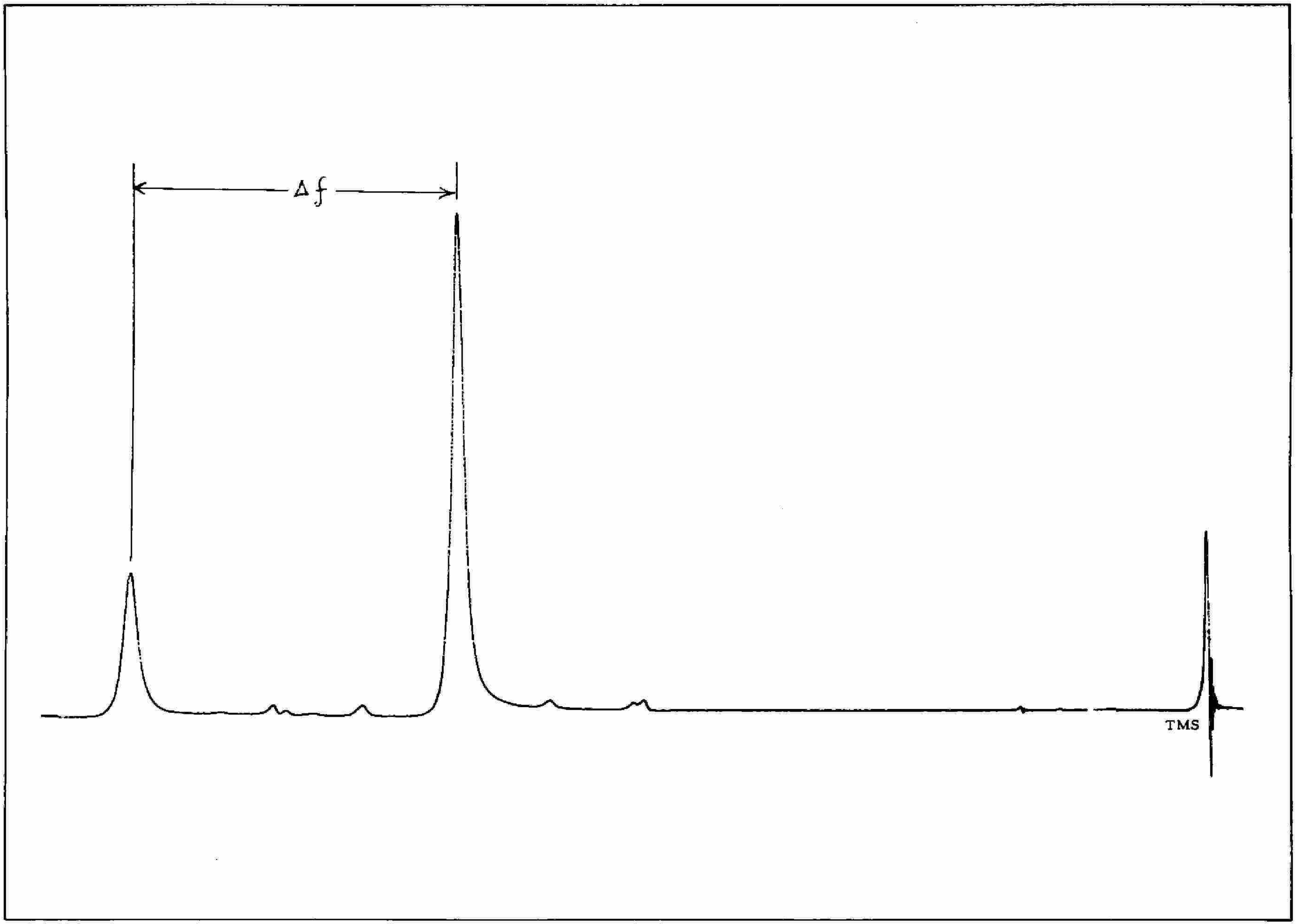

FIGURE 1-47. LOW TEMPERATURE

1) Only the TEMPERATURE DECREASING lamp comes ON.

2) The separation of the peaks starts to increase.

k. The temperature should stabilize in 10 to 15 minutes with the following states evident.

1) Both INCREASING and DECREASING lamps come ON.

2) The spacing between the reference lines is 209.5 Hz to the centers of the multiplets ± 1.6 Hz.

l. If the conditions at -35°C and -65°C are not met, perform the calibration procedures for VT in the Variable Temperature section of this Handbook.

> NOTE
>
> It may be necessary to adjust the PHASE of the spectra with a change in temperature.

m. Turn the Temperature Controller to +34°C and await stabilization.

n. Turn the gas flow OFF.

o. Turn the Temperature Controller OFF.

p. Leave the pressure cap on the probe stack until the pressure on the gas line from the bottle is zero.

1.3.4 OSCILLOSCOPE TEST

A. PRELIMINARY SET UP

1. Preset all controls prior to operation with the EM-390.

BRIGHTNESS	Fully clockwise. The AC power is turned on but the scope will require about a minute to warm up. After the trace is visible, reduce brightness to a desirable level.

