SIGMA/1500
DIGITAL ADF
MAINTENANCE MANUAL

CONTENTS

(Note: All Figures are printed on white within their appropriate sections.)

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4141 Kingman Dr.
Indianapolis, Indiana 46226
(Area 317-546-1111)

Price: Single Copy $20.00

SECTION I
GENERAL INFORMATION

1-1. Introduction

This service manual contains all of the information normally required to install, operate, and maintain the Genave SIGMA/1500 Digital ADF.

1-2. Description

The SIGMA/1500 is a self-contained, digitally-tuned, automatic direction finding receiver complete with integral regulated power supply and remote mounting indicator. It is a completely solid state design utilizing 67 active silicon transistors and 11 silicon integrated circuits. The SIGMA/1500 features automatic out-of-range warning, inflight lock-on test, beat frequency oscillator, and automatic electronic band switching.

The receiver frequencies from 200 KHz to 1.699 MHz in 1 KHz steps are selected on the front panel, digital frequency selectors. The digital frequency selectors preswitch the receiver band selection circuits and send control signals to the crystal stabilized, phase-locked-loop, frequency synthesizer. The selected receive frequency appears in the digital frequency readout windows above the frequency selectors. These readouts are designed to provide maximum reading ease through the use of magnifying lenses and airline-style "lunar-white" backlighting.

The receiver is a single conversion superheterodyne type utilizing a 141.5 KHz intermediate frequency. The frequency synthesizer is a state-of-the-art computer circuitry design which provides exact frequency control on any of the 1,499 receiver channels. The receiver provides a maximum of 20 milliwatts of high quality audio output which is sufficient to drive an audio amplifier or headphones.

The indicator features airline-style "lunar-white" backlighting, a rotatable azimuth, a well defined directional pointer, and unique 45° localizer intercept markers.

The receiver's internal regulated power supply makes possible the low power-drain operation of the entire SIGMA/1500 system. It is designed to meet or exceed the minimum operational characteristics for ADF receivers as outlined in RTCA Paper DO-137.

1-3. Specifications

Number of Transistors:	67, all silicon
Number of Diodes:	23
Number of Integrated Circuits:	11
Heading Card:	Rotatable
Lighting:	Internal—Lunar White
Size:	Receiver: 6.1″ × 2″ × 8.6″ Indicator: 3.3″ × 3.3″ × 4″
Weight:	Receiver: 3.5 lbs. Indicator: 1 lb. Loop: 1.5 lbs.
Loop Cable:	12 ft. standard
Power Required:	13.75 volts DC ADF function: 1.2 amps Receive mode: 1.1 amps (above current drains include .5 amp for internal back-lighting of receiver and indicator)

Meets or exceeds MOC DO-137

Frequency Range:	200 to 1699 kHz in 1 kHz steps
Modes of Operation:	OFF, ADF, REC, BFO
ADF Bearing Accuracy:	± 3° input @ 70 microvolts per meter
Image Rejection:	80 db @ 200 kHz, 400 kHz 70 db @ 800 kHz 55 db @ 1600 kHz
Receiver Selectivity:	2 kHz min. @ 6 db down 14 kHz max. @ 70 db down
Receiver Sensitivity:	ADF mode: not more than 100 microvolts per meter for 6 db $\frac{s+n}{n}$ Receiver mode: not more than 70 microvolts per meter for 6 db $\frac{s+n}{n}$
Audio Output:	20 milliwatts maximum across 600 ohm load. Frequency response within 10 db from 300 to 2000 Hz
Quadrantal Error Correction:	6° built-in
Sense Antenna Input:	Matches 220 Pf cable capacity and 50 Pf antenna He = .25 meter

1-4. Equipment Supplied

a. 1—SIGMA/1500 Digital ADF Receiver
b. 1—Receiver Mounting Tray with Hardware
c. 1—SIGMA/1500 Digital ADF Indicator with mounting hardware
d. 1—LAMBDA/1500 ADF Loop Antenna with mounting hardware
e. 1—Loop Antenna Cable, 12 foot, with connectors
f. 1—Sense Antenna Cable, 10.66 foot
g. 1—Sense Antenna Connector, Phono, Male

1-5. Equipment Required, But Not Supplied

a. Sense Antenna, Genave LAMBDA/50 Recommended

NOTE: See sense antenna and cable capacitance information contained in SIGMA/1500 Installation Manual.

b. Audio Isolation Amplifier (Genave TAU/80, 81, 100 or TAU/80A), Auxiliary Audio Input to other equipment, or Headphones
c. Power and Signal Cabling, As Required
d. 1—250 ohm, 5 watt, Dimmer Pot (Optional, for backlight dimming)

SECTION II

INSTALLATION MANUAL

The following Section

is reproduced

and included with every

SIGMA/1500

It is made a part of

this manual

for your permanent

reference

GENERAL AVIATION ELECTRONICS, INC.
4141 KINGMAN DRIVE, INDIANAPOLIS, INDIANA 46226

INSTALLATION MANUAL

SIGMA/1500 DIGITAL ADF

Please Note:

THIS UNIT MUST BE INSTALLED BY a properly certificated and authorized person in accordance with the Federal Aviation Regulations, Part 43. No responsibility for improper installation of this unit is either implied or assumed by the manufacturer. Units shown to be installed in violation of the FARs will not be covered by the warranty and will remove any and all responsibility from the manufacturer for such equipment.

GAE PART NO. 1090935

Warranty

Products bearing the trademark "GENAVE" or the trade name "GENERAL AVIATION ELECTRONICS, INC." have been fabricated by skillful technicians, under the strictest quality control conditions, using the finest materials and component parts available.

When properly adjusted and competently operated according to factory specifications and instructions, General Aviation Electronics, Inc. unconditionally guarantees and warrants all parts and bench service labor for one (1) full year from the date of the original installation of the unit.

This warranty shall not apply to malfunction, which in the opinion of General Aviation Electronics, Inc. is the result of abusive use, accident, willful destruction, improper or unauthorized repair or installation. All service under this warranty must be performed by an Authorized Genave Distributor, or by returning the unit or units, freight pre-paid, to the factory at Indianapolis, Indiana.

GENERAL AVIATION ELECTRONICS, INC.

By ______________________
Elmore W. Rice, III, President

The Company offers no other guarantees or warranties expressed or implied

Proper Installation Will Assure Quality

The unit you are installing is a high quality, rugged, complex piece of electronic equipment. It has been manufactured under rigid quality control and has been fully tested and operated at high temperatures to stabilize the component parts.

Proper installation of the unit into your customer's aircraft is essential to complete the quality assurance program under which the unit was manufactured.

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Specifications:

Number of Transistors:	67, all silicon
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Audio Output:	20 milliwatts maximum across 600 ohm load. Frequency response within 10 db from 300 to 2000 Hz
Quadrantal Error Correction:	6° built-in
Sense Antenna Input:	Matches 220 Pf cable capacity and 50 Pf antenna He = .25 meter

Unpacking

CAREFULLY REMOVE the unit and its mounting accessories from the shipping container by removing the staples from the top of the carton and lifting the contents straight out. The carton should be saved until the installation is complete in the event that damage is discovered or return of the unit is necessary for some reason. Any damage due to shipping should be reported and a claim filed as soon as possible with the shipping company. (If it is necessary to re-ship, use our container which is specifically designed for that purpose.)

Pre-Installation Check

VISUALLY INSPECT the unit for any obvious external damage, such as dents, loose wires, etc. Any damage not related to shipping should be reported to General Aviation Electronics, Inc., 4141 Kingman Drive, Indianapolis, Indiana (46226), Area Code 317-546-1111, as soon as possible.

Damage due to shipping should be reported to and a claim should be filed promptly with the transportation company.

All units are shipped in perfect operating condition. However, a pre-installation electrical test may be performed to assure that the unit has suffered no internal damage during shipment. For a detailed test procedure, refer to the Maintenance Section of the Service Manual. DO NOT ATTEMPT to bench test the unit without proper equipment as specified in the Service Manual.

Receiver Installation

PLANNING

THE LOCATION of the unit in the aircraft should be carefully selected with due consideration to the following:

1. A maximum amount of separation should be maintained between the SIGMA/1500 equipment and DME and ATC transponder equipment.
2. The unit generates only a very small amount of heat and, as such, does not require any type of cooling. However, the unit must NOT be mounted directly above a vacuum tube device or any other equipments that generate a large amount of heat unless such equipments have cooling provisions installed to keep the heat generated therein from coming in contact with other equipments mounted in close proximity to them.

   MOUNTING THE UNIT DIRECTLY OVER UNCOOLED VACUUM TUBE EQUIPMENT OR IN THE HOT AIR BLAST OF ANY DEVICE, INCLUDING CABIN HEATERS, WILL AUTOMATICALLY VOID THE WARRANTY

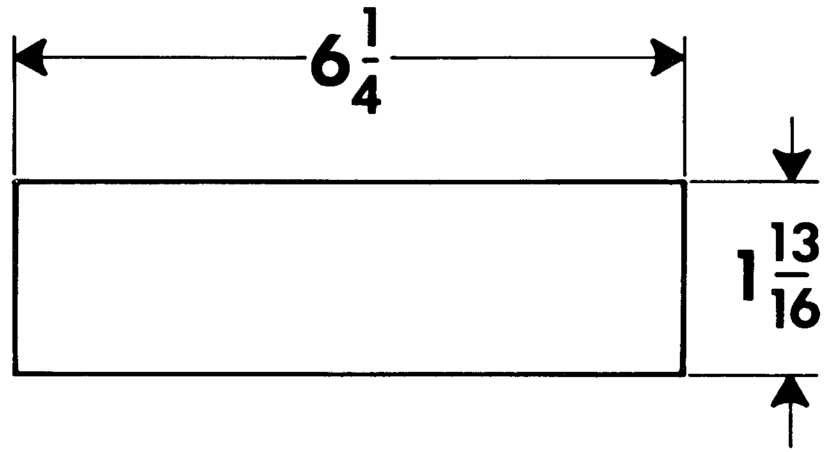
3. The placement of the unit should be such that all controls are easily accessible.

INSTALLATION STEPS

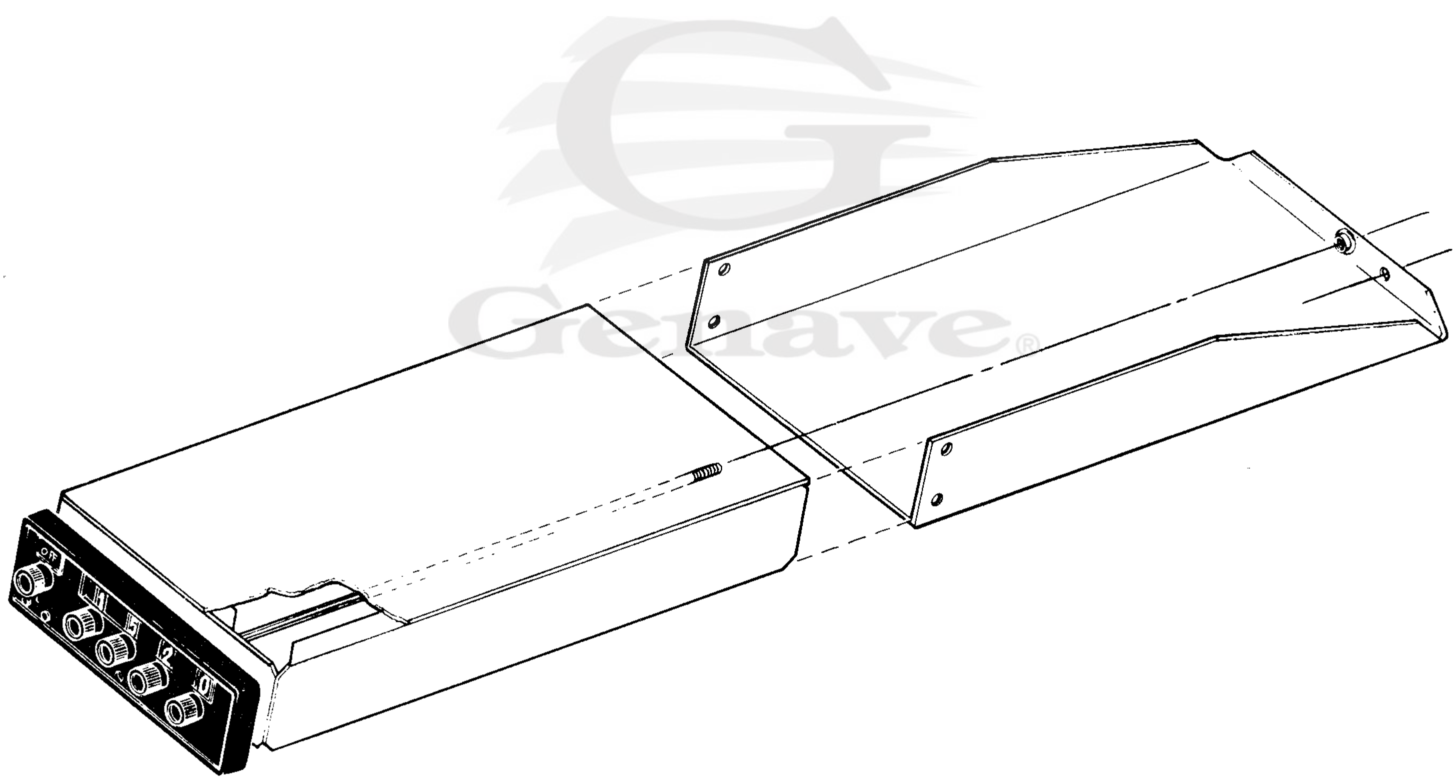
1. The aircraft panel cutout for the SIGMA/1500 is 6 1/4" wide x 1 13/16" high. Make this cutout in the selected location.
2. Insert the supplied mounting rack into the cutout. Mark the rack mounting holes on the panel support brackets on both sides of the cutout. If the location chosen does not provide the brackets, two angle brackets must be made and Installed. Drill out the marked mounting holes with a #27 drill.
3. Install the rack in the aircraft panel, using the holes drilled in step 2, the #6-32 Binder head screws, washers, and nuts supplied. All screws must have their heads inside the rack.
4. Fabricate the power and signal cable using the connector socket supplied. A wiring diagram is shown in this manual.
5. Connect the cable just fabricated to the appropriate points in the aircraft's electronic system. Do not route the cables close to cabling from DME or ATC transponder equipment. The unit will need to be removed from the panel later in the installation procedure, therefore secure the cables at the appropriate tie points but leave the cabling unsecured behind the aircraft's instrument panel. The excess cable behind the instrument panel will be secured later. (See Installation Planning, Step 4, under section headed "Loop Antenna Alignment" and Step 1 under section headed "Post Installation Checks".)
6. Insert the unit into the rack. Tighten the mounting bolt to secure the unit in the panel. Do not use excessive torque on the bolt. Tighten only until the unit is snugly secured against the front panel.

7. For optimum performance of the SIGMA/1500 Digital ADF system, it is recommended that interference filters be installed on the alternator or generator, gear motors, strobe lighting devices, flap motors, etc. of all aircraft not so equipped.

Panel Cutout



Mounting Rack



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Indicator Installation

PLANNING

THE LOCATION of the Unit in the aircraft should be carefully selected with due consideration to the following:

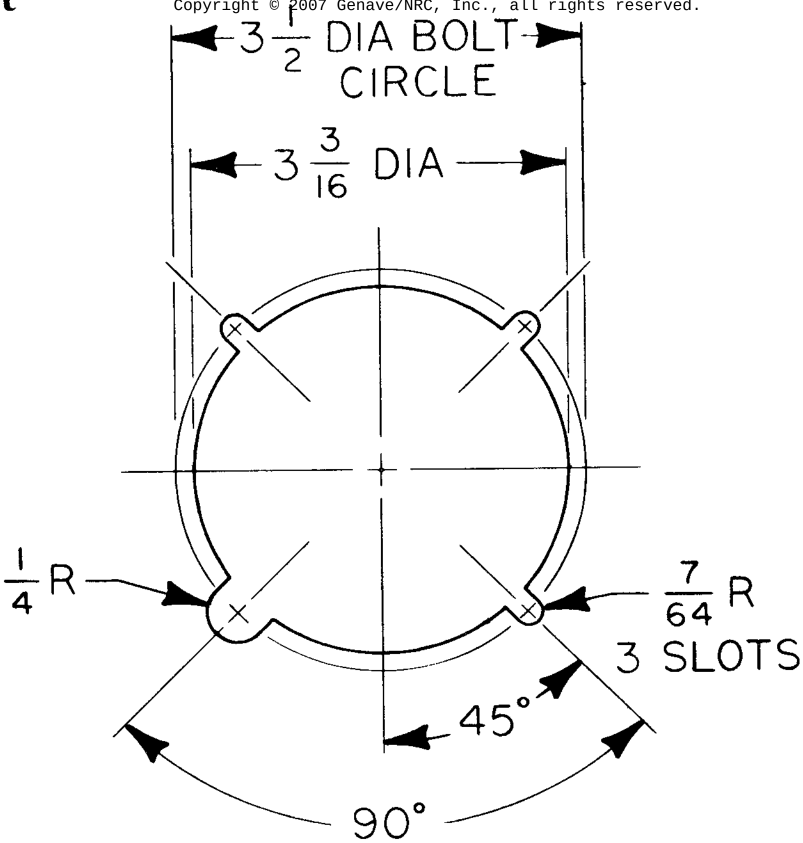
1. A maximum amount of separation should be maintained between the SIGMA/1500 equipment and DME and ATC transponder equipment.
2. The unit generates only a very small amount of heat and, as such, does not require any type of cooling. However, the unit must NOT be mounted directly above a vacuum tube device or any other equipments that generate a large amount of heat unless such equipments have cooling provisions installed to keep the heat generated therein from coming in contact with other equipments mounted in close proximity to them.

   MOUNTING THE UNIT DIRECTLY OVER UNCOOLED VACUUM TUBE EQUIPMENT OR IN THE HOT AIR BLAST OF ANY DEVICE, INCLUDING CABIN HEATERS, WILL AUTOMATICALLY VOID THE WARRANTY
3. The placement of the unit should be such that all controls are easily accessible and the entire face of the indicator is easily viewed.

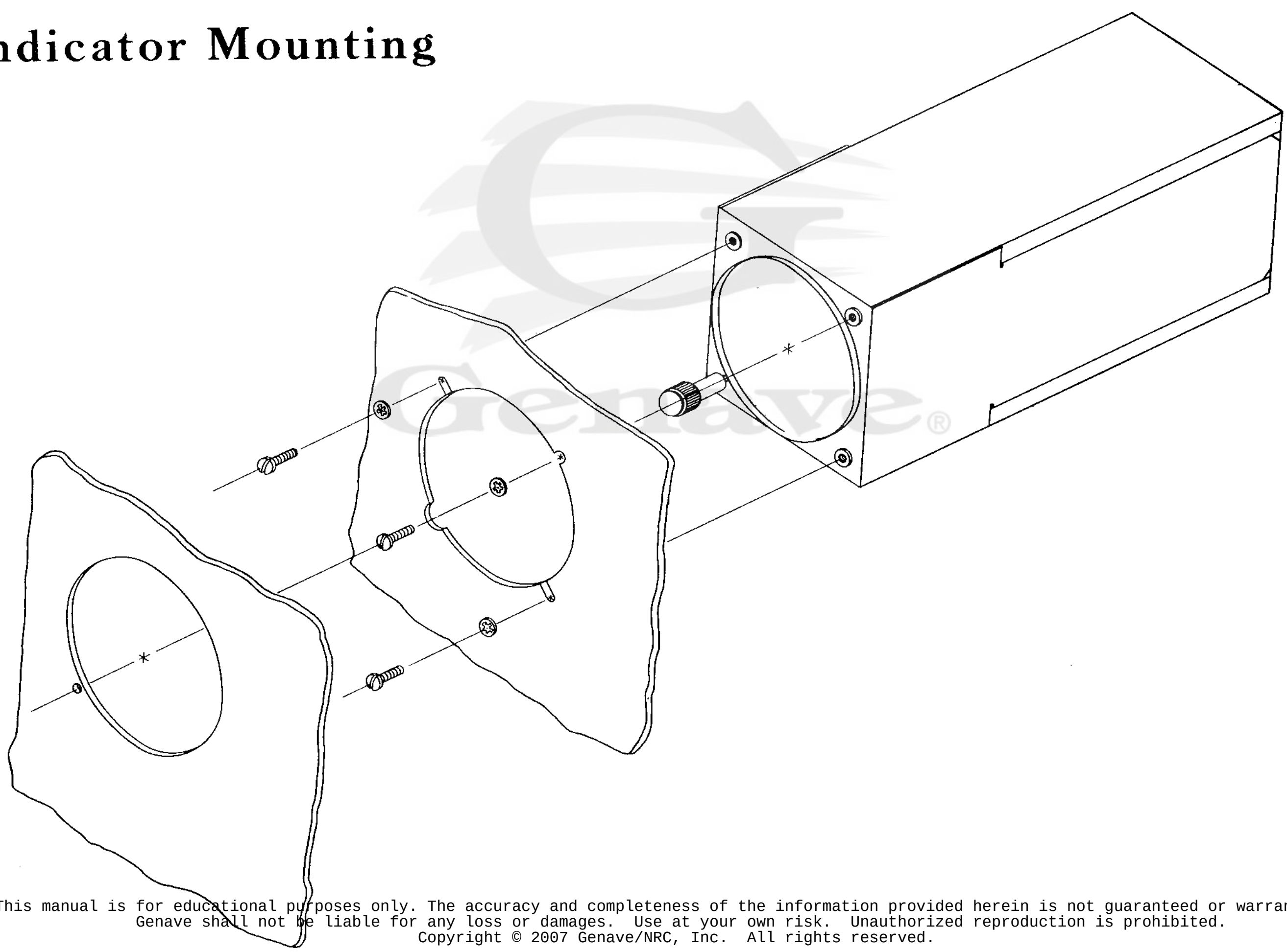
INSTALLATION STEPS

1. The aircraft panel cutout for the SIGMA/1500 Indicator is the standard round instrument hole shown in this manual.
2. Install the indicator in the aircraft panel, using #6-32 Binder head screws and lock-washers.
3. Connect the power cable to the SIGMA/1500 Receiver. Do not tie cables behind the instrument panel. These cables will be secured later. (See Installation Planning, Step 4, under section headed "Loop Antenna Alignment" and Step 1 under section headed "Post Installation Checks".)

Panel Cutout



Indicator Mounting



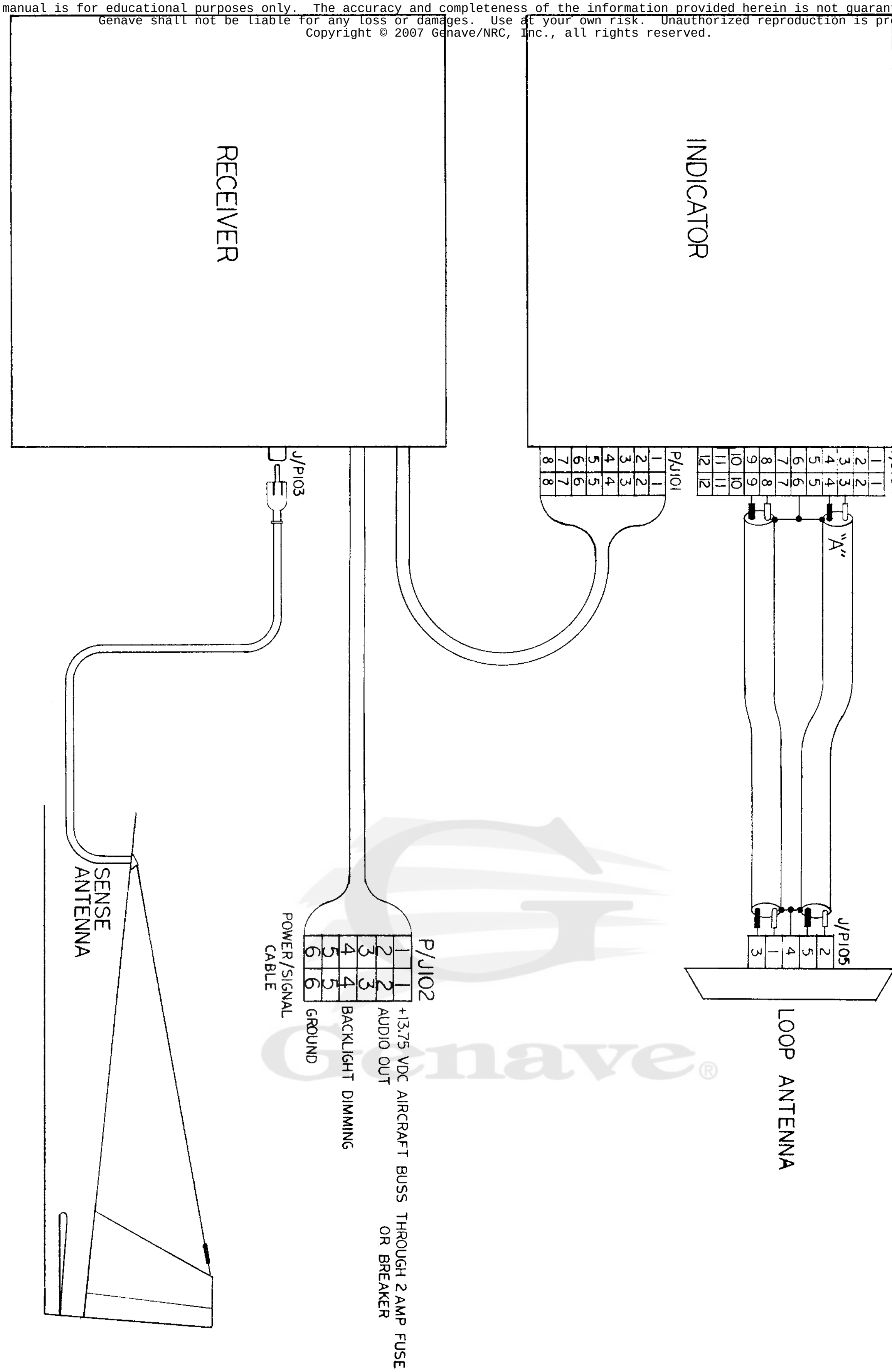


Figure 1
INTERWIRING DIAGRAM

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Antenna Installation

GENERAL

The performance of the SIGMA/1500 Digital ADF will depend largely upon the effectiveness of the antenna system. System accuracy depends upon the proper location of the sense and loop antennas. If accurate "over-the-station" performance is required, the following factors are important:

1. The two antennas must be mounted exactly on the fore-aft centerline of the aircraft, the loop antenna on the bottom and the sense antenna on the top. For configurations other than this the cabling from the loop antenna must be rewired (See Loop Antenna Installation).
2. If a whip type sense antenna is used, it must be located at least 3 feet from the propeller(s), and mounted in a location having sufficient structural strength to prevent damage due to vibration or ice loading.
3. The fixed loop should be parallel to the ground when the aircraft is in its normal flight attitude.

NOTE:

1. Do not route the sense and loop antenna cables with any cables from transmitters, especially DME and ATC transponders.
2. Avoid locating the sense and loop antennas near other antennas.
3. Use only the cables supplied and do not shorten any of them or the receiver alignment will be affected. The loop cable is 12 feet long which should be sufficient for most applications. (If longer cables are required, see cable information in the Maintenance Manual.)

SENSE ANTENNA

The SIGMA/1500 Digital ADF is designed to operate with a 270 pfd. sense antenna system. The antenna itself should exhibit 50 pfd. of capacity while the cable provides the remaining 220 pfd. of capacitance. The effective height of the antenna should be 0.25 meters. The Genave LAMBDA/50 ADF Sense Antenna is recommended.

The following chart and illustration should be used to plan the sense antenna installation. This chart lists the various values of shunt capacitance (Cs) necessary for various combinations of length and perpendicular height above the airframe to maintain the correct antenna capacitance and effective height.

LENGTH (inches)	HEIGHT (inches)	Ø (degrees)	C_S (pfd)
90	35	23.0	33.0
92	33	21.2	32.5
94	32	19.6	32.0
96	30	18.3	31.3
98	29	17.0	30.7
100	28	16.0	30.0
102	27	15.0	29.3
104	26	14.2	28.7
106	25	13.5	28.0
108	24	12.9	27.5
110	24	12.7	27.0
112	23	12.0	26.7
114	23	11.5	26.3
116	22	11.0	25.8
118	21	10.5	25.4
120	21	10.0	25.0
122	20	9.7	24.4
124	20	9.4	23.8
126	19	9.1	23.3
128	19	8.8	22.7
130	19	8.5	22.0
132	18	8.2	21.5
134	18	7.8	20.9
136	17	7.6	20.3
138	17	7.3	19.7
140	17	7.0	19.0
142	16	6.8	18.3
144	16	6.5	17.6
146	16	6.3	17.0
148	15	6.2	16.5
150	15	6.0	16.0
152	15	5.7	15.6
154	14	5.3	15.3
156	14	5.1	15.2
158	14	4.9	14.9
160	14	4.6	14.0

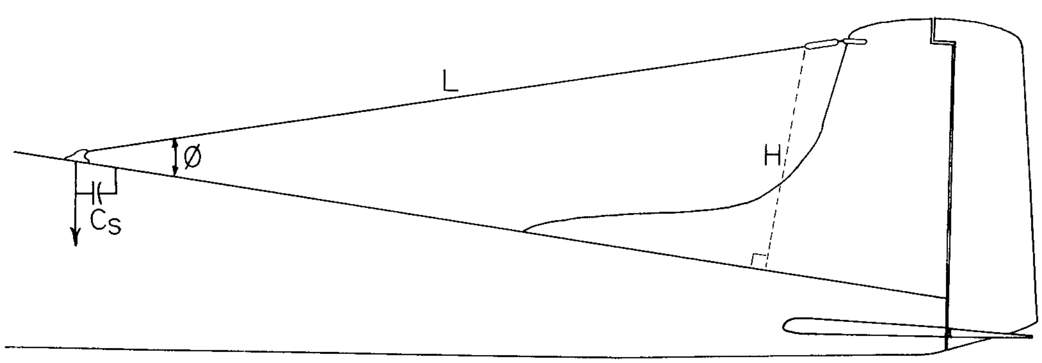


Figure 2

The coaxial sense antenna cable supplied with the SIGMA/1500 is cut to a critical length (10.5 feet) to provide 220 pfd. of capacitance and therefore the length of this cable should not be altered.

If it is absolutely impossible to utilize the length of cable supplied with the SIGMA/1500 it is possible to fabricate your own sense antenna cable using various coaxial cables, provided the length of the cable is cut to provide the necessary 220 pfd. of cable capacitance. The following chart provides the capacitance per foot for various common cables:

Cable Type	Description	Pfd/foot
RG 11 A/U	Stranded, Polyethylene	20.5
RG 58 A/U	Stranded, Polyethylene	30.5
RG 58 A/U	Stranded, Cellular Polyethylene	26.0
RG 59 B/U	Solid, Polyethylene	21.0
RG 62 B/U	Solid, Polyethylene	13.5
RG 63 B/U	Solid, Polyethylene	10.0
RG 114 A/U	Solid, Polyethylene	6.5
RG 179 B/U	Stranded, Teflon	19.5
RG 180 B/U	Stranded, Teflon	15.0
RG 187 A/U	Stranded, Teflon	19.5
RG 188 A/U	Stranded, Teflon	29.0
RG 195 A/U	Stranded, Teflon	15.0

A whip antenna may be used in installations where the wire antenna is impractical. If a whip antenna is used, a fixed capacitor is required in shunt with the antenna to make the total antenna capacitance 50 pfd. If the antenna capacitance is unknown, a capacitance bridge of Q-meter may be used to determine the antenna capacitance.

INSTALLING THE GENAVE LAMBDA/50
(Optional -- not supplied with the SIGMA/1500)

1. Using the stripping tool provided, strip the protective covering from one end of the antenna wire without nicking the wire. Insert antenna wire into tool as shown in figure 3. Place blade into slot and, rotating the cable, cut the insulation.

2. Insert stripped end into gripper on spring insulator assembly as shown in figure 4. Pull on antenna wire to insure that it is securely locked in gripper.

3. The length of antenna wire should now be determined and the remaining end of the antenna wire cut and stripped as instructed in step 1.