FOCUS	Adjust for sharpest trace
X GAIN	Fully clockwise
X SHIFT	MID RANGE
Y SHIFT	MID RANGE
VOLTS/CM	0.5
STABILITY	Fully clockwise
TRIG LEVEL	Fully counterclockwise (AUTO)
DC/AC (Slide Switch)	DC
NORMAL/TV FIELD (Slide Switch)	NORMAL
TIME/CM	100 milliseconds
VARIABLE	Fully clockwise
TRIG	+

2. Adjust X-GAIN and X-SHIFT so that the trace is 10 cm in length and centered horizontally on the screen.

3. Adjust the Y-SHIFT to vertically center the trace on the screen.

B. DISPLAY OF SPECTRUM

In order to display a spectrum or a portion of a spectrum on the oscilloscope:

1. Operate the EM-390 in the NORMAL Mode using the TMS-$CHCl_3$ sample 943346-07.

   a. Select 10 PPM SWEEP WIDTH.

   b. Place TMS at chart zero in the unlocked mode.

c. Record the spectrum setting RF and GAIN parameters for normal display.

2. Depress the OSCILLOSCOPE Mode Switch.

a. The recorder display should be presented on the oscilloscope screen.

b. The 10 cm display corresponds roughly to the 10 PPM spectral range.

c. The TMS peak is at the right edge of the screen and the $CHCl_3$ peak is 7.3 centimeters to the left.

d. Adjust the scope Y-SHIFT control to position the display about 2 centimeters from the bottom of the screen.

e. Switch the recorder OFF.

f. Adjust the SWEEP ZERO control to center the display on the oscilloscope.

Since the slowest scope sweep rate is about 3 times faster than the fastest recorder sweep rate, spectrum peaks will have a much larger ringing pattern than normally seen on the recorder.

If the above conditions are not met, go to the Accessory Panel PCB section and perform the calibrations enumerated there.

1.3.5 TIME AVERAGING COMPUTER TEST

A. PRELIMINARY

Interfacing the ORTEC-547 with the EM-390 is accomplished by connecting the 547 interface cable to the Burndy connector on the rear panel of the EM-390 labeled TAC. The oscilloscope cables for X and Y input are connected as labeled.

B. OPERATION

The ORTEC-547 may be operated in either the TRIG or RECUR mode with the EM-390. The following are examples of data accumulations in each of these modes using 1 percent ethylbenzene with 1 percent TMS. Calibration of the ORTEC-547 is discussed in the ORTEC-547 Handbook.

> **NOTE**
>
> It is possible to accumulate data in the RECUR or TRIGGER MODES when the EM-390 is internally locked. However, it is impossible to trigger on the same peak to which the spectrometer is locked.

1. RECUR Mode

Adjust the ORTEC-540 controls as follows:

POWER	ON
FIELD OFFSET	N/A
FIELD POS/NEG	N/A
INPUT NMR TRIGGER LEVEL	N/A
INPUT MODE	NMR RECUR
INPUT ADD/SUBTRACT	ADD
AUTO STOP SCANS	2
CONTROL	STOP
SWEEP WIDTH	900 Hz
SWEEP TIME	120 SEC x 1
DISPLAY AMPLITUDE	1
DISPLAY RANGE	2^9
DISPLAY MODE	CRO
DISPLAY BASELINE	CENTER POSITION
DISPLAY VIEW	MEMORY

OSCILLOSCOPE VOLTS/CM	0.1
OSCILLOSCOPE TIME/CM	EXT.

See the Oscilloscope section for the oscilloscope operation details.

Accomplish the following:

a. Change CONTROL to CRT and press ERASE to clear the memory.

b. Balance DISPLAY output by adjusting BASELINE POSITION while changing RANGE and AMPLITUDE controls through their extremes until the line on the oscilloscope is centered at mid-range and does not change position when AMPLITUDE or RANGE is changed.

   This assumes that the oscilloscope has likewise been independently zeroed at mid-range prior to the above operation.

c. Adjust COARSE and FINE OFFSET to place TMS to zero. Run a 10 PPM spectrum of ethylbenzene on the EM-390 using optimum conditions making certain that all sample peaks are on scale.

Adjust the controls of the EM-390 as follows:

Select TAC	Depress TAC button
END OF SWEEP	Add +10 PPM (1 SWEEP WIDTH)

> NOTE
>
> When the TAC button is depressed the END OF SWEEP becomes the BEGINNING OF SWEEP. Also, the X-drive of the recorder no longer drives the field sweep thus movement of the recorder arm has no effect in this mode.

To accumulate data, accomplish the following on the ORTEC-547.

a. Depress STOP.

b. Depress RUN.

2. TRIG Mode

Adjust the ORTEC-547 controls as follows:

POWER	ON
FIELD OFFSET	890 Hz
FIELD POS/NEG	POS
INPUT NMR TRIGGER LEVEL	4
INPUT MODE	NMR SEARCH
INPUT ADD/SUBTRACT	ADD
AUTO STOP SCANS	2
CONTROL	STOP
SWEEP WIDTH	900 Hz
SWEEP TIME	120 Seconds x 1
DISPLAY AMPLITUDE	1
DISPLAY RANGE	2^9
DISPLAY MODE	CRO
DISPLAY BASELINE	CENTER POSITION
DISPLAY VIEW	MEMORY
OSCILLOSCOPE VOLTS/CM	0.1
OSCILLOSCOPE TIME/CM	EXT

Accomplish the following:

a. Change CONTROL to CRT and press ERASE to clear the memory.

b. Balance DISPLAY output by adjusting BASELINE POSITION while changing RANGE and AMPLITUDE controls through their extremes until the line on the oscilloscope is centered at mid-range and does not change position when AMPLITUDE or RANGE is changed.