4. Drill the necessary holes and attach the fuselage mount as illustrated in figure 5.

5. Drill the appropriate holes for the stabilizer mounting bracket as illustrated on the drilling template of figure 6.

6. Insert remaining end of the antenna wire into the gripper of the fuselage mount. See figure 7.

7. Attach the spring insulator assembly to the stabilizer bracket as shown in figure 8.

8. Mount stabilizer bracket to vertical stabilizer stretching the antenna wire taut.

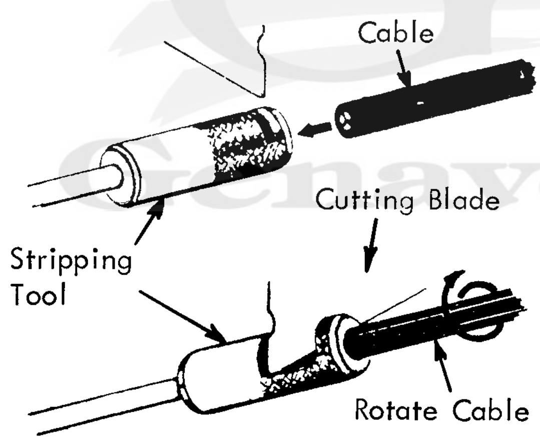


Figure 3

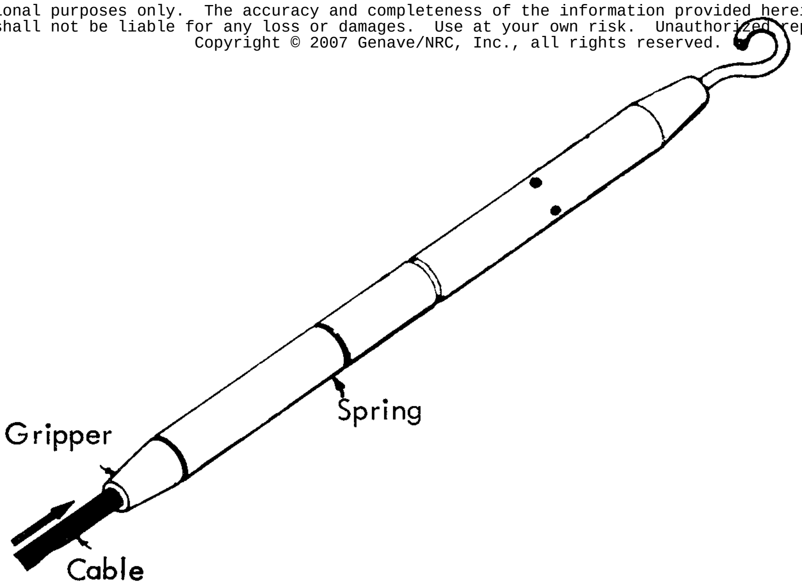


Figure 4

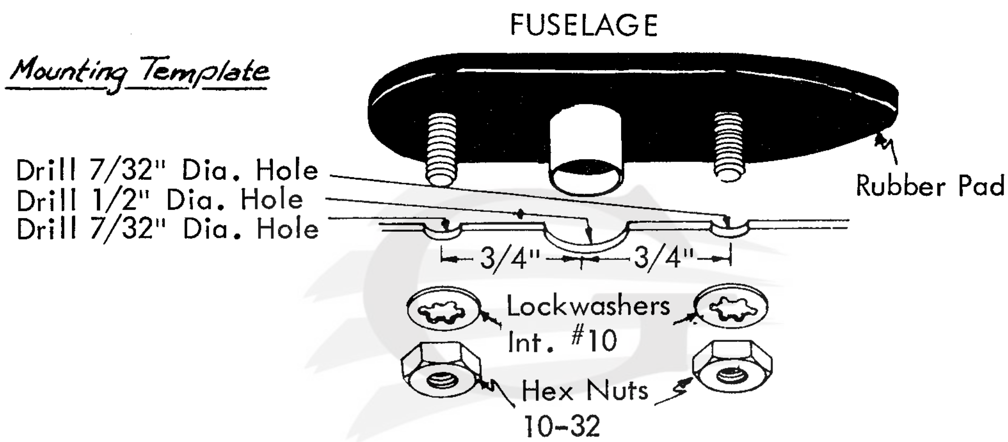


Figure 5

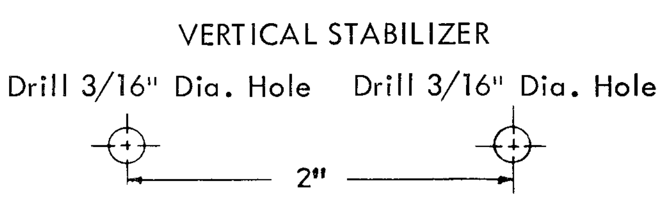


Figure 6

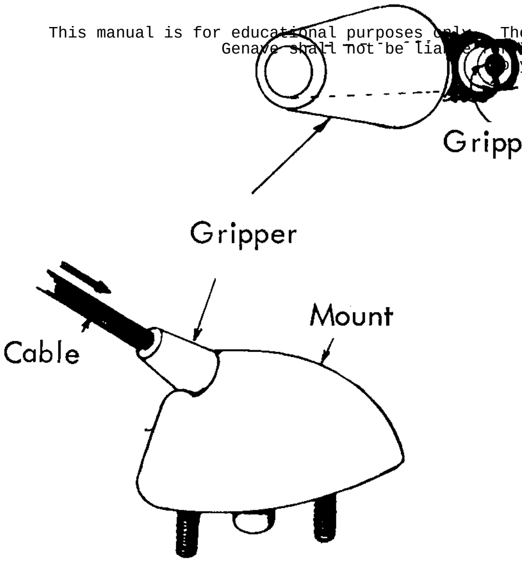


Figure 7

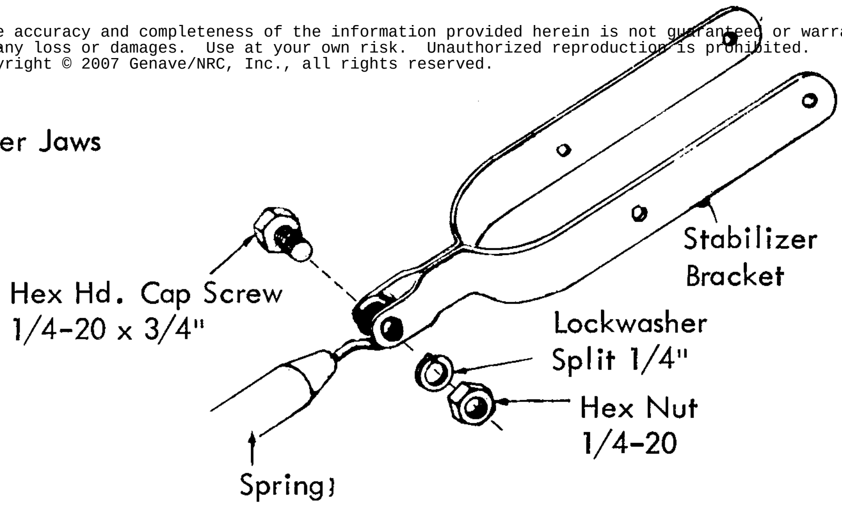
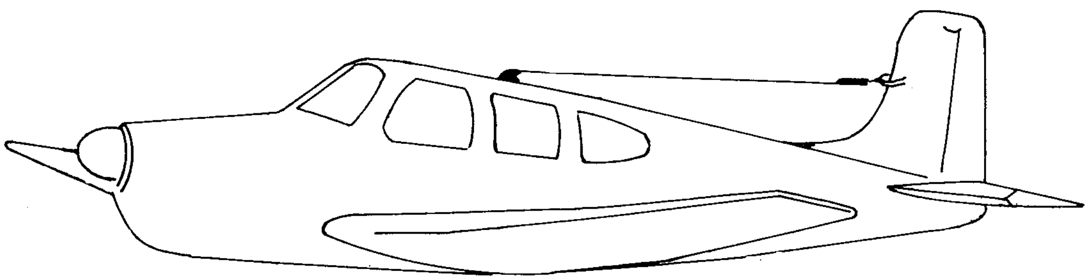


Figure 8



Should it ever become necessary to remove the antenna wire from the grippers proceed as follows:

1. Cut off antenna wire approximately 2" from gripper.
2. Strip insulation of stub (See figure 9).
3. Insert tool as shown and, pressing it down into the gripper, pull the wire out (See figure 10).

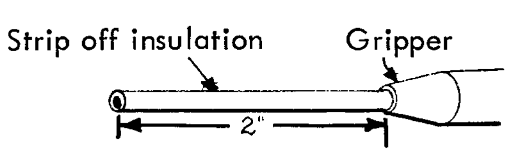


Figure 9

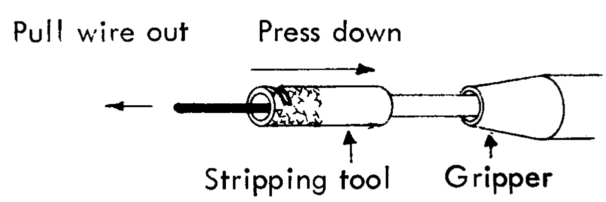


Figure 10

LAMBDA/50 Illustrations Courtesy Antenna Specialist Company

Loop Antenna Installation

(Supplied with the SIGMA/1500)

GENERAL

The loop antenna cables are cut to a critical length (12 feet). Do not attempt to shorten these cables. If longer cables are required, see cable information in the SIGMA/1500 Maintenance Manual.

The loop antenna cable connectors, as supplied, are wired for installations in which the loop antenna will be bottom-mounted and the sense antenna top-mounted. If an antenna configuration other than this is desired, the loop cable connections at J104, the 12-pin connector which attaches to the indicator, will have to be changed.

If it is necessary to change the loop cable connections at J104, proceed as follows:

1. Using a screwdriver, loosen the cable clamps on the connector cover of J104.
2. Remove the cover from J104, using the screwdriver.
3. Note the two blue cables coming from the loop antenna. One cable will be labeled "A" and will be attached to pins 3 and 4 of J104. The unlabeled cable connects to pins 8 and 9 of J104. Note that each cable has one clear and one blue insulated wire.
4. Using the chart below, determine the cable connector wiring changes necessary for the selected antenna configuration.

Configuration	Cable A		Unmarked Cable	
	Clear	Blue	Clear	Blue
Bottom-Loop, Top-Sense	Pin 3	Pin 4	Pin 8	Pin 9
Top-Loop, Top-Sense	Pin 4	Pin 3	Pin 8	Pin 9
Top-Loop, Bottom-Sense	Pin 4	Pin 3	Pin 9	Pin 8
Bottom-Loop, Bottom-Sense	Pin 3	Pin 4	Pin 9	Pin 8

5. Remove the insulating sleeving and unsolder the necessary pin connections.

6. Place new insulating sleeving over the cable leads and resolder the wires to the appropriate new pin connections.

7. Replace the connector cover and tighten the cable clamp.

INSTALLATION PLANNING

Select the mounting location for the fixed loop antenna so that the inherent 6 degree quadrantal error compensation factor corrects for the aircraft quadrantal error.

To provide an inherent 6 degree quadrantal error factor, the cross wound coils for the fixed-loop antenna are of different dimensions. When installing the fixed loop, a position should be selected where the quadrantal error caused by the physical presence of the aircraft is nearly cancelled by the 6 degree compensation of the loop. This must be accomplished by a trial and error process as follows:

1. Install the SIGMA/1500 Receiver and Indicator in the aircraft panel (See Receiver Installation). Do not tie the cable harnesses to the airframe until the ground tests have been completed.

2. Temporarily tape the loop to the underside of the aircraft on the centerline. Run the loop cable along the centerline and connect to the bearing indicator via the door or window or vent, etc. without drilling any holes.

3. If aground compass rose pattern is available, position the aircraft on the compass rose pattern. If no compass rose pattern is available, use an alternate method to determine angles and degrees.

NOTE: Make certain that there are no metal hangers, phone wires, fences, buried cables, etc. near the aircraft that might cause an error in the indicated bearing.

4. Locate a radio station at least 20 miles from the aircraft and tune the SIGMA/1500 ADF to take a bearing on the station. The exact location of the station's transmitting antenna must be known.

5. Rotate the aircraft on the compass rose until the nose of the aircraft is pointing directly at the station's transmitting antenna. The bearing indicator must read zero.

6. Rotate the aircraft counter-clockwise around the compass rose in 15 degree increments. Compare the directional gyro and bearing indicator readings at each increment. The difference in the two readings is the quadrantal error. The maximum quadrantal error should occur at 45, 135, 225, and 315 degrees.

7. Repeat steps 2, 4, 5, and 6 until a loop position is found where the 6.0 degree loop compensation reduces the quadrantal error to a minumum.

8. Drill 5 mounting holes at the selected location in the fuselage as shown in figure 11.

9. Install the neoprene gasket between the doubler plate and the aircraft skin (See figure 12).

10. Mount the doubler plate to the aircraft skin using the two 6-32 screws provided. Be sure that the side of the doubler plate connector box, from which the cables exit, is towards the front of the aircraft.

NOTE: Because moisture can be a problem in loop antenna installations, every surface should be coated with a good sealer such as PlioBond, RTV, or ECO-801 Type A.

11. Install the loop by inserting the plug on the loop into the socket of the doubler plate. The arrow on the antenna must point forward. Secure the antenna in place using the two 10-32 screws and washers.

12. All cables, including those attached to the bearing indicator and receiver should now be secured.

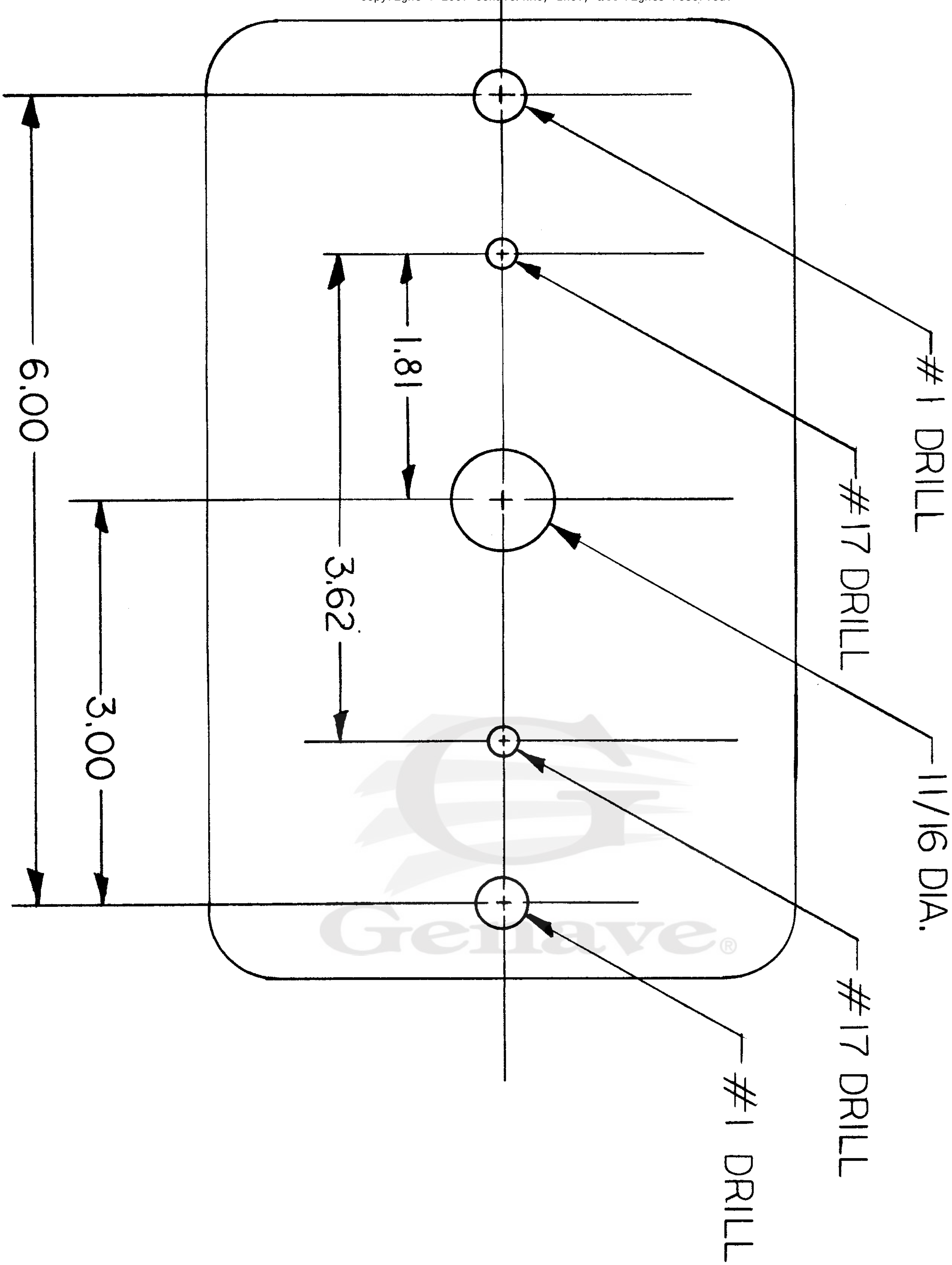


Figure 11
LOOP ANTENNA DRILLING TEMPLATE

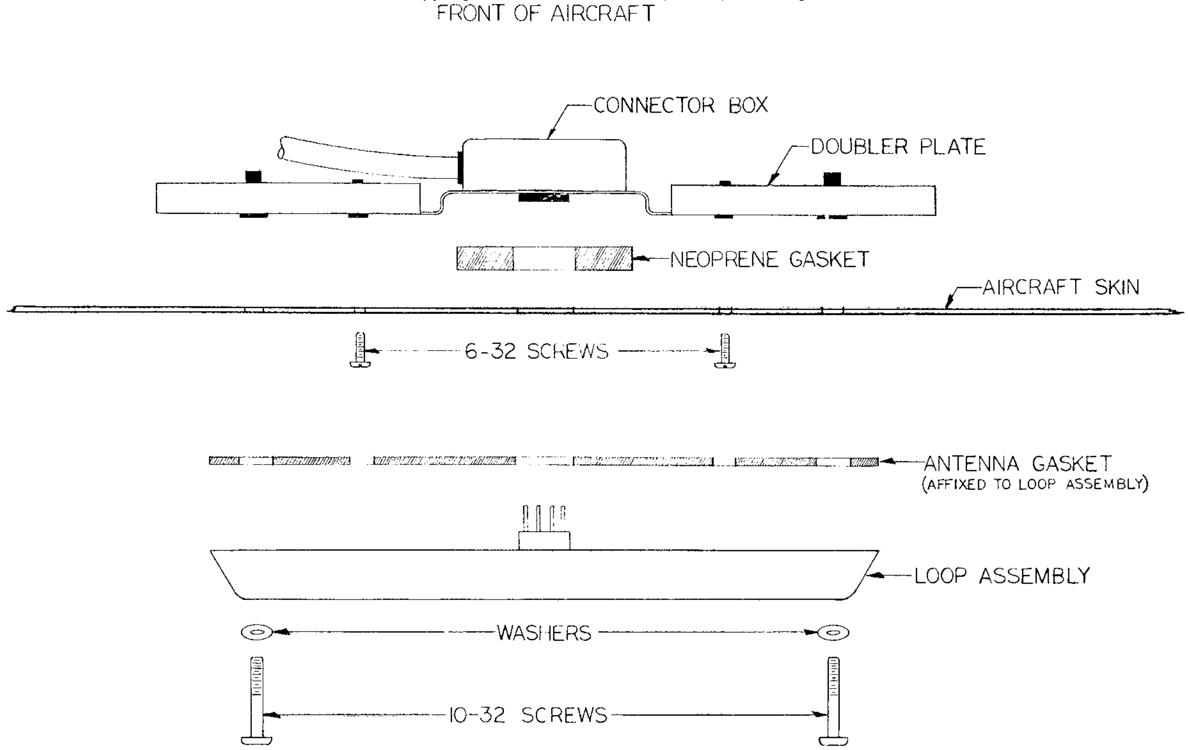


Figure 12
LOOP INSTALLATION

Post Installation Check

1. All cabling should now be checked to insure that it is properly secured and does not interfere with aircraft controls.

2. Update the appropriate logs and papers of the aircraft.

3. Fill out the installer's portion of the warranty card.

4. Have your customer fill out and sign the remainder of the warranty card. The warranty card MUST be completed by both the installer and the customer and returned to Genave for the warranty to be in effect.

5. Upon completion of the installation, a flight test is desirable to insure that the unit is operating properly.

6. Give the SIGMA/1500 ADF Pilot Information Manual to your customer.

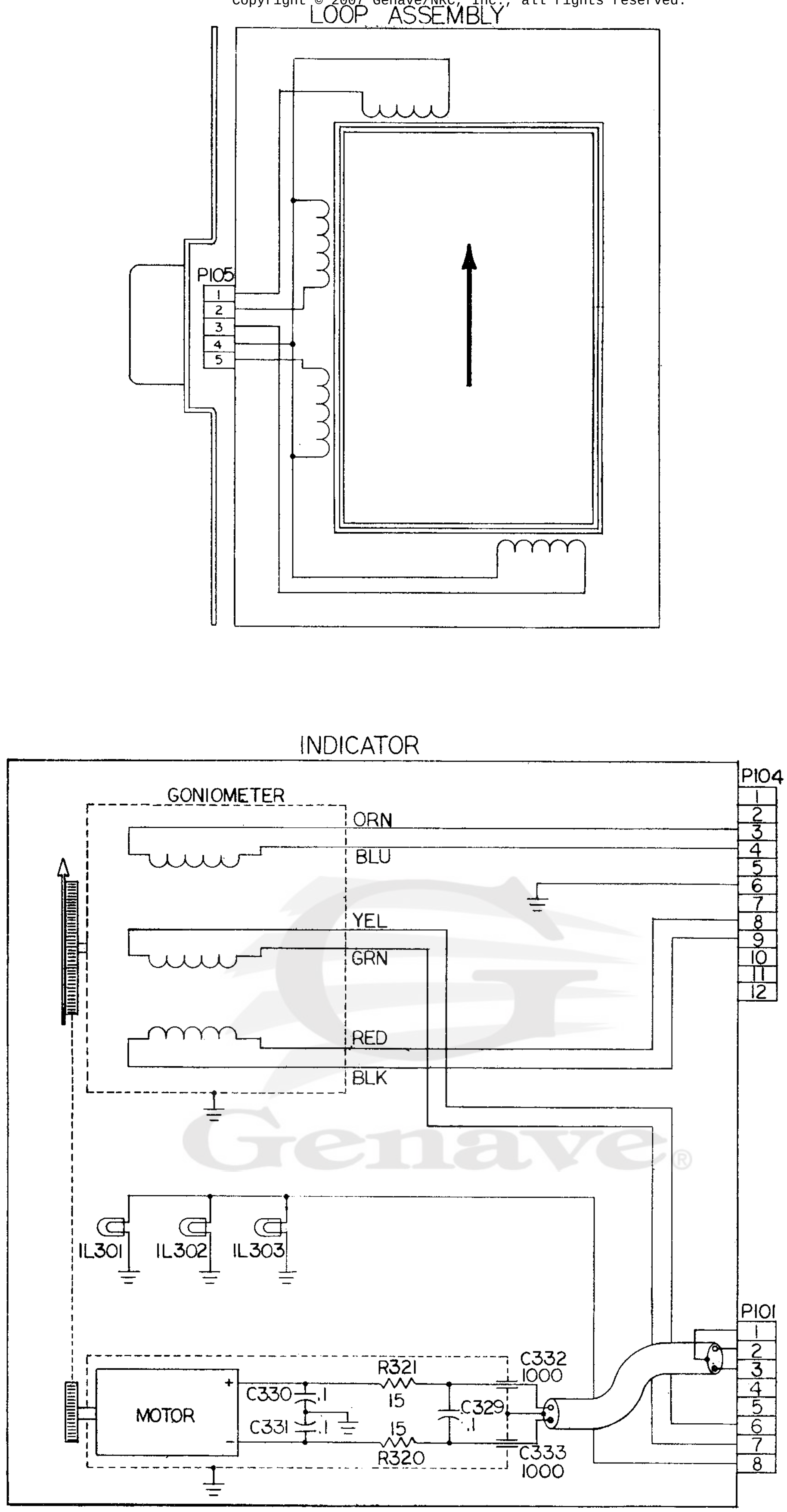


Figure 13
LOOP & INDICATOR SCHEMATIC

Is EMI Jamming Your ADF?

A common complaint about ADFs in smaller general aviation planes is that the needle does not point dependably to an NDB (nondirectional beacon) until the airplane is practically on top of the station. "Never has worked worth a damn on the navaid band, even when it was new, etc." *In most cases the ADF installation is at fault, not the set itself.* Usually the ADF is being confused by EMI in the 200 to 400 kHz band originating within the airplane, electrical noise which should have been suppressed during installation, but wasn't. Most often the EMI (electromagnetic interference) comes from the generator or alternator, and sometimes from the transponder (even in "Standby"), the DME, strobe lights, rotating beacon, electric turn and bank, flap and gear motors and suchlike.

Why avionics shops regularly install ADFs in small planes without adding any EMI filtering is one of life's minor mysteries, but my experience has for years been that even the best-reputed shops often omit filters unless specifically told to include them. The larger the airplane, generally speaking, the more careful the installation. The same shop that will throw an excellent ADF into an unsuppressed Musketeer, so that the set is useless or hazardous for navigation, will install the same set in a King Air with all kinds of suppression. They know how—they just don't do. Perhaps those who run some of the shops think that pilots of small planes use their ADFs only for music and ball scores in flight; with some of the installations they give us, that's about all an ADF is good for!

To find out what an ADF can do in the absence of EMI, you have to test it on the ground with everything else in the airplane shut off. Chances are you'll be pleased with how well the set performs under these conditions, and vexed that it doesn't do nearly as well in flight. In fact, the set will probably DF on signals you hadn't even heard before.

If your ADF is transistorized, have no fear of its running the battery down. To limit battery drain by items which come on with the master switch and to ensure that the test is valid, make certain that panel lights are out, and that circuit breakers or fuses for the turn needle, gas gauges, etc., are pulled, if possible. And don't mix up the fuses! One popular transistorized ADF plays through a loudspeaker only if another set, usually the No. 1 nav/com, is also turned on. The No. 1 nav/com, if it contains vacuum tubes, does drain the battery. The solution is to play such an ADF through headphones only, leaving the No. 1 nav/com turned off. Headphones are preferable in these tests, anyway.

With the plane on the ground, away from metal buildings and arrays of nearby powerlines and wire fences, tune in the 200 to 400 kHz navaid band on "Receive." In this mode you are using only the sense antenna, the wire which usually runs lengthwise along the fuselage. (Beech sometimes uses a large vertical whip.) Tune across the band and note the general performance. Strong stations do not concern us here —they can overpower noise generated on board the airplane. Tune carefully to a weak station which is not being interfered with by a strong one. You should be able to read the ident and locate the station geographically. Now, switch to "ADF." A certain amount of background buzz is normal in "ADF." (Some older sets label this position "COMP," for radio compass.) Now you are using the loop antenna as well. The needle should turn, probably rather sluggishly because the station is weak, and point to the station. Press and release the "TEST" button to verify the indication. Write down the indication. If possible, do the same thing for a second weak station in another direction.

The foregoing is the best the ADF can do when there is no interference generated on board the aircraft. The next step is to turn on items of electrical equipment and note whether the ADF indication is affected while it is supposedly pointing to each weak station. Since the worst offender is usually an unsuppressed (meaning unfiltered) alternator or generator, that is the next item to check. Shut off the ADF; start the engine; make sure the generator/alternator is on; and turn the ADF back on and switch it to "Receive." Retune carefully to one of the test stations. Listen in the headphones for excess noise (whine or "hash") which worsens as the throttle is advanced to 2,000 rpm or more. In some airplanes there is no excess noise until a certain rpm is reached; in others the excess noise is proportional to rpm. (If you prefer not to run up at 2,000 rpm or higher, you can do what follows in flight. But you'll probably get better results on the ground, for reasons mentioned later on.) Still at 2,000 rpm, switch to ADF. Does the needle turn and point to the same bearing as before? It should. If the needle moves to a new bearing when tuned to either test station, or begins to turn aimlessly, the ADF is probably being confused by electrical noise from the generator/alternator. As a final check, reduce the throttle to idle, shut off the generator/alternator and go back to cruise power. (Some airplanes are placarded against turning the alternator off and on at cruise power. The reason is that voltage surges which accompany the switching just might possibly damage some transistorized avionics gear. It is okay, however, to turn the alternator on and off at idle power.) If the ADF needle points steadily to where it did with the engine off, you definitely need an EMI filter on the alternator/generator. The filter should have been installed when the ADF went in.

Now shut the engine down and, in quick succession, run the same test with each item of electrical equipment previously mentioned as likely to cause ADF noise. Any item which causes the ADF needle to misbehave needs its own EMI filter, regardless of whether you can hear audible noise from it. Transponders in particular can confuse an ADF without putting much audible noise into it.

William E. Daniel, of the well-respected avionics shop Barbour-Daniel Electronics, Inc., at the Bridgeport (Conn.) Municipal Airport, says that the basic job in suppressing ADF noise is to find out where the noise is coming from and how it gets into the set. He lists three paths:

1. The A+ bus (the dc output lead of the generator/alternator).
2. The sense antenna.
3. The loop antenna.

If tests on the ground have shown the generator/alternator to be a source of noise, the first step is to install a filter on the A+ bus. Sometimes, especially with generators, a simple capacitor

If your ADF acts 'confused' and doesn't seem to work too well, it's probably the fault of the installation and not the set itself. Here's how to check for electromagnetic interference—the probable culprit—and how to cope with it

by RICHARD J. BLUME / AOPA 60201

(that's another word for condenser) wired between the A+ terminal of the generator and its frame (or ground) is all that is needed. The capacitor short-circuits the noise to ground without affecting the dc. Generally, though, it's much better to install a real EMI filter. These not only short-circuit the noise more effectively than a simple capacitor, they also block it. EMI filters have three terminals. (So do coaxial capacitors, apparently. Two of the terminals are really the same, however.) One is ground, which is the metal case of the filter. The other two are wired in series with the A+ bus where it comes out of the generator or alternator. It doesn't matter which terminal of the filter goes to the alternator and which to its load. If the A+ lead is covered with grounded shielding braid, as in Beech or Cessna, the braid must first be cut in order to wire the filter in series with the A+ lead. Then the cut ends of the braid must be soldered together. If the A+ lead is not shielded, as in Cherokees, the filter should be installed as close to the alternator as possible. It is important to make excellent ground connections of clean bare metal tight against clean bare metal.

There are many good EMI filters on the market. One is Cessna part number S1629-1. It can be bought from Cessna or from the companies which make it for Cessna. One is Hisonic Inc., 249 North Troost, Olathe, Kan., 66061. Hisonic calls theirs part number 20-0222-10 when selling direct. The filter is rated to pass 40 amps and will work at up to 50 volts dc, which means it's okay to use on 28 volt systems, as well as 14 volt. An electrically identical filter which will carry 100 amps is Hisonic part number 22-0295-10. Installing the filter sometimes improves operation of VHF nav/com gear, by the way. There is less background noise on marginal signals, and less needle wavering on weak omnis. Strobe lights and flap and gear motors may occasionally require EMI filtering too.

The generator/alternator EMI filter will ordinarily prevent the worst noise from getting to the ADF. If some remains, the next step is to install a choke coil in series with the A+ lead of the ADF, right where it comes off the ADF circuit breaker. A coil which works is Narco part number 1149-1.

New alternators occasionally are stubborn noisemakers, even with filters added at the factory. Aircraft manufacturers sometimes change the alternator if a factory-installed ADF picks up too much noise. In replacing a defective alternator, make certain the replacement has a filter on it if the original one did. Don't buy a new filter if the old one can be removed from the old alternator and used again. Also, consider yourself lucky if a rebuilt alternator gives low radio noise. Daniel says you're better off buying a new alternator—"Practically nobody knows how to rebuild them properly. Automotive shops in particular are hopeless."

ADF antenna cables should be separated wherever possible from other electrical and electronics cables, because these might couple noise into them. (So-called shielded cables are not completely effective.) In stubborn cases, this can mean placing them on the other side of the fuselage.

The next most common sources of ADF confusion are probably the DME and transponder (even in "Standby"). Because each case is different, and because the equipment works at low microwaves, it's best to turn over any such problem to an experienced avionics man. If you have no access to one, remember that manufacturers of avionics know about the problem and will send service information on request.

It is well known that ADFs are affected by thunderstorms and precipitation static. This latter is partly relieved by simple conducting wicks attached to the wingtips and tail. What is less well known is that ADFs respond to EMI originating on the ground. Cities radiate electrical noise, which is the sum of the noise radiated by all the electrical equipment in the city. To observe it, one should use a well-suppressed ADF with a signal strength (tuning) meter. On the ground or off in the boondocks, switch the ADF to "Receive," tune around 200 to 250 kHz between stations, so all you can hear is static. Note the position of the signal strength meter. Now take off and fly over a city. Leave the switch in "Receive." The bigger the city, the more noise the meter will show. EMI from cities can occasionally mask an LOM (locator, outer marker). Teterboro, N.J., is a case in point. Because the noise from cities does not seem to propagate horizontally, it is possible to hear the TEB LOM on the ground some 20 to 30 nm away, but not in the air over New York City, 10 nm away. This information is given to persuade pilots near large cities to noise-test their ADF installations entirely on the ground.

EMI from cities is not confined to the ADF navaid band, by the way. Have you ever wondered why, after carefully setting your VHF squelch on the ground, noise often punches through shortly after climbout, requiring you to reset it? The cause usually is not high bus voltage produced by full-throttle operation. The squelch is being opened by EMI radiated by what you're flying over.

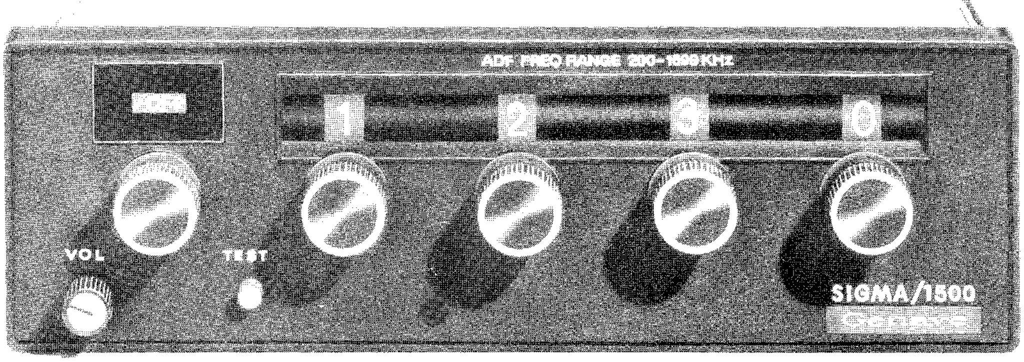
A sharp avionics man can often diagnose troubles in an aircraft electrical system just by listening to the noise the troubles cause in the plane's radios. Charles C. Linberg, proprietor of the Ozark Aircraft Radio Company at the Spirit of St. Louis Airport, has made tapes of the different kinds of radio noise caused by various sources, such as the alternator, magnetos, strobe lights, electric t&b, etc., for the instruction of local A&Ps and pilots. For his valuable work on this topic, Linberg won the 1971 FAA Aviation Mechanics Safety Award in the general aviation category [Sept. PILOT, page 39]. □

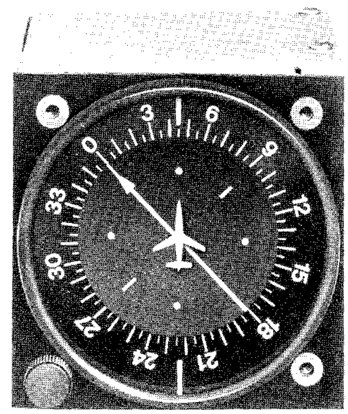
THE AUTHOR

Richard J. Blume (AOPA 60201) is an electronics engineer at the Naval Research Laboratory in Washington, D.C. He obtained his private license on floats in 1949 and now has over 1,400 hours and the commercial, ASMEL, instrument, CFI glider, and hot air balloon ratings. Blume authored two previous articles that appeared in the PILOT this year. He wrote "A Fresh Look at ADF," which appeared in the March issue, and "A Fresh Look At the Instrument Panel," which appeared in the June issue.

► FROM THE NOVEMBER 1972 ISSUE OF THE AOPA PILOT REPRINT THE AOPA PILOT

SECTION III
OPERATING MANUAL





3-1. OPERATING CONTROLS AND INDICATORS

The SIGMA/1500 has eight operating controls and indicators as listed below:

1. Function Selector Control
2. Function Readout
3. Volume Control
4. Frequency Selectors
5. Frequency Readouts
6. In-Flight Lock-On Test
7. Azimuth Rotation Knob
8. Bearing Indicator

To operate the SIGMA/1500, rotate the Function Selector Control clockwise until the desired function appears in the Function Readout window. The ADF position places the indicator into operation thereby indicating the direction to the station. The REC position places the receiver only into operation to allow listening to the station without presentation of directional information. The BFO mode allows the pilot to read CW encoded station identifiers. Full counterclockwise rotation returns the unit to the OFF condition.

NOTE: The ADF *will* indicate direction to the station when the Function Selector is in either the ADF or the BFO positions.

Select the desired receive frequency by rotating the Frequency Selector knobs until the correct frequency appears in the Frequency Readout windows above the selector knobs. Turn knobs clockwise to increase frequency. Knobs may be turned counterclockwise to reduce frequency. Automatic electronic band switching eliminates manual band switching by the pilot.

If a frequency outside the ADF range (200-1699 MHz) is selected, the indicator needle will automatically begin slewing (rotating) when the Function Selector is in the ADF mode. When this happens, a station within the proper range should be selected. To verify the selected frequency within the proper ADF range listen for the station identifier. Additional indication will be given by activating the In-Flight Lock-On Test as described below.

Adjust Volume Control to desired listening level. Rotate the Volume Control knob clockwise to increase volume and counterclockwise to reduce volume.

The In-Flight Lock-On Test button activates the in-flight self-test for signal acquisition and lock-on feature. With the Function Selector in the ADF mode, depress the "TEST" button and hold until the indicator needle deviates significantly from the previous bearing. Release the "TEST" button. If the signal selected is "live" the indicator needle will return to its original bearing. If the signal is inadequate or absent, the needle will stop or wander erratically.

The Bearing Indicator indicates, by means of the bearing needle, the direction to the station being received when the ADF is operating in the ADF mode. An exclusive feature of the SIGMA/1500 Bearing Indicator is the localizer intercept position markings. Unique dots on the pointer disc of the bearing indicator mark 45 degree positions. When approaching the localizer on a standard 45 degree localizer intercept course, the bearing needle will rotate until the appropriate 45 degree mark appears directly beneath the top lubber line, thereby indicating course interception. Basically, the bearing indicator unit will function as a substitute for an RMI in this application.

The Azimuth Rotation Knob allows setting outer azimuth card on the bearing indicator to agree with the aircraft heading. Rotate the knob clockwise or counterclockwise to turn the azimuth card. If the aircraft heading is dialed beneath the top lubber line, the indicator needle will indicate the bearing to the station. If zero is dialed beneath the top lubber line, the indicator needle will indicate the relative bearing to the station. The outer azimuth card may also be used to set in wind correction angle to facilitate direct tracking to the station.

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SECTION IV
MAINTENANCE MANUAL

4-1. INTRODUCTION

This section provides the basic information required to electronically test, align, and repair the SIGMA/1500 Digital ADF. It is assumed that the person working on the unit has a reasonable familiarity with the principles and terminology of navigational electronics as applied to the aviation field.

4-2. THEORY OF OPERATION

I. General

The SIGMA/1500 employs 67 silicon transistors, 11 integrated circuits, and 23 diodes in an all solid state design. The circuitry of the SIGMA/1500 can be divided into 24 functional circuit blocks (See Figure 4-4-1) These functional circuit blocks are as follows:

A. Antennas
  1. Loop Antenna
  2. Sense Antenna

B. Goniometer/Servo Circuits
  1. Goniometer
  2. Motor
  3. Chopper
  4. Servo Amplifier

C. Receiver Circuitry
  1. Loop Amplifier
  2. Balanced Modulator
  3. Sense Amplifier
  4. RF Amplifier
  5. Mixer
  6. IF Amplifier
  7. Detector
  8. Emitter Followers
  9. AGC Emitter Follower
  10. Audio Amplifier

D. Synthesizer Circuitry
  1. Voltage Controlled Oscillator
  2. Squaring Amplifier
  3. Programable Counter
  4. Phase Detector
  5. Active Filter
  6. 128 KHz Oscillator
  7. 128 KHz Divider

E. Power Supply
  1. Voltage Regulator

To understand the entire SIGMA/1500 ADF system it's important that the basic principles of direction finding be understood. The dominant principle employed by the direction finding process of the SIGMA/1500 is that the combination of a reference (Sense) signal with the signal received by a loop type antenna will yield a cardioid response characteristic when the loop is rotated with respect to a distant fixed signal source.

The mechanical and electrical problems encountered when attempting to rotate a large antenna can be quite complex. In order to eliminate these problems a goniometer system is employed within the SIGMA/1500 system. The fixed loop receives the electromagnetic field relationships and transmits them to the goniometer. The goniometer recreates, within its enclosure, the same electromagnetic fields as those received by the loop antenna. A movable rotor winding within the goniometer then functions as the rotatable loop antenna.

The loop signal received by the goniometer rotor is amplified and split into two separate phases, each 180° apart, which are alternately combined with the sense signal. The chopper circuitry alternately connects one and then the other loop output phase to the added circuitry, where the loop signal will be combined with the sense signal. The chopper also simultaneously applies the receiver output to the respective servo amplifier input. This process provides the necessary drive signals to the motor, causing the motor to rotate the goniometer rotor winding to the signal null position.

When the sense signal plus the in phase loop signal ($E_0 + E_1$) equals the sense signal minus the loop signal ($E_0 - E_1$), the voltages applied to the input to the servo amplifier are equal ($V_1 = V_2$) and the motor is stopped in the null position (See Figure 4-4-2). When the goniometer rotor is not in the null position V_1 will not equal V_2 and the motor will be driven in the direction necessary to produce the null.