   This assumes that the oscilloscope has been likewise independently zeroed at mid-range prior to the above operation.

c. Adjust COARSE and FINE OFFSET to place TMS to zero. Run a 10 PPM spectrum of ethylbenzene on the EM-390 using optimum conditions making certain that all sample peaks are on scale.

Adjust the controls of the EM-390 as follows.

Select TAC	Depress TAC button
END OF SWEEP	Add +10 PPM (1 SWEEP WIDTH)

NOTE

When the TAC button is depressed the END OF SWEEP becomes the BEGINNING OF SWEEP. Also, the X-drive of the recorder no longer drives the field sweep thus movement of the recorder arm has no effect in this mode.

Do not lock on TMS!

To accumulate data, accomplish the following:

a. Press STOP.

b. Press RUN and observe that the SEARCH light comes ON.

c. When the TMS signal is swept through, note whether the TRIG light is activated.

d. If the TRIG light is not activated, increase the SPECTRUM AMPLITUDE FINE control on the EM-390 until this occurs.

e. Switch to TRIG Mode.

After two scans, the 547 will automatically stop data accumulation.

3. Display of Accumulated Data

The accumulated data may be displayed on either the scope or EM-390 recorder.

a. This is accomplished by

1) Pressing CRT after scan has stopped.

2) Selecting DISPLAY VIEW Mode as MEMORY.

The spectral display may be adjusted on the oscilloscope using the RANGE and AMPLITUDE controls of the ORTEC-547.

b. EM-390 Recorder Readout

Perform the following:

1) Adjust the amplitude of the oscilloscope displayed spectrum such that the largest signal is 0.8 to 1 volt using the AMPLITUDE and RANGE controls.

2) Adjust the EM-390 SPECTRUM AMPLITUDE FINE control to 10.

3) Depress EXT on the EM-390 Recorder.

4) Select 547 CONTROL as STOP.

5) Select 547 DISPLAY MODE as PEN.

6) Move the EM-390 pen to the 10 PPM position on the chart.

7) Select 5 Minute Scan (300 Second) on both the 547 and EM-390 SWEEP TIME.

8) Simultaneously depress CRT on the 547 and FORWARD SCAN on the EM-390 to record the accumulated spectrum.

4. Integration

To integrate and record the accumulated data on the EM-390 accomplish the following:

a. Set up the 547 controls.

CONTROL	STOP
DISPLAY MODE	INTEG
DISPLAY AMPLITUDE	1
RANGE	2^9
SWEEP TIME	30 Seconds x 1

All other controls as before.

b. Set up the EM-390 controls:

RECORDER MODE	EXT.
SWEEP TIME	0.5 Minute
SPECTRUM AMPLITUDE	10

c. Depress CRT and null integrator drift using INTEG BALANCE and INTEG RESET while scanning.

d. Simultaneously depress CRT on the 547 and FORWARD SCAN on the EM-390 to record the integral.

> NOTE
>
> To increase integral amplitude, increase AMPLITUDE switch. If it is impossible to balance INTEG BALANCE after increasing AMPLITUDE proceed as follows.

1) Display accumulated spectra on oscilloscope.

2) Adjust spectra to mid-range on oscilloscope with BASE POSITION with AMPLITUDE at 1.

3) Change AMPLITUDE to 8.

4) Use baseline ROLL and INPUT ADD/SUB to either add or subtract memory until spectrum baseline is at mid-range on oscilloscope.

5) Now, repeat integration procedure and INTEG BALANCE should null.

NOTE

When many spectra are accumulated, it will usually be necessary to use the RANGE switch in addition to the AMPLITUDE switch to both center the spectra on the scope and also to null INTEG BALANCE in the integration mode.

1.3.6 FLUORINE-19 SENSITIVITY TEST

The Fluorine sensitivity requirements are defined using the 0.75 percent solution of 1,2-dibromo-1, 1-difluoroethane sample (943346-32). The sensitivity shall be a minimum of 35 to 1 on the out lines of the multiplet.

Use the following parameters.

SPINNER SPEED	40 rps
RF POWER	0.15 mG
FILTER	0.5 Second
SWEEP WIDTH	2 PPM
SWEEP TIME	5 Seconds
SPECTRUM AMPLITUDE	30,000

Print out the multiplet and determine signal-to-noise as shown in Figure 1-48.