In order to produce a visual indication for the pilot, a pointer is attached to one end of the goniometer rotor shaft. Therefore, when the null condition is reached the pointer will indicate a relative direction to the selected station.

II. Detailed Theory

A. Antennas

1. *Loop Antenna*—The LAMBDA/1500 Loop Antenna consists of two, two-segment loop windings wound upon a ferrite core at right angles to each other. Each winding is connected to antenna common (P105, pin 4) between the two identical segments, therefore, the segments appear electrically symmetrical about each side of the antenna common connection. The common connections of the loop segments provide a balanced loop configuration, thereby preventing degeneration of loop directivity.

When the plane of a single loop winding is perpendicular to the magnetic field of the radiated signal, maximum difference of potential will exist across the ends of the loop winding. When the plane of the windings are parallel with the magnetic field of the radiated signal, the potential difference between the end terminals of the winding will be zero. When the plane of lateral and longitudinal windings of the loop antenna are lying at 45° angles with respect to the magnetic field of the radiated signal, the potential differences across the loop windings are approximately equal.

The basic system of the ADF relies upon comparison of the potential differences across the two loop windings when mixed with the sense antenna signal which is used to resolve the 180° ambiguity.

The loop winding potentials are directly proportional to the cross-sectional area of the loop winding. The LAMBDA/1500 loop antenna is constructed so that the loop winding with its plane lying along the lateral axis has a slightly larger cross sectional area. This is intended to provide the necessary 6° error compensation required to correct for the effects of the airframe upon the electromagnetic lines of force from the received signal.

The loop cable is used to convey the balanced loop signal information to the goniometer in the indicator head. The capacitance of the loop cable and therefore its length is critical in that the capacitance of loop resonance must not be exceeded.

2. *Sense Antenna*—The LAMBDA/50 is the sense antenna recommended for use with the SIGMA/1500 ADF. The SIGMA/1500 is designed to operate with a 270 pfd. sense antenna system. The antenna should exhibit 50 pfd. of capacity while the cable provides the remaining 220 pfd. The effective height of the antenna should be 0.25 meters. The Installation Manual contained in Section II provides the information required to fabricate the sense antenna. It may be necessary to add an additional shunt capacitance across the antenna in some configurations. Figure 2, Section II contains the information concerning values of such shunt capacitances. It should be noted that the exact capacitance value listed in the table is not necessary, only the nearest standard value is required to provide satisfactory operation.

The signal received from the sense antenna is used to resolve the 180° ambiguity of the loop signals. The output of the open wire antenna will always be the directly induced voltage while the loop depends upon the difference between induced voltages on each side of the loop. This phenomenon causes the output of the loop antenna to differ in phase by 90° from that of the sense antenna. The circuitry within the receiver shifts the phase of the loop signal by an additional 90° before mixing it with the sense signal. When the loop signal, which has been shifted the additional 90°, is mixed with the sense signal it will either aid or oppose the sense signal resulting in a cardioid directional sensitivity pattern.

B. Goniometer/Servo Circuits

1. *Goniometer*—The signals received by the loop are transferred via the loop cables to the goniometer located in the indicator unit. The stator windings within the goniometer are positioned at right angles to each other as are the loop antenna windings, therefore, the goniometer recreates the magnetic field at the antenna within its enclosure.

The rotor winding within the goniometer can be rotated and acts in the same manner as a rotatable loop. As the rotor winding is rotated the number and direction of magnetic force lines which are cut by the windings vary and therefore the rotor winding output will vary in amplitude and phase. The rotor output is fed to the loop amplifier via pin 7 of P101.

2. *Motor*—The motor is used to rotate the rotor winding of the goniometer. The motor is mounted within a shielded enclosure along with a filter circuit. The filter circuit is used to prevent the transfer of motor generated noise to the receiver circuits.

The motor drives the rotor of the goniometer via a 4 gear reduction system which provides a 750:1 gear ratio. This ratio provides rapid resolution and pointer tracking and prevents pointer overshoot. The motor, complete with its filter and shielded enclosure is mounted within the indicator unit.

3. *Chopper*—The chopper circuit is a multivibrator operating in the 45 Hz range. The chopper provides the switching signals to perform the ADF function. The chopper circuitry is located on the synthesizer/servo board within the receiver unit and consists of Q301, Q302 and associated circuitry. C301, R308, C302, and R307 are used to set the output frequency of the chopper. CR302 and CR304 are used to hold the multivibrator transistors out of saturation. This provides faster switching times and easy starting of the multivibrator. CR301 and CR303 are also used to speed-up the transistor switching. The 180° out-of-phase chopper outputs are applied to the balanced modulator and the servo amplifier.

4. *Servo Amplifier*—The servo amplifier circuitry is located on the synthesizer/servo circuit board and provides control voltages to the motor. Audio from the audio emitter followers of the receiver is applied to Q303, the first servo amplifier. Q304 and Q305 function as electronic switches to apply the amplified audio to the proper channel of the following servo amplifier. Q304 and Q305 are alternately switched off and on in synchronization with the balanced modulator switching. Approximate 45 Hz switching signals are supplied to the switches via the chopper output lines.

IC311A and IC311B amplify the audio levels applied to their respective channels R323 serves as the Servo Balance Adjustment and is used to equalize the servo amplifier outputs. C309 is used as a filter on the "Servo Kill" line. The "Servo Kill" line is used to turn-off IC311A and B when the direction finding function is not in use (Rec mode).

When SW305, the Function Selector Switch, is in the REC position +9VDC is applied to the servo kill line, driving pins 2 and 6 of IC311A and B, respectively, to ground. This will drive the outputs of both IC's to ground potential. Since both outputs are driven to ground, the inputs (pins 3 and 5) will have no effect upon the outputs. This insures that both lines have the same potential and therefore the motor receives no drive signals.

The outputs of IC311A and IC311B are applied to Q315 and Q316, and to Q313 and Q314. These two complementary transistor pairs function as servo power amplifiers to provide the necessary motor drive current. R331, R332, C310, C311, and C312 comprise a noise filter which is used to prevent the transfer of motor generated noise to other circuitry within the unit.

The servo motor lines will both maintain the same DC level at the null condition (approximately 7 VDC). When one of the combined loop and sense signals is of a higher level than the other, one servo motor line will go higher in amplitude while the other goes lower. This action will cause the motor to rotate the goniometer rotor in the direction necessary to once again obtain a signal balance (null position).

SW306, the Test Switch, is a part of the servo amplifier circuitry. When SW306 is depressed, Pin 5 of IC311B is pulled to ground potential, reducing the output of IC311B. When the test switch is depressed the motor will slew the goniometer rotor off the null position. Once the test button has been released the ADF pointer should return to its original position if a valid signal is being received. Pin 5 of IC311B is also connected to the out-of-range warning line. When a frequency outside the receiver range (200 to 1699 KHz) is selected the out-of-range warning line will pull Pin 5 to ground causing the indicator needle to rotate until a correct frequency is selected or the direction finding function is deactivated.

C. Receiver Circuitry

1. *Loop Amplifier*—The loop amplifier is comprised of Q118, Q119, Q120, Q121, Q122, Q123, Q124, Q125, Q134, and their associated circuitry. The input to the loop amplifier is the output signal from the rotor windings of the goniometer. The loop amplifier input is applied to the primary of T121, the low-band loop amplifier transformer.

Electronic bandswitching is employed throughout the tuned R.F. circuitry of the loop amplifier, sense amplifier, and R.F. amplifier. The electronic bandswitching employed, eliminates the need for complicated mechanical slide switches on the receiver board. The principle embraced by the electronic bandswitching within the SIGMA/1500 requires that the R.F. input be applied across the primary of a single transformer. The secondary of the input transformer is paralleled with other inductances which can be switched in and out of the circuit. When the total inductance is provided the necessary shunt capacitance in the form of fixed capacitors and varactors, the LC circuit formed can be tuned to resonance. For example, when receiving in the 200 KHz to 399 KHz range (Band A) Q135 is turned-on placing C182 and C179 in shunt with T121. CR107, the varactor diode, is used to tune the circuit to the exact frequency desired. When the frequency selectors are rotated to tune a frequency in the 400 KHz to 799 KHz (Band B) range, the Band B enable line is switched from ground to +9 V. This action turns-off Q135, removing C182 and C179 from the tuned circuit. The 9 VDC applied to the Band B enable line turns-on Q119 and Q134, placing T120 and C178 and C181, respectively, in parallel with T121. This LC circuit is again tuned by the shunt capacitance of CR107, the loop amplifier varactor diode. When the frequency selectors are rotated to a frequency setting between 800 KHz and 1699 KHz (Band C) the Band B enable line will remain at the 9 VDC level and the Band C will come up to +9 VDC also. This action will turn-off Q134 and turn-on Q118 removing C178 and C181, and placing T119, C120, and C177 in parallel with the other two inductors, T120 and T121. CR107 will again be used to track-tune the circuit.

As can be seen from the switching description, only one sequence of transformer alignment will be satisfactory. Therefore, the alignment procedures given should be strictly adhered to.

The loop signal received from the appropriate LC network is applied to the gate of Q120, the loop amplifier source follower. The source follower output is applied to Q121, the first loop amplifier. The collector load for Q121 consists of R163 and its parallel capacitance. The parallel capacitance provides the additional 90° phase shift necessary to resolve the phase difference between the sense antenna input and the loop signal, as previously discussed. The capacitance necessary to provide the correct phase shift will change with the frequency being received. Therefore, the parallel capacitance is switched as receiver bands are changed.

When receiving in Band A (200 to 399 KHz) the Band B enable line and the Band C enable line will both be at nearly ground potential which will turn-on Q122 and Q123. This will place C189 and C190 in parallel with C187. When a frequency in Band B (400 to 799 KHz) is selected the Band B enable line will come up to approximately +9 VDC turning-off Q122 and leaving only C189 and C187 in parallel. When a frequency in Band C (800 to 1699 KHz) is selected both the Band B enable line and the Band C enable line will come up to approximately +9 VDC turning-off both Q122 and Q123 and leaving C187 as the only phase correction capacitance.

The output of the phase correction network is applied to Q124, which along with the associated circuitry forms an adjustable gain amplifier stage. This stage is used to adjust the loop signal to the level necessary to perform directional resolution.

The output of the variable gain amplifier stage is applied to the final fixed-gain loop amplifier comprised of Q125 and associated circuitry. The final, fixed-gain loop amplifier applies the phase-corrected loop signal to the balanced modulator.

2. *Balanced Modulator*—The balanced modulator consisting of CR108, CR109, and T122 is used to provide the two opposite phase loop signals which are added to the sense signal. The phase of the balanced modulator output is dependent upon the polarity of the chopper output lines. When chopper line A is switched to ground chopper line B will remain at approximately 9 VDC, causing one side of T122's primary winding to conduct. When the polarity of the chopper lines reverse, the other side of T122's primary will conduct causing the output of T122's secondary to reverse. The approximate 45 Hz chopper output will therefore cause the output polarity of T122 to change at an approximate 45 Hz rate also. The balanced modulator output is applied to the sense amplifier.

3. *Sense Amplifier*—The signal from the sense antenna is applied to the primary of T103 via J103 and L101. L101 is used to provide VHF suppression of the sense input. The bandswitching method employed in the sense amplifier is identical to the loop amplifier bandswitching. The output transformer secondaries are varactor tuned by CR101 and coupled to the gate of the sense source follower, Q103.

At the source of Q103 the loop signal is added to the sense signal. The signal on the source of the source follower is applied to an LC bandshaping circuit consisting of L102, C126, and C121 or C125. The LC bandshaping circuit is used to provide a more level output response from the sense amplifier. When receiving in Band A (200 to 399 KHz) both Q138 and Q139 are turned-on, placing C126, C121, and C125 in parallel. When receiving in Band B (400 to 799 KHz) the Band B enable line turns-off Q139, placing C121 and C126 in parallel and tuning the LC bandshaping circuit to the appropriate range. When receiving in Band C (800 to 1699 KHz) both Q138 and Q139 are turned-off, causing C126 to be sole bandshaping capacitance. The response corrected, composite signal is applied to Q140, the sense emitter follower. The output of the sense emitter follower is applied to the RF amplifier.

4. *RF Amplifier*—The RF amplifier consists of a single common emitter amplifier followed by a bandswitched double-tuned circuit. The RF amplifier, comprised of Q105 and associated circuitry, amplifies the composite signal and applies it to the double-tuned stage. Receiver AGC voltage is applied to the base of Q105 via R187. The first section of the double-tuned stage is comprised of T104, T105, T106, and their associated coupling and tuning capacitors, while the second section consists of T107, T108, T109, and their associated coupling and tuning capacitors. The inductances and parallel tuning capacitors are switched in and out of the circuit by means of the same bandswitching techniques employed in the loop amplifier. The RF amplifier output is applied to the mixer.

5. *Mixer*—The mixer circuitry is comprised of Q110 and associated circuitry. The voltage controlled oscillator output is applied to the source of Q110. The VCO tracks 141.5 KHz above the input signal frequency. L103 and C185 form a 141.5 KHz series tuned trap to maximize the mixer gain at 141.5 KHz. The mixer output is fed to the IF amplifier circuit via the double-tuned filter stage of T110, T111, and their associated coupling and tuning capacitors.

6. *IF Amplifier*—The three-stage IF amplifier is comprised of Q111, Q112, Q113, and their associated circuitry. The IF amplifier is single frequency tuned to 141.5 KHz and provides approximately 90 db of gain. AGC voltage is applied to the base of the first two IF amplifiers. A triple tuned filter is employed between Q112 and Q113 to provide increased skirt selectivity.

When the BFO function is selected, a 1 KHz beat frequency is applied to the base of Q113, the last IF amplifier. The output of the IF amplifier is applied to the detector.

7. *Detector*—CR104 and CR105 in conjunction with C166 and C167 form a voltage doubling detector. CR110 is used to provide temperature compensation while C168 functions as audio bypassing. The detector output is applied to the emitter follower.

8. *Emitter Follower*—Q114 and associated circuitry form the first emitter follower. The output of the first emitter follower is fed to a second emitter follower comprised of Q115 and associated circuitry. The two emitter followers are cascaded in order to provide sufficient detector isolation. Output from the two emitter followers is applied to the audio amplifier and to the servo amplifier.

9. *AGC Emitter Follower*—The output of the detector emitter followers consist of the composite audio and a DC level. The DC level provides biasing for Q116, the AGC emitter follower. R146 and C169 form an integrator, across which the AGC level is developed. R149 is used to adjust the AGC level. The AGC control signal developed is applied to the RF amplifier and the first two stages of the IF amplifier.

10. *Audio Amplifier*—The signal from the detector emitter followers is also applied to an audio amplifier consisting of Q117 and associated circuitry. CR106, R147, C170, R148, and C171 form a noise limiter. The noise limiter output is applied across R152, the volume control. The output signal which is dependent upon the volume control setting, is applied to Q117. Q117 functions as a fixed-gain darlington pair audio amplifier and provides up to 20 milliwatts of audio to a 600 ohm load. The audio output from the audio amplifier is applied to Pin 2 of J102.

D. Synthesizer Circuitry

1. *Voltage Controlled Oscillator* — The VCO functions as the local oscillator for the receiver. The VCO is so designed that it allows the receiver to be tuned in precise 1 KHz steps. This is accomplished by phase locking the VCO to a crystal standard.

The VCO circuitry is located on the receiver circuit board. The VCO consists of a bandswitched and track-tuned LC resonant circuit which is coupled to an amplifier with adequate feedback to sustain oscillation. The bandswitched LC circuit is comprised of T201, T202, T203 and their associated tuning capacitors. The bandswitching method employed in the VCO is identical to that employed in the other receiver sections. Q202, Q203, Q136, and Q137 are used to perform the bandswitching. When tuning Band A (200 to 399 KHz), C209 is in series with the track tuning diode, CR201. When Band B is selected, Q205 switches C217 into parallel with C209 to insure that CR201 will tune the LC circuit over the entire band. When Band C is selected, Q204 switches C216 into parallel with C217 and C209.

Q201 functions as a source follower and matches the LC circuit into the base circuit of Q206, the amplifier. The amplifier output is applied to Q208 and Q207. Q208 functions as an emitter follower to match the VCO output into the mixer circuit of the receiver. Q207 functions as an inverter and shifts the phase of the amplifier output as required to sustain oscillation. The inverter output is applied to a limiter circuit comprised of CR202 and CR203. The limiter output is fed back to the input of the first emitter follower and used to maintain the oscillation. The limiter output is also applied to the squaring amplifier.

2. *Squaring Amplifier*—The output of the VCO must be amplified and shaped into a square wave before it can be used to drive the programable counter. This is the function of Q322, Q323, Q324, and associated circuitry, which form the squaring amplifier. CR310 functions as temperature compensation on the base of Q322, the emitter follower. Q323 operates as a saturated amplifier and feeds the limiter circuit of C317, R348, R349 and CR309. Q324 operates as a driver and feeds the squared and amplified signal to the programable counter.

3. *Programable Counter* — The programable counter is used to divide the squared VCO output by a number which is dependent upon the desired receive frequency. This number is the desired receive frequency plus the IF frequency ($F_r + F_i$). The resulting output frequency should be 1 KHz when the VCO is tuned to the desired injection frequency. The programable counter output is compared with a standard frequency to determine the tuning adjustments necessary to maintain the VCO on the desired frequency.

When discussing the logic circuitry of the SIGMA/1500, the following conventions will be used:

1. All inputs and outputs operate between 0 VDC and +5 VDC with respect to ground.
2. The terminology "up" designates a level approximating +5 VDC with respect to chassis ground.
3. The terminology "down" designates a level approximating 0 VDC with respect to chassis ground.

The amplified and squared VCO output is applied to the clock inputs of IC301, IC302, IC303, IC306 and IC307. The line connecting these inputs will be referred to as the "clock input." IC301, IC302 and IC303 function as the programable dividers. The programable dividers are programmed by the frequency selector switches: SW301, SW302, and SW303. The programming is accomplished by opening or grounding pins 3, 4, 5, and 6 of the IC's. The switching logic employed follows the 9's compliment of a binary coded decimal. A switching truth table depicting the switching logic, is shown in Figure 4-4-5.

When the dividers are operating, the first divider, IC301, will count the number of clock pulses set in on the units frequency selector, SW301. Once the correct number of clock inputs have been counted, IC301 will apply an upward enable output to the next divider. When this enable signal is applied to IC302 pin 10 the IC starts counting clock pulses in increments of ten. When the programmed number of increments of ten have been counted, IC302 will apply an enable to IC303, which starts counting in increments of one-hundred. When the programmed number of increments of one hundred have been counted, an upward "terminal count" signal is provided by pin 15 of IC303. This "terminal count" signal will occur on the next clock pulse after the total count. In other words, if 200 were set into the frequency selectors, on the 200th clock pulse a "terminal count" output will be generated by IC303 (See Figure 4-4-3).