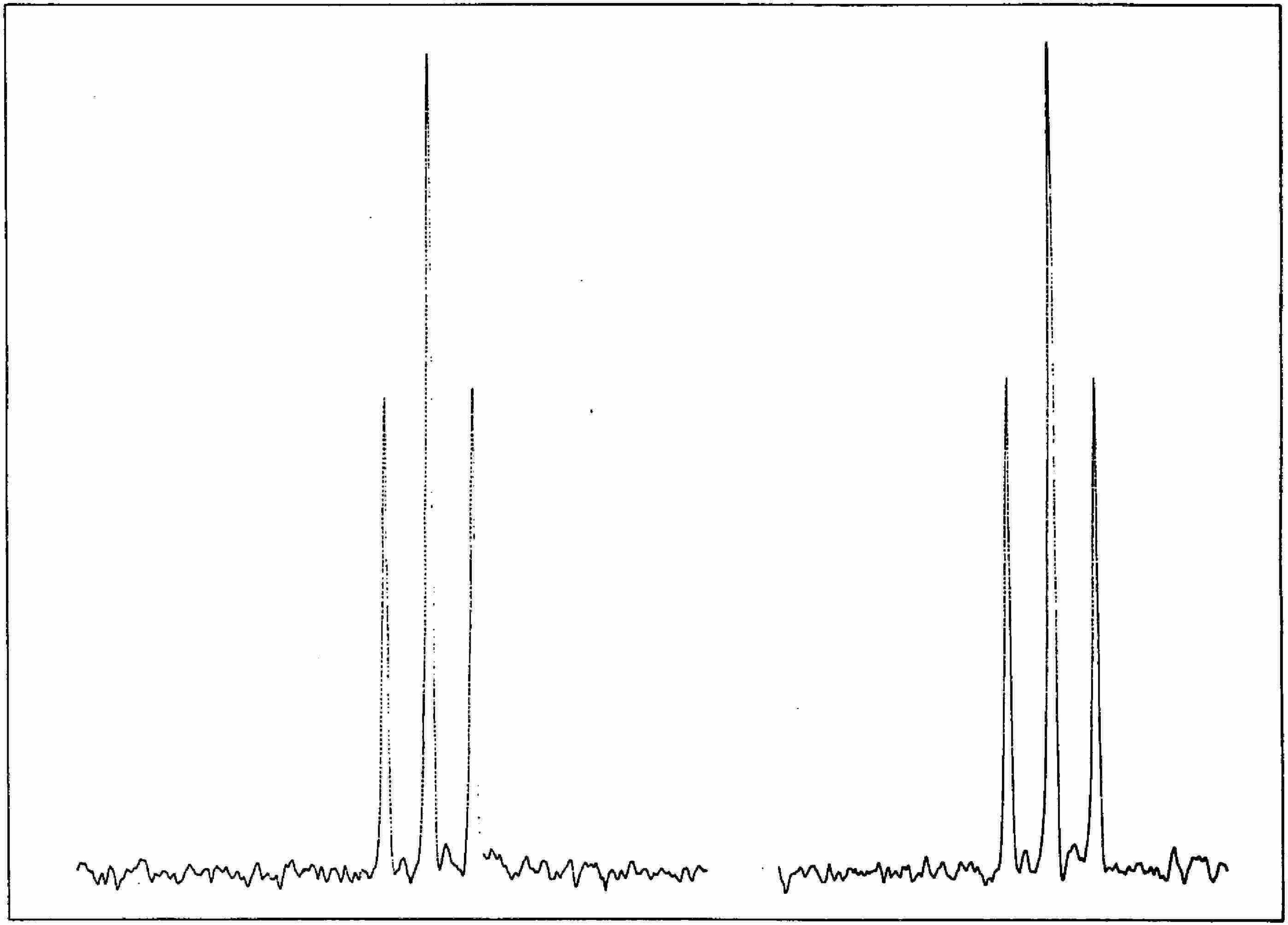

FIGURE 1–48. FLUORINE-19 SENSITIVITY

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EM-390 TRAINING NOTES

SECTION 2.0
MAGNET TEMPERATURE CONTROL

2.1 FUNCTION

The magnet temperature controller PC board has the control circuitry and amplification to regulate two separate ovens. One is used to control the magnet oven temperature and the other is for a possible future application. The circuits are electrically isolated with the exceptions of a common IC containing four amplifiers.

The sensing elements, heaters, and high power pass-transistor for the heater are mounted elsewhere but will be discussed as part of the circuit. The circuit is normally powered from the system but can be powered from an auxiliary battery supply (not furnished).

2.2 THEORY OF OPERATION

1. INPUT CIRCUITS AND CONTROL

The testpoints 1 through 4 shown in Figure 2-1 are convenience test points only. The Alnico Temperature Sensor of the magnet is connected to TP1 and TP2. The Yoke Temperature Sensor of the magnet is connected to TP3 and TP4. The desired values for Temperature versus Resistance of these thermistor sensors are included in Table 2-1. The proper operating point 34°C produces a resistance of 2000 ohms.

There are six thermistors wired in series — parallel on the oven surface which form the input to the Magnet Temperature Control PCB. The sensors are part of an input bridge circuit consisting of the sensor resistance, R1, R2, and R5. The bridge is balanced at 34°C (nominal resistance 1334 ohms, actual balance point from 1290 to 1370 ohms). The values of temperature vs resistance are given in Table 2-2.

IC U1D (pins 12, 13, and 14 of U1) is the amplifier for the error signal on the input. The amount of current flow in the magnet is proportional to the degree of imbalance of the input. IC U1D drives Q1 when its output is positive causing current to flow to produce heat in the oven. Negative outputs are limited at +1.8 volts minimum by the series

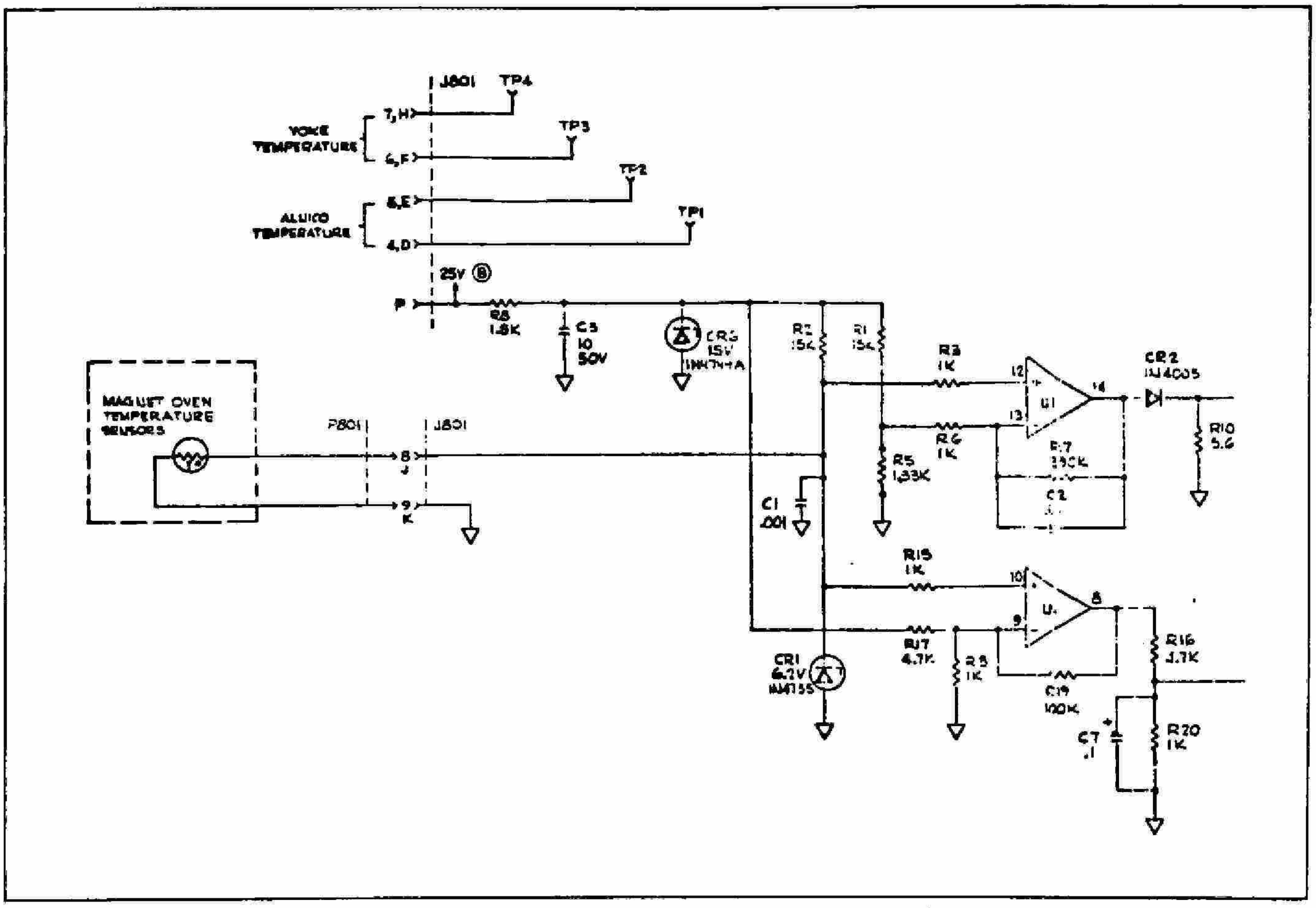

FIGURE 2-1. INPUT CIRCUITS

TABLE 2-1

Temperature vs Resistance Characteristics — Alnico and Yoke Thermistors

Temperature (°C)	Resistance (Ohms)
19	3930
21	3592
23	3282
25	3000
27	2742
29	2506
31	2290
33	2093
34	2000
35	1912
37	1748

limiting diode CR2 and the required base-emitter potentials of Q1 amplifier-driver and Q203 pass-gate.