The JK flip-flop circuits of IC306 and IC307 are fed the "terminal count." When SW304, the thousands kilohertz selector is in the "0" position only IC307 will be enabled. SW304 will hold pin 12 of IC306 down which pulls pin 13 of IC307 up. The "terminal count" output from IC303 will cause the output of IC307 to change states from down to up. This JK output is provided at pin 8 of IC307 and is termed the "reset enable." If we consider our example from above, the "reset enable" will occur on the 201st clock pulse.

Before the programable divider output can be compared with the reference, an additional 142 counts must be provided to allow for tracking of the VCO 142 KHz above the receive frequency (high side injection). Since IC307 did not provide a "reset enable" until the next clock pulse following the programmed count, one of the additional counts required is already provided. One more clock pulse is required to reset the JK flip-flops (IC306 and IC307) after the "reset" is received from IC305C. Therefore, an additional 140 counts must be provided before the counter produces an output.

The "reset enable" generated by IC307 is applied to IC305A, the counter output buffer, and to IC305C, the reset gate. The reset gate will not provide the downward reset output until the two remaining inputs go up. These two inputs are tied to the 100 count output of IC303 and the 40 count output of IC302. These two divider outputs will not come up until an additional 140 counts have been made following the "terminal count." When this happens a "reset" is applied to the counter circuitry and the counting process is reinitiated.

The reset output is inverted by IC305B and applied as an upward output to IC305A, the counter output buffer. The counter output buffer will provide a downward output pulse coincident with the programmed count plus 142 additional counts.

IF the thousands selector is set to the "1" position, pin 12 of IC306 will be up and the output, pin 8, will be down. The programable dividers will count out the hundreds, tens, and units increments as before, but since pin 3 of IC307 is down the JK will not toggle. (Refer to Figure 4-4-3.)

The application of the "terminal count" to IC306 will make it toggle, however, it will not toggle until the next clock pulse; thereby preventing the toggle of IC307. Since IC307 did not generate a "reset enable" the programmable counter will continue to run for another 1000 clock pulses and then generate a "terminal count." When this "terminal count" reaches IC307, pin 3 will be up. This will cause IC307 to toggle providing a "reset enable." The programable dividers will now begin their 140 additional counts, as before. When the 140 count lines to IC305C (pins 9 and 10) go up, a reset signal will be sent to the IC's and a counter output will be generated, as before.

The resulting programmable counter output should be a 1 KHz output when the VCO is tracking properly. This means that the following relationship exists:

$$\frac{F_{VCO}}{F_{rec} + 142\ \text{KHz}} = 1\ \text{KHz}$$

The programmable counter output is applied to the phase detector.

4. *Phase Detector*—The phase detector is comprised of IC310, Q329, and associated circuitry.

The programable counter output is applied to pin 3 of IC310, a phase and frequency detector. The 1 KHz reference signal is applied to pin 1 of IC310A. When the programable counter output goes lower in frequency than the 1 KHz reference, the phase and frequency counter output at pin 13 of IC310A will go low. Conversely, when the programable counter output goes higher in frequency than the 1 KHz reference, the phase and frequency detector output at pin 2 will go low. When the programable counter output is in phase with the 1 KHz reference both outputs will be high. IC310B functions as a charge pump and converts the phase and frequency detector outputs to fixed amplitude positive and negative pulses. C322, C328, L302, and C323 function as a noise filter on the +5 VDC line. The output of the charge pump is applied to the lead-lag active filter.

5. *Active Filter*—Q329, IC310 and associated circuitry form an RC lead-lag active filter. This filter provides an output voltage proportional to the phase error. L303 and C324 form a noise filter on the +5 VDC line. The output of the active filter is the varicap tuning voltage applied to the VCO and to the loop amplifier, sense amplifier, and RF amplifier circuits of the receiver. If the signal from the VCO is lower than the frequency desired, the active filter will produce a slightly higher output voltage which will in turn tune the VCO to the desired frequency. If the VCO output goes higher in frequency, the tuning voltage will be reduced.

6. *128 KHz Oscillator*—The 128 KHz oscillator is used to provide the standard 1 KHz reference signal for the phase detector. The 128 KHz oscillator is comprised of Q237 and associated circuitry. Y301, the 128 KHz crystal serves as the frequency determining element of the oscillator. C319 provides the necessary feedback to sustain oscillation. Oscillator output is taken off the source circuit and applied to the oscillator driver, Q328. The driver output is applied to the 128 KHz divider.

7. *128 KHz Divider*—The 128 KHz standard signal from the oscillator is divided by 128 by the circuitry of IC308 and IC309. IC308 operates as a divide by eight circuit while IC309 operates as a divide by sixteen circuit. The output of the 128 KHz divider will be the 1 KHz reference signal applied to the phase detector.

The 1 KHz reference signal will also be used as the BFO injection signal. When SW305 is switched to the BFO position, the 1 KHz reference signal is applied to the base of Q113, the last IF amplifier. When an RF signal is present on the base of Q113, a 1 KHz beat note will be detected and fed to the audio amplifier. The BFO feature is used to provide a 1 KHz tone when receiving a CW station identifier.

E. Power Supply

1. *Voltage Regulator*—The SIGMA/1500 contains its own internal regulated power supply. The 14 VDC input from the aircraft buss is switched by SW305, the Function Selector. When the function selector is in the REC, ADF, or BFO positions power will be applied to the regulated power supply. L301 functions as a noise filter on the input line. Q321 functions as the +5 VDC regulator. CR307 sets the reference level on the base of Q319 and Q321. CR308 is used to provide additional protection for the integrated circuits should the regulator fail.

CR306 protects against overvoltage spikes on the 14 VDC line. The output from CR306 is applied to the servo amplifier, audio amplifier, and to the 9.0 VDC regulator. Q318, Q317, Q319, Q320, and associated circuitry form the +9.0 VDC regulator. Q318 functions as a series regulator while Q317 provides current limiting. The low internal resistance of L306 is used as the current sensing element. If the current through L306 exceeds approximately 200 milliamps, Q317 will turn-on causing Q318 to turn-off.

R341 sets the output of the regulator to 9.0 VDC. CR307 functions as the reference for the differential amplifier of Q319 and Q320. The collector of Q319 provides the regulator control output, which is applied to the base of Q318. C313 provides filtering of the 9.0 VDC output line.

Out-of-Range Warning

If the frequency selectors; SW301, SW302, SW303, and SW304; are set to frequencies below 200 KHz or above 1699 KHz, the ADF mode is unuseable. IC304, Q326, and Q325 are used to decode the switch settings. If an unuseable frequency has been set into the frequency selectors either Q326 (for all frequencies above 1699 KHz) or Q325 (for all frequencies below 200 KHz) will turn-on, grounding the range warning line. When the range warning line is pulled to ground the servo amplifier will drive the motor in the indicator continuously. The indicator pointer will only stop revolving when a valid frequency has been selected or a function other than ADF or BFO has been selected.

NOTE: Although the direction finding function of the SIGMA/1500 is prevented outside the 200 KHz to 1699 KHz range, the receive function will remain operative. The receiver sensitivity outside the operating band limits may be somewhat limited, however.

4-3. TEST EQUIPMENT REQUIRED

a. HF Signal Generator
Hewlett-Packard HP-606 or equivalent

b. ADF Signal Simulator
Tel-Instrument CES-116A or equivalent

c. Sense Adapter, for above
Tel-Instrument or equivalent (See figure 4-4-9)

d. Digital Voltmeter
Genave NU/1240, Weston 1240, or equivalent

e. Frequency Counter, DC to 2 MHz, high impedance input Genave NU/200, Computer Measurements Corp. Model 616A, Hewlett-Packard Model 5233, or equivalent

f. AC Voltmeter, any accurate instrument

g. Power Supply, 13.75 VDC @ 3 Amps, Filtered

4-4. ALIGNMENT PROCEDURES

A. *Preliminary*

1. Remove the tip cover by removing the three #4 self-tapping screws at the top of each side panel, and the two screws at the top of the rear panel.
2. Remove the screws from the main shield (three #4 self-tapping screws in each side panel, and one in the rear panel). Pivot the receiver board forward along with the main shield in order to expose the synthesizer/servo board.
3. Connect the receiver to the receiver alignment setup shown in Figure 4-4-7.
4. Set the function selector to the REC mode.
5. Adjust the filtered power supply to 13.75 VDC.

B. *Power Supply Adjustment*

1. Connect the digital voltmeter to TP301 (+9 VDC line).

NOTE: Location of the test points and adjustments for the synthesizer/servo board are shown in Figure 4-4-12, Figure 4-4-13, and on the illustration affixed to the bottom of the main shield.

2. Adjust R341, the Voltage Adjust Pot, to obtain a voltmeter reading of 9.00 ± .25 VDC.

C. *Balance Adjustment*

1. Set the function selector to the ADF position and tune the frequency selectors to 300 KHz.
2. Using a screwdriver loosen the cable clamp and remove the cover from P101. Connect the digital voltmeter across pins 2 and 3 of P101.
3. Set R323, the Balance Pot. (located on the Synthesizer/Servo Board), to produce a voltmeter reading of 0 ± .05 VDC.

D. *AGC Adjustment*

1. Pivot the receiver board and main shield back into place and replace the seven #4 screws removed in Part A, Step 2, above.
2. Set the function selector to the REC mode and check receiver frequency to insure that 300 KHz is selected.
3. Connect the digital voltmeter to TP103.
4. Adjust R149, the AGC Adjust, to produce a voltmeter indication of 1.40 ± .05 VDC.

E. *Oscillator Alignment*

NOTE: The low and high tuning voltages for each of the three bands are listed on the illustration on the inside of the top cover.

1. Connect the frequency counter to TP102.
2. Connect the digital voltmeter to TP101.
3. Set the frequency selector to 200 KHz and the function selector to the REC mode.
4. While monitoring the counter for a stable 342 KHz reading, adjust T203 for the correct tuning voltage shown for 200 KHz on the illustration.
5. Set the frequency selector to 399 KHz.
6. While monitoring the counter for a stable 541 KHz reading, adjust C203 for the correct tuning voltage shown for 399 KHz on the illustration.
7. Repeat steps 3 through 6 until there is no further change in the correct tuning voltages due to tuning interaction.
8. Set the frequency selector to 400 KHz.
9. While monitoring the counter for a stable 542 KHz reading, adjust T202 for the correct tuning voltage shown for 400 KHz.
10. Switch the frequency selector to 799 KHz and monitor the counter for a stable 941 KHz reading while tuning C202 to the correct tuning voltage listed on the illustration.
11. Repeat steps 8, 9, and 10 until there are no further changes in the correct tuning voltage shown for 400 KHz and 799 KHz.
12. Switch the frequency selector to 800 KHz and monitor the counter for a stable 942 KHz reading while tuning T201 for the correct tuning voltage shown for 800 KHz in the illustration.
13. Switch the frequency selector to 1699 KHz and monitor the counter for a stable 1841 KHz while tuning C201 for the correct tuning voltage listed on the illustration.
14. Repeat steps 12 and 13 until there are no further changes in the correct tuning voltages due to interaction.

F. *I.F. Alignment Procedure*

1. Set the frequency selector to 300 KHz and the function switch to the REC mode.
2. Set the VTVM to 1.5 VDC full scale and connect to TP103 in order to monitor the AGC voltage.
3. Disconnect the frequency counter from

TP102 and use it to set the output of the HF signal generator to exactly 141.5 KHz.

4. Disconnect the frequency counter and connect the signal generator to TP104 through a 22 pfd capacitor.
5. Adjust the output attenuator of the signal generator for 1.25 volts on the VTVM.
6. Adjust transformers T110, T111, T112, T113, T114, T115, T116, T117, and T118 (in that order) for minimum AGC voltage indicated on the VTVM.

NOTE: During the alignment procedures of step 6, keep the AGC voltage indicated on the VTVM within the range of 1.10 to 1.30 volts by reducing the output from the signal generator as required.

G. *Sense Alignment*

1. Set the function switch to the REC mode.
2. Connect the receiver to the sense alignment setup shown in Fig. 4-4-8.
3. Set the VTVM to 1.5 volts full scale and connect to TP103.
4. Set signal generator and frequency selector to 200 KHz.
5. Adjust signal generator output attenuator to produce an approximate 1.25 volt reading on the VTVM.

NOTE: In the following steps keep the AGC voltage on the VTVM in the range of 1.10 to 1.30 volts by reducing the output of the signal generator.

6. Adjust T103, T106, and T109 (purple cores) for minimum AGC voltage as indicated on the VTVM.
7. Set the signal generator and frequency selector to 399 KHz and adjust the signal generator attenuator for a 1.25 volt indication on the VTVM.
8. Adjust tuning capacitors C103, C116, and C131 for minimum AGC voltage as indicated on the VTVM.
9. Repeat steps 4 through 8 until no further changes are noticed.
10. Set the signal generator and frequency selector to 400 KHz and adjust the signal generator attenuator for a 1.25 volt indication on the VTVM.
11. Adjust T102, T105, and T108 (orange cores) for minimum AGC voltage as indicated on the VTVM.
12. Set the signal generator and frequency selector to 799 KHz and adjust the signal generator attenuator for a 1.25 volt indication on the VTVM.
13. Adjust tuning capacitors C102, C115, and C130 for minimum AGC voltage as indicated on the VTVM.
14. Repeat steps 10 through 13 until no further changes are noted.
15. Set the signal generator and frequency selector to 800 KHz and adjust the signal generator attenuator for 1.25 volts as indicated on the VTVM.
16. Adjust T101, T104, and T107 for minimum AGC voltage as indicated on the VTVM.
17. Set the signal generator and frequency selectors to 1699 KHz and adjust the signal generator attenuator for 1.25 volts as indicated on the VTVM.
18. Adjust tuning capacitors C101, C114, and C129 for minimum AGC voltage as indicated on the VTVM.
19. Repeat steps 15 through 18 until no further changes are noted.

H. *Loop Alignment*

1. Turn unit over so that bottom of receiver circuit board is accessable. Connect a wire jumper between TP105 (end of R319) and TP301 (+9 V line).
2. Connect the receiver to the loop alignment setup shown in figure 4-4-9.
3. Turn the ADF simulator heading to 90° from that shown on the SIGMA/1500 indicator. This will insure that the greatest possible error signal is present.
4. Turn function selector to ADF.
5. Connect the AC VTVM to the output of the receiver as shown in figure 4-4-9. Set the AC VTVM to the 1 volt full scale range.
6. Set the signal generator and frequency selector to 200 KHz. Adjust the signal generator output attenuator for a generator output of 10 millivolts.

NOTE: During the following steps keep the volume control adjusted for a useable audio level as displayed on the 1 volt scale of the AC VTVM.

7. Adjust T121 (purple core) for maximum

audio output (the audio output will consist of the 4 Hz error voltage) as indicated on the AC VTVM.

8. Set the signal generator and frequency selector to 399 KHz.
9. Adjust C179 for maximum audio output as indicated on the AC VTVM.
10. Repeat steps 6 through 9 until no further changes are noted.
11. Set the signal generator and the frequency selector to 400 KHz.
12. Adjust T120 (orange core) for maximum audio output as indicated on the AC VTVM.
13. Set the signal generator and the frequency selector to 799 KHz.
14. Adjust C178 for maximum audio output as indicated on the AC VTVM.
15. Repeat steps 11 through 14 until no further changes are noted.
16. Set the signal generator and frequency selector to 800 KHz.
17. Adjust T119 (red core) for maximum audio output as indicated on the AC VTVM.
18. Set the signal generator and the frequency selector to 1699 KHz.
19. Adjust C177 for maximum audio output as indicated on the AC VTVM.
20. Repeat steps 16 through 19 until no further changes are noted.
21. Remove the wire jumper installed in step 1.

I. *Loop Gain Adjustment*

1. Connect the receiver to the loop alignment setup shown in figure 4-4-9.
2. Set the signal generator and the frequency selectors to 300 KHz.
3. Adjust the signal generator output attenuator and modulation controls to produce a 100 uv/meter signal strength in the ADF simulator and 30% modulation at 1 KHz.

NOTE: Signal strength in the ADF simulator is dependent upon the calibration of the simulator itself. To determine the exact generator output level necessary to produce the desired signal strength consult the calibration data contained in the Owner's Manual for the ADF Simulator. For the CES-116A an approximate 5 to 1 level to signal strength is required, thus making the required generator output level 500 microvolts.

4. Set the function switch to ADF.
5. Adjust R172, the Loop Gain Control, for a 6 db (S + N)/N noise figure as indicated on the AC VTVM by switching the audio modulation off and on.

J. *Goniometer Pointer Adjustment*

NOTE: The following adjustment should only be performed if the indicator has been disassembled. This procedure is used to realign the pointer needle if either the pointer disc, the goniometer, or the goniometer drive shaft have been separated from the other parts.

1. Connect the SIGMA/1500 to the Loop Alignment Setup of Figure 4-4-9.
2. Set the signal generator to 500 KHz and apply a 500 uv/mtr signal to the system.
3. Tune the ADF to 500 KHz and place the function selector in the ADF position.
4. Remove the top cover of the indicator as described in Section 4-6, Part C.
5. Loosen the large screw on the goniometer mounting bracket.
6. Set the simulator to a 0° heading and rotate the indicator azimuth card until the 0° mark lines up with the top lubber on the dial.
7. Rotate the goniometer within the mounting bracket until the pointer needle lines up with the 0° mark on the azimuth card and the lubber line.
8. Press the goniometer firmly against the gear mounting bracket and tighten the goniometer mounting bracket screw.