TABLE 2-2

Temperature vs Resistance Characteristic — Magnet Sensors

Temperature (°C)	Resistance (Ohms)
24	2092
25	2000
26	1912
27	1828
28	1747
29	1670
30	1597
31	1527
32	1460
33	1395
34	1334
35	1275
36	1219
37	1166
38	1114

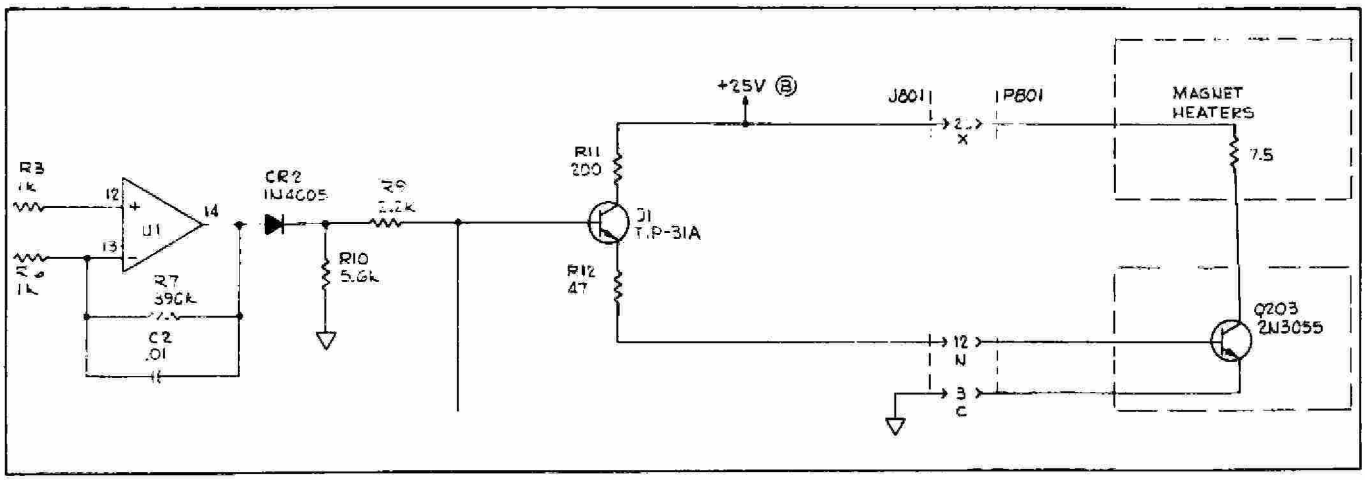

FIGURE 2-2. CONTROL CIRCUITS

A positive output of IC U1D causes Q1 to conduct which in turn causes Q203 to conduct. The higher the positive input to Q1, the higher the current in Q203. The current of Q203 is in series with the 7.5 ohm heater windings (33 sections) to +25 volt DC Magnet Supply.

2. SAFETY CIRCUITS

With the system operating normally and the input circuits at or near balance, the voltage division of +15 volts at zener diode CR5 produces about 1.5 volts at the non-inverting input of U1C. The inverting input of IC U1C has about +2.8 volts fixed potential from the +15 volts produced by CR5 through voltage divider R17 and R18. The output of U1C is then negative keeping Q2 shut-off which allows Q1 to operate.

If the input sensors however were opened by electrical failure or opening of the connecting cable, the voltage on the non-inverting input pin 10 of IC U1C would go more positive than the bias on U1C pin 9. The voltage at pin 10 would be limited to +6.2 volts by zener diode CR1. In this case, U1C output goes positive turning on Q2 which grounds the base of Q1 which removes the current flow from the magnet heater elements.