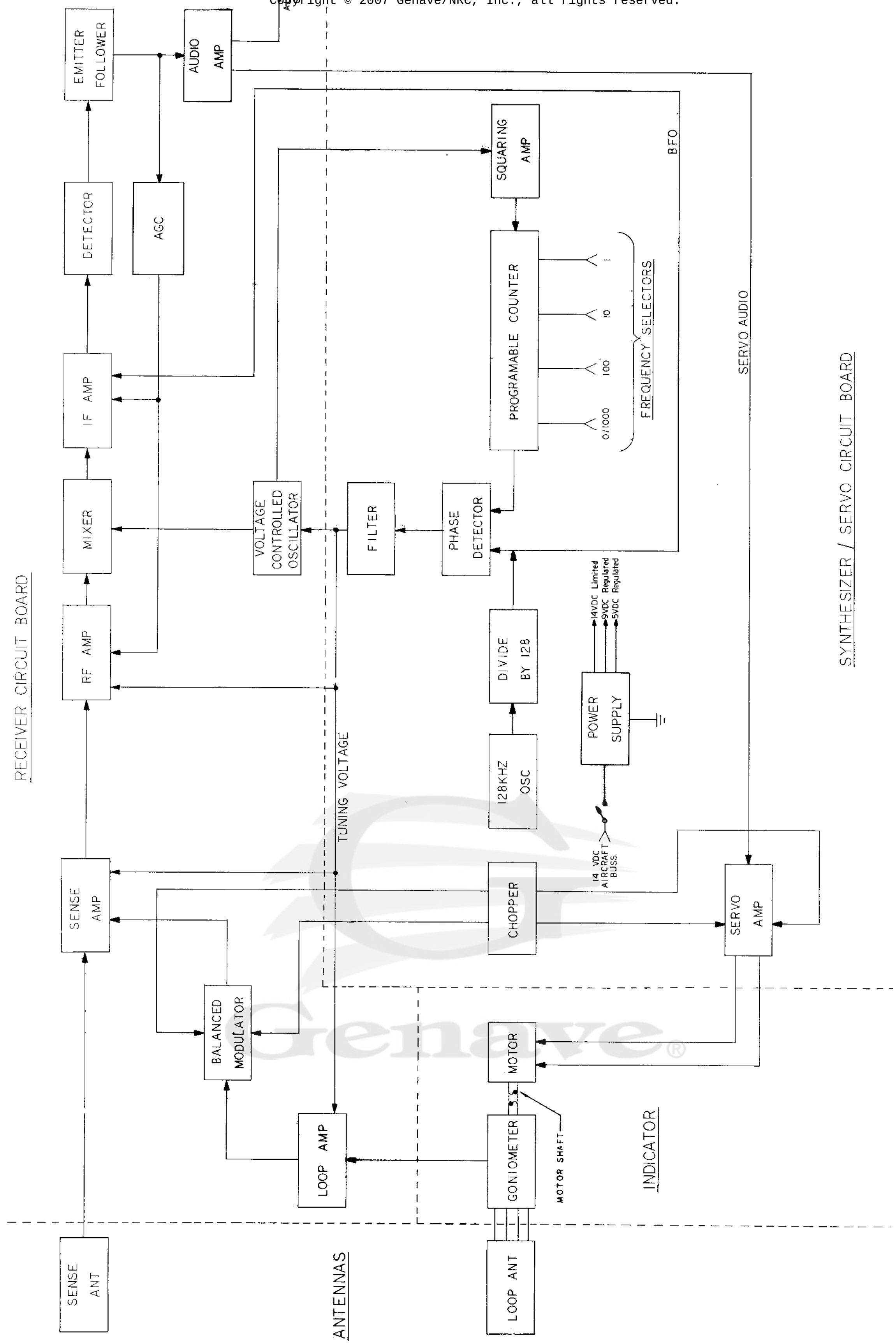

Figure 4-4-1
BLOCK DIAGRAM

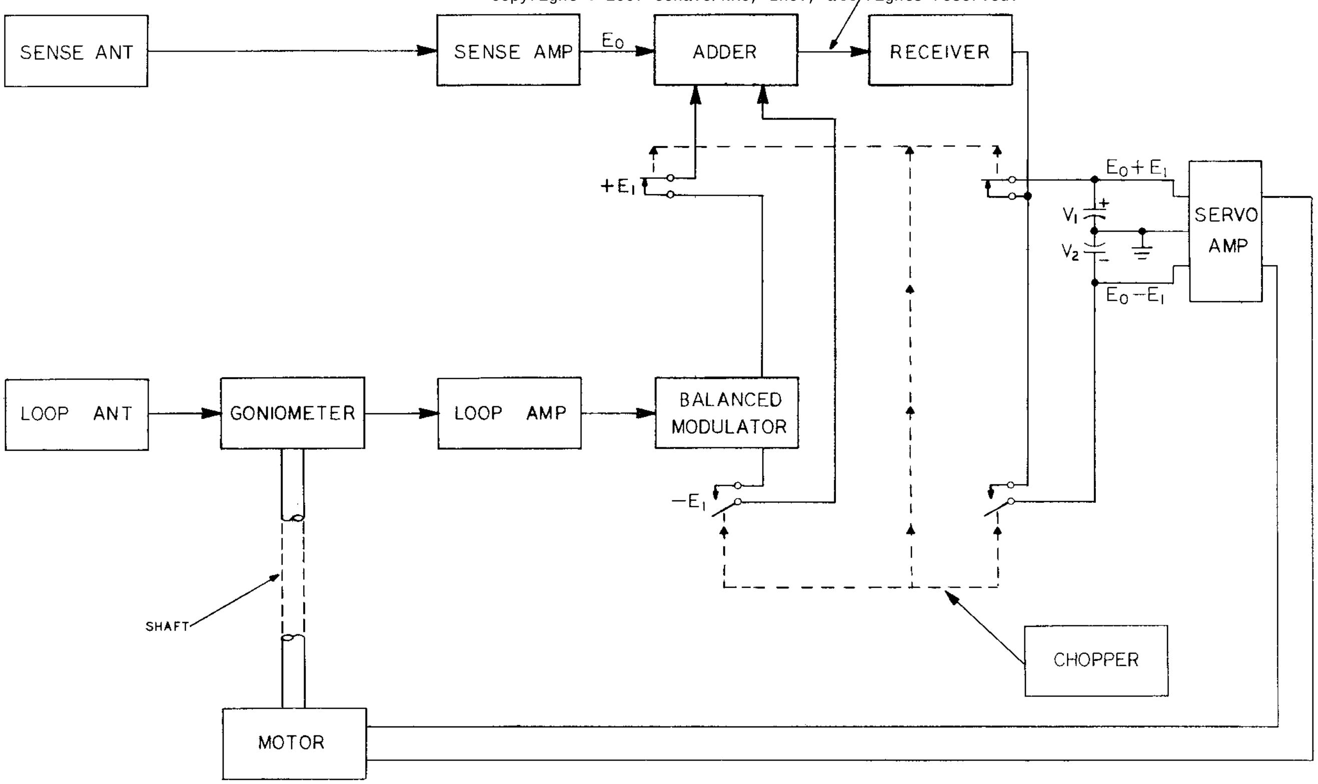

Figure 4-4-2
BASIC ADF SYSTEM

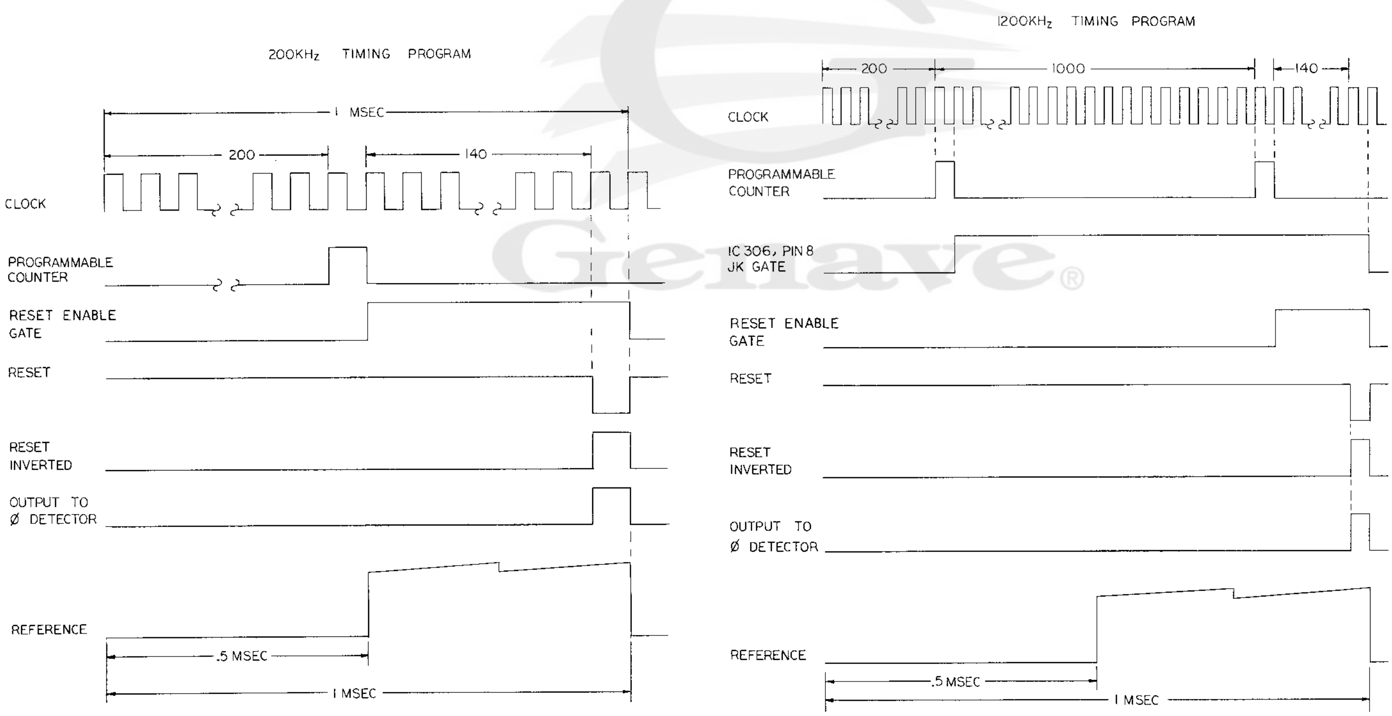

Figure 4-4-3
SYNTHESIZER TIMING DIAGRAMS

BANDSWITCHING TRUTH TABLE

SECTION	DEVICE	BAND A 200-399KHz	BAND B 400-799KHz	BAND C 800-1699KHz
Enable Lines	B Enable	Gnd	+9V	+9V
	C Enable	Gnd	Gnd	+9V
Loop Amp	Q118	OFF	OFF	ON
	Q119	OFF	ON	ON
	Q134	ON	ON	OFF
	Q135	ON	OFF	OFF
Phase Correction	Q122	ON	OFF	OFF
	Q123	ON	ON	OFF
Sense Amp	Q101	OFF	OFF	ON
	Q102	OFF	ON	ON
	Q128	ON	ON	OFF
	Q129	ON	OFF	OFF
LC Bandshaping	Q138	ON	ON	OFF
	Q139	ON	OFF	OFF
RF Amp	Q106	OFF	OFF	ON
	Q107	OFF	ON	ON
	Q130	ON	ON	OFF
	Q131	ON	OFF	OFF
	Q108	OFF	OFF	ON
	Q109	OFF	ON	ON
	Q133	ON	ON	OFF
	Q132	ON	OFF	OFF
VCO	Q202	OFF	OFF	ON
	Q203	OFF	ON	ON
	Q136	ON	ON	OFF
	Q137	ON	OFF	OFF
	Q204	OFF	OFF	ON
	Q205	OFF	ON	ON

DIVIDER PROGRAMMING

	IC Divider Pin No.	6	5	4	3
Switch Setting (9's Complement)	0	1	0	0	1
	1	1	0	0	0
	2	0	1	1	1
	3	0	1	1	0
	4	0	1	0	1
	5	0	1	0	0
	6	0	0	1	1
	7	0	0	1	0
	8	0	0	0	1
	9	0	0	0	0