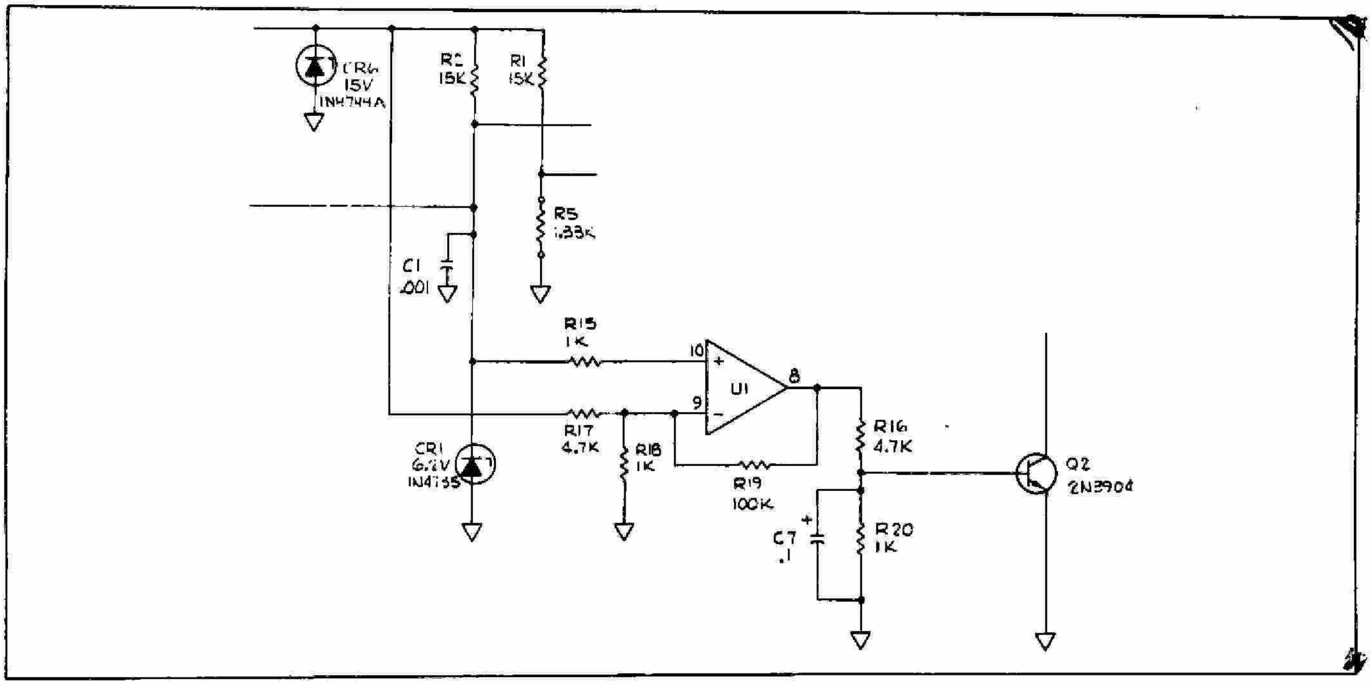

FIGURE 2-3. SAFETY CIRCUIT

2.3 CALIBRATION AND ADJUSTMENTS

No tests or adjustments are possible with this circuit except to observe the system for normal operation.

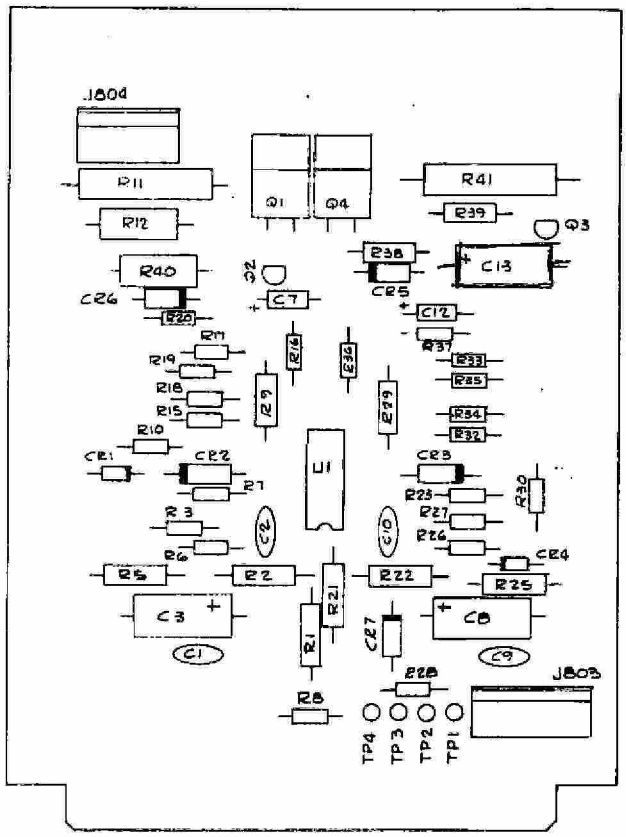

FIGURE 2-4. COMPONENT LAYOUT

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SECTION 3.0
CONSOLE POWER SUPPLY

3.1 FUNCTION

This assembly receives 115 Volts AC from the input power transformer and translates this to DC Power for all components in the EM-390 System.

These DC outputs are:

1. ±24 Volt Unregulated System Supply
2. ±15 Volt Regulated System Supply
3. ±24 Volt Unregulated Recorder Supply
4. +24 Volt Unregulated Magnet Heater Supply
5. +10.5 Volt Regulated Variable Temperature and digital circuitry supply.

3.2 THEORY OF OPERATION

1. POWER INPUT CIRCUITS – AC DISTRIBUTION

The input AC may be of 115 volts AC, 208 volts AC, or 230 volts AC. The diagram in Figure 3-1 shows the circuits configured for 115 volts AC.

P201 is the input power cord to an indicating lamp-switch S201. When S201 is depressed, power is applied through F1 and F2 (3 ampere for 115V, 1.5 ampere for 208/230V) to pins 2 and 7 of the transformer. Power is applied immediately to B201, the platen fan. For 115 volt input there is a jumper from pin 3 to pin 4 and from pin 8 to pin 10.

The transformer connections for 208 volt operation are made to pins 2 and 9. A jumper is installed from pins 4 to 8.

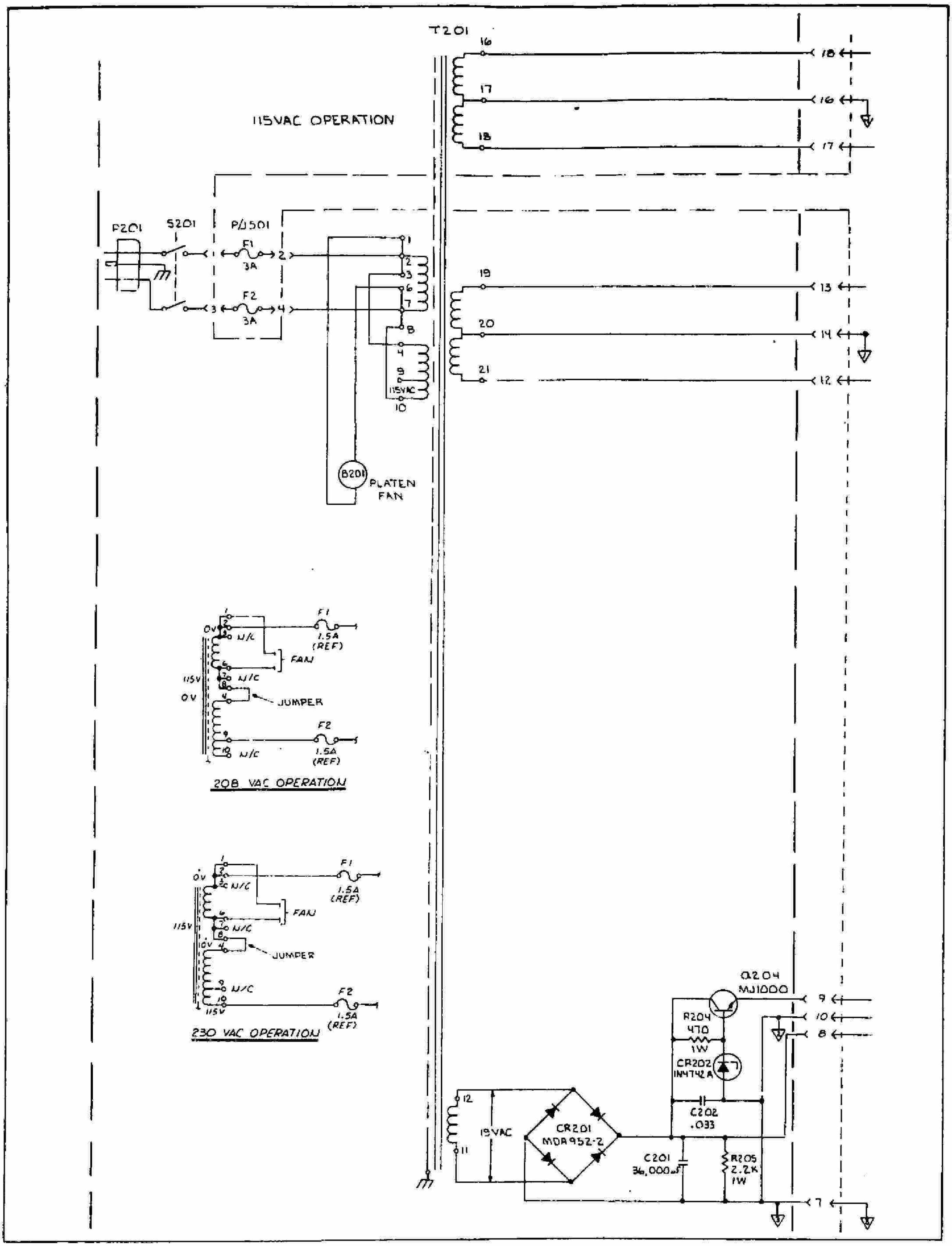

FIGURE 3-1. AC DISTRIBUTION

The transformer connections for 230 volt operation are made to pins 2 and 10. A jumper is installed from pins 4 to 8.

Secondary 1, pins 16, 17, and 18, produces 19-0-19 volts rms to the ±24 volt Unregulated Supply for the recorder.

Secondary 2, pins 19, 20, and 21, produces 19-0-19 volts rms to the ±24 volt Unregulated Supply for the system. The ±15 volt Regulated Supply for the system is evolved from this ±24 volts DC.

Secondary 3, pins 11 and 12, produces 19 volts rms to a full-wave bridge rectifier CR201 which produces +24 volts Unregulated to the magnet temperature control circuits and to an 11 volt regulator circuit. This circuit is Q204 referenced by CR202, a 12 volt zener diode. The series regulator Q204 applies about 11 volts to the digital circuit voltage regulators and to the Variable Temperature Controller.

2. RECORDER SUPPLY

The 38 volts AC center-tapped (19-0-19) is applied to a full-wave bridge rectifier consisting of CR1, CR2, CR3, and CR4. The positive output of the bridge is filtered by C1 with bleeder R1 which produces +24 volts ± 1.5 volts at TP1 (TP1 to TP3) with a ripple of 1.8 volts peak-to-peak. The negative output of the bridge is filtered by C2 with bleeder R2 which produces -24 volts ± 1.5 volts at TP2 (TP2 to TP3) with a ripple of 1.8 volts peak-to-peak.

These voltages are applied to the Normally Open (NO) contacts of K1 which is energized by turning the recorder on. When energized, the ±24 VDC unregulated is applied to the recorder circuits.

A third section of the relay (pins 4, 8, and 12) is available although not currently used. This relay was initially used to operate the recorder fan only when the recorder was on but the loss in cooling during the recorder-off periods adversely affected the system stability. The fan is now in the circuit all the time and these contacts are available for other uses if desired.

3. SYSTEM SUPPLIES

The 38 volts AC center-tapped (19-0-19) is applied to a full-wave bridge rectifier consisting of CR6, CR7, CR8, and CR9. The positive output of the bridge is filtered by C3 with bleeder R3 which produces +24 volts ± 1.5 volts with a typical ripple of 2.0 volts peak-to-peak to be used as the System Unregulated +24 volts. The negative output of the bridge