1 = Pin Open
0 = Pin Grounded

Figure 4-4-5
DIVIDER PROGRAMING

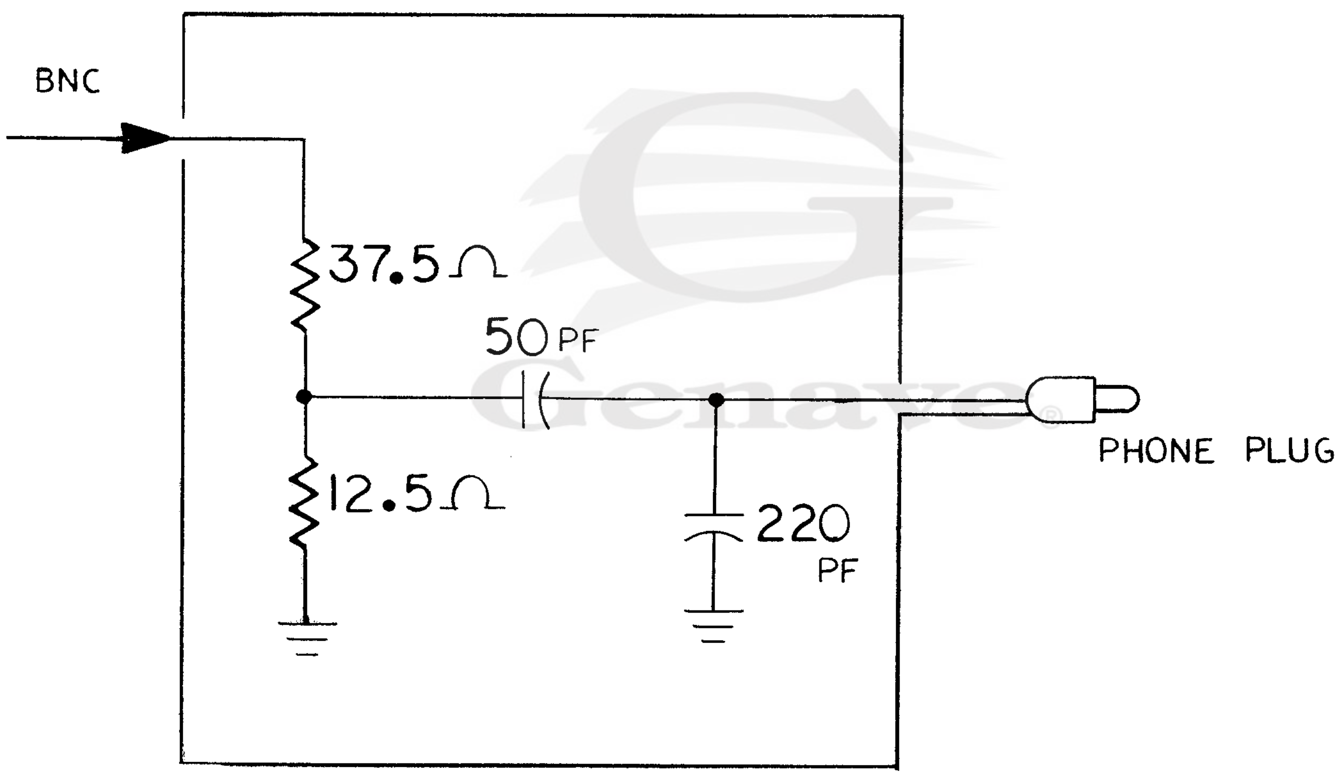

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Figure 4-4-6
SENSE ADAPTER

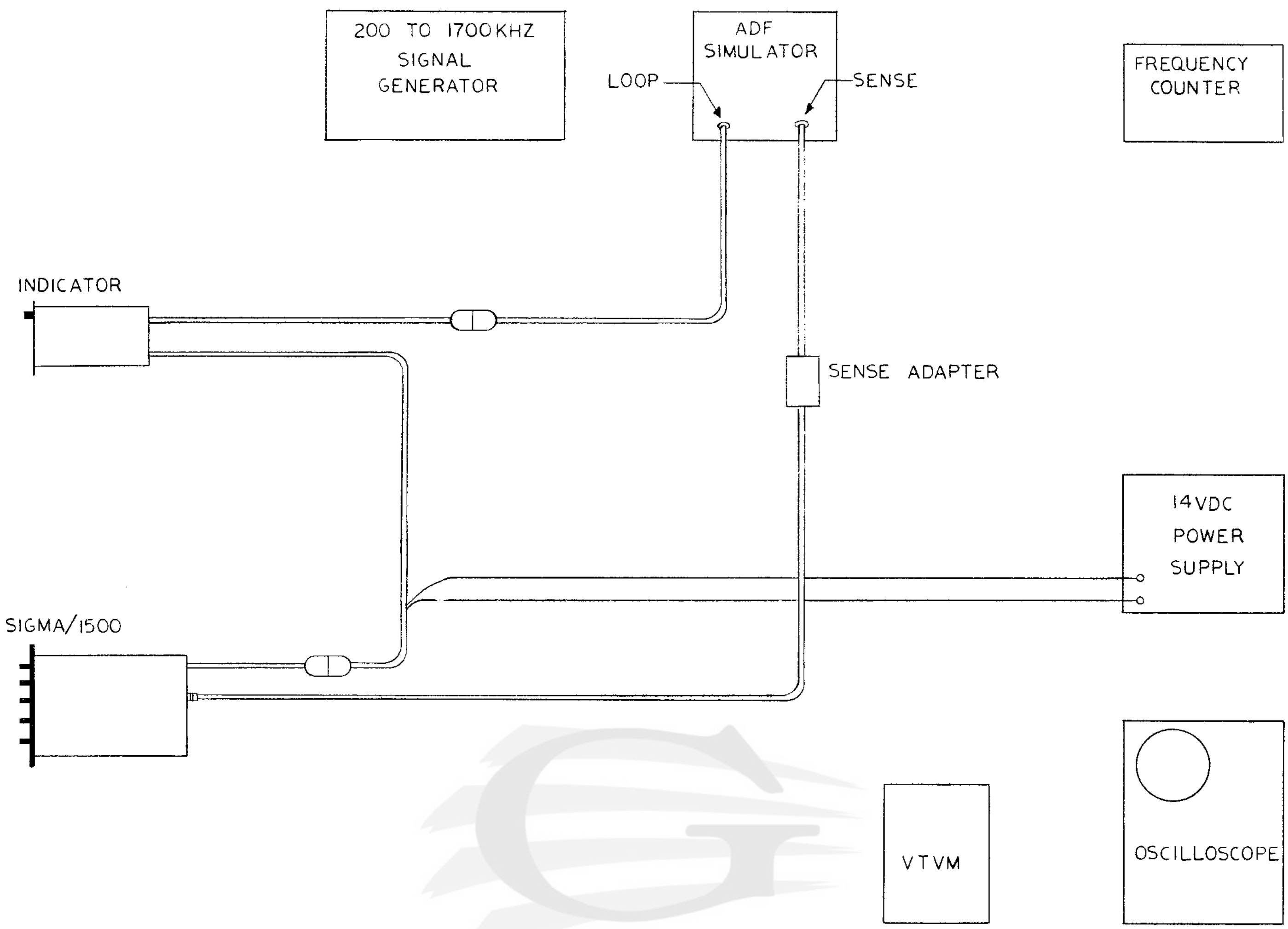

Figure 4-4-7
RECEIVER ALIGNMENT SETUP

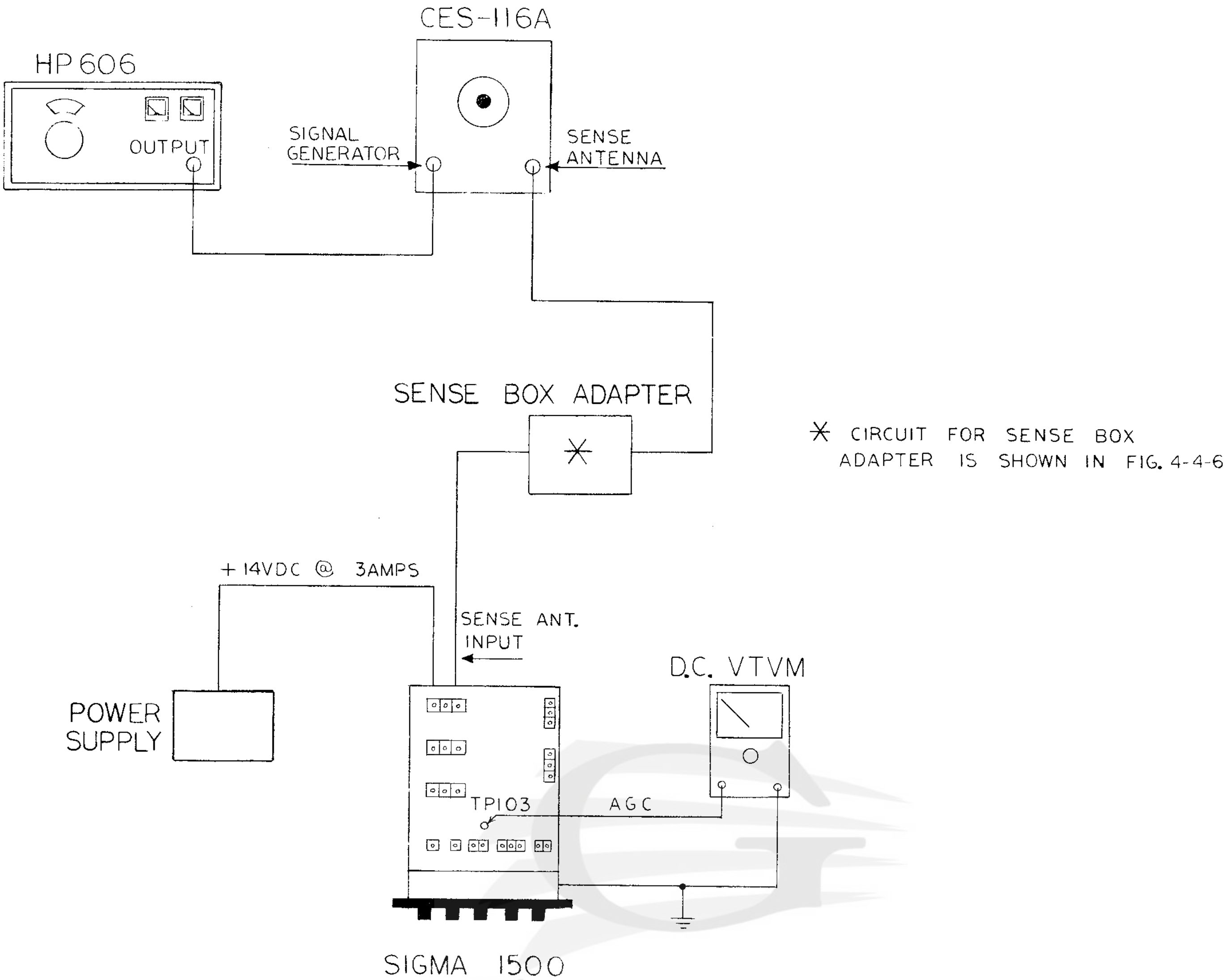

Figure 4-4-8
SENSE ALIGNMENT SETUP

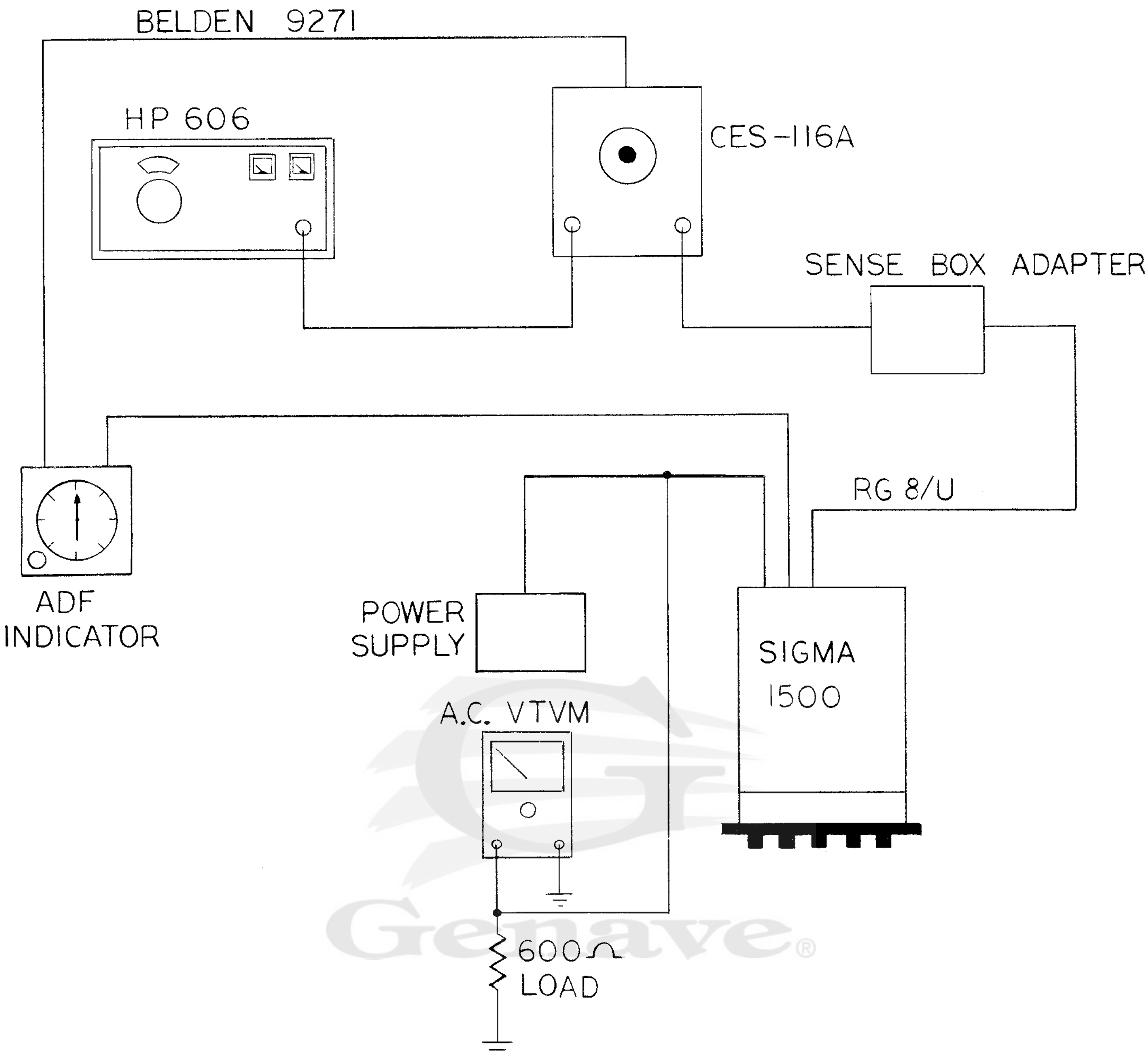

Figure 4-4-9
LOOP ALIGNMENT SETUP

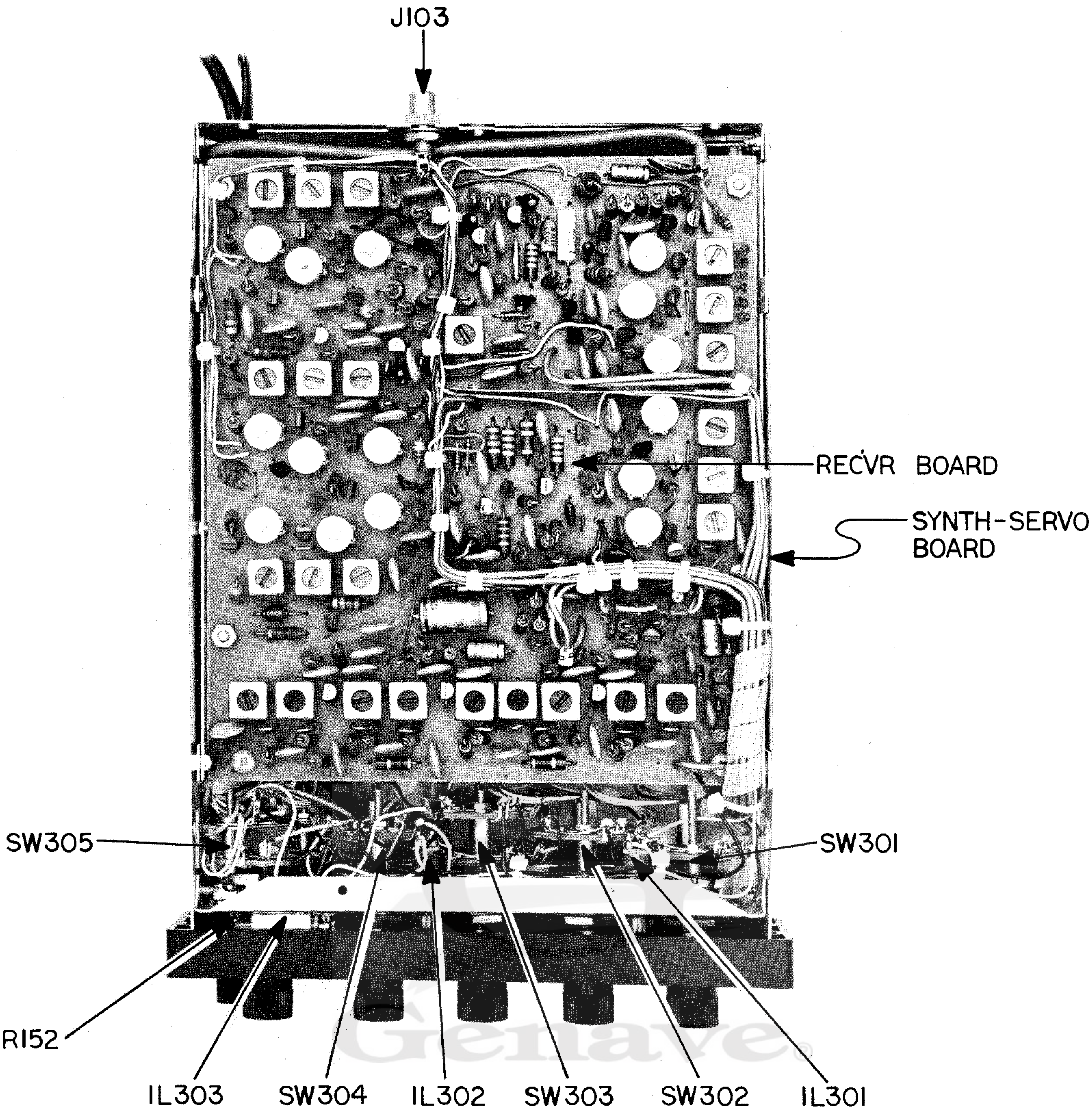

Figure 4-4-10
RADIO, TOP VIEW

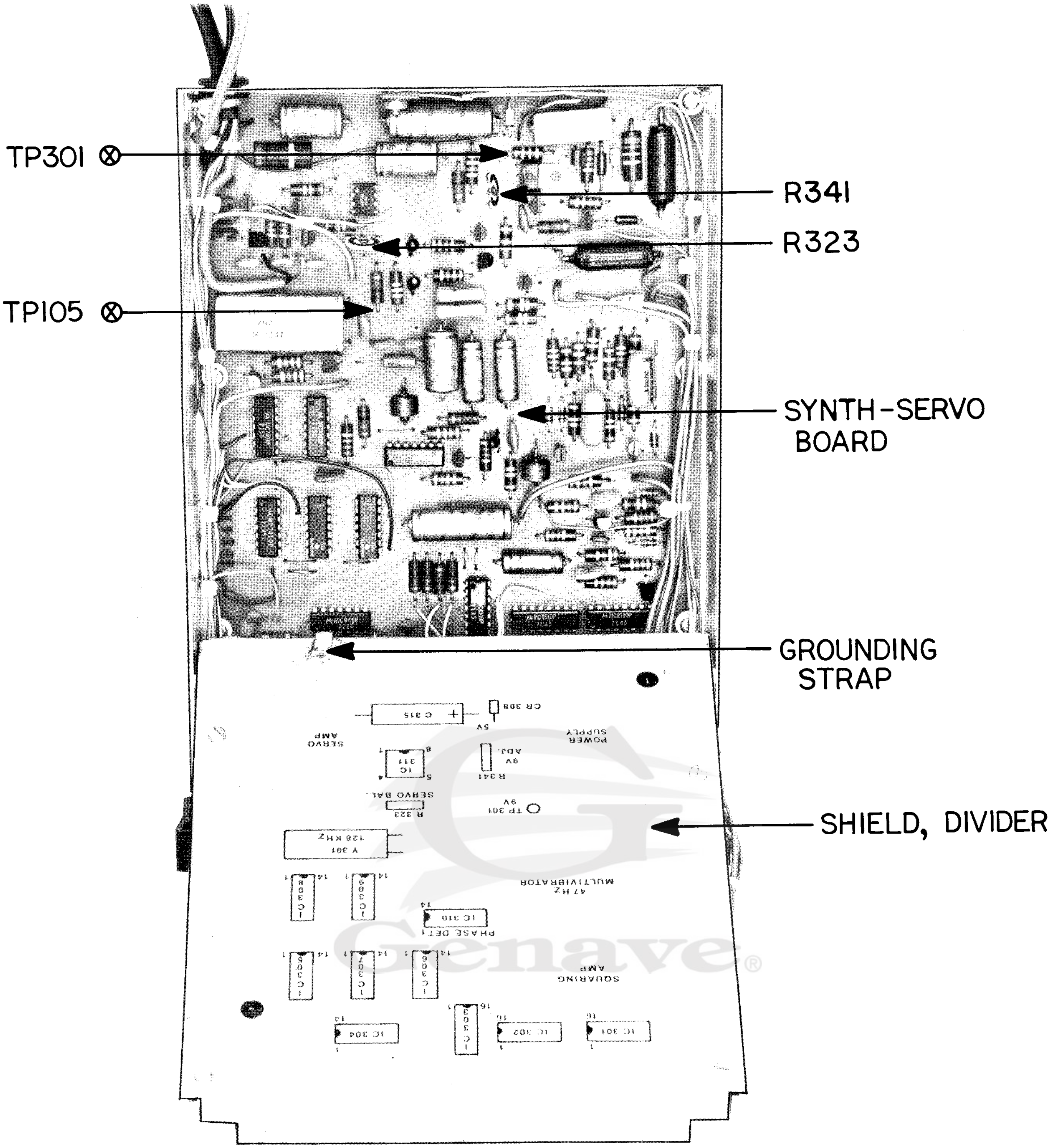

Figure 4-4-11
RADIO, TOP VIEW
Rcvr. Board Open

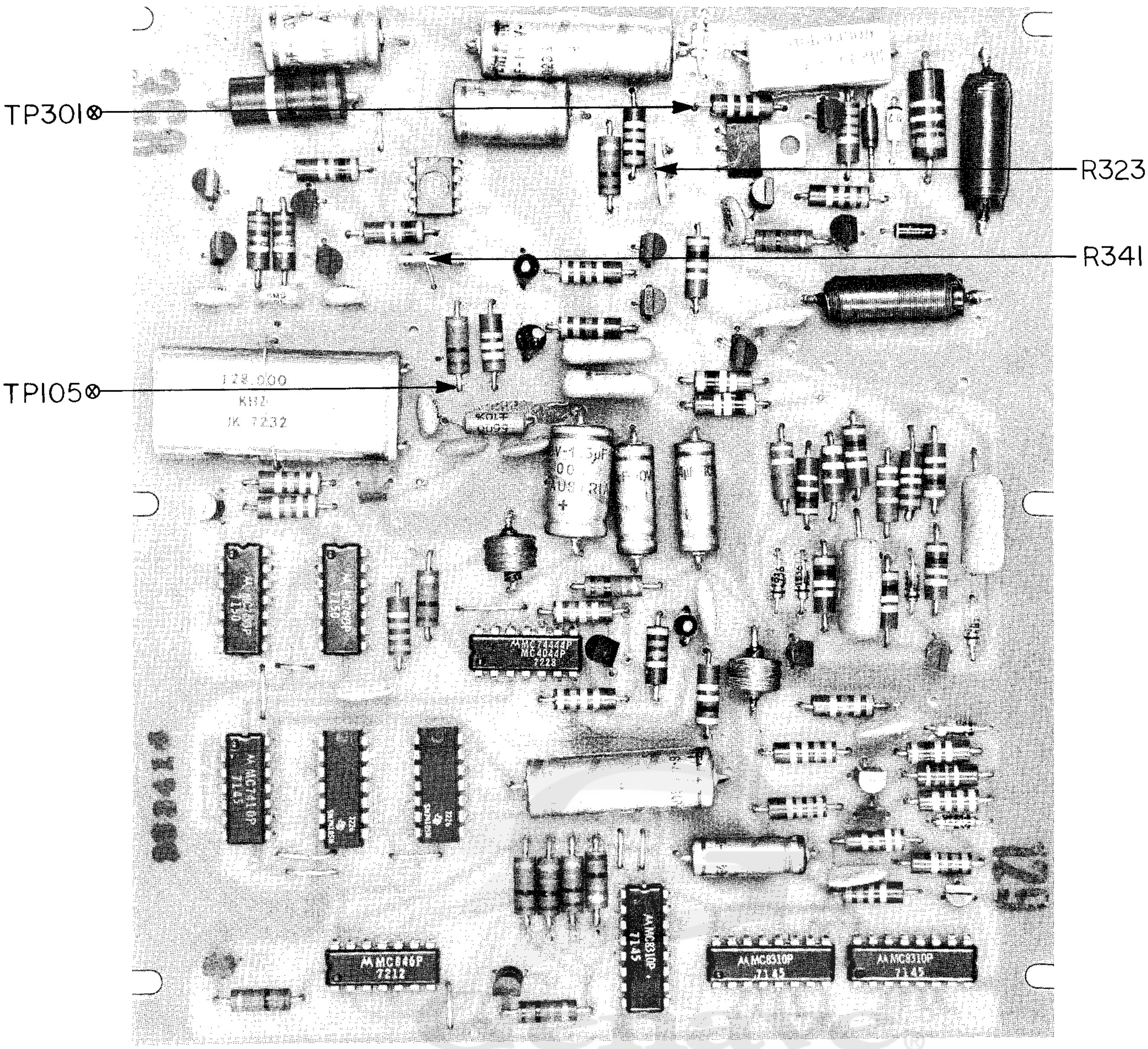

Figure 4-4-12
SYNTHESIZER/SERVO BOARD ALIGNMENT ADJUSTMENTS

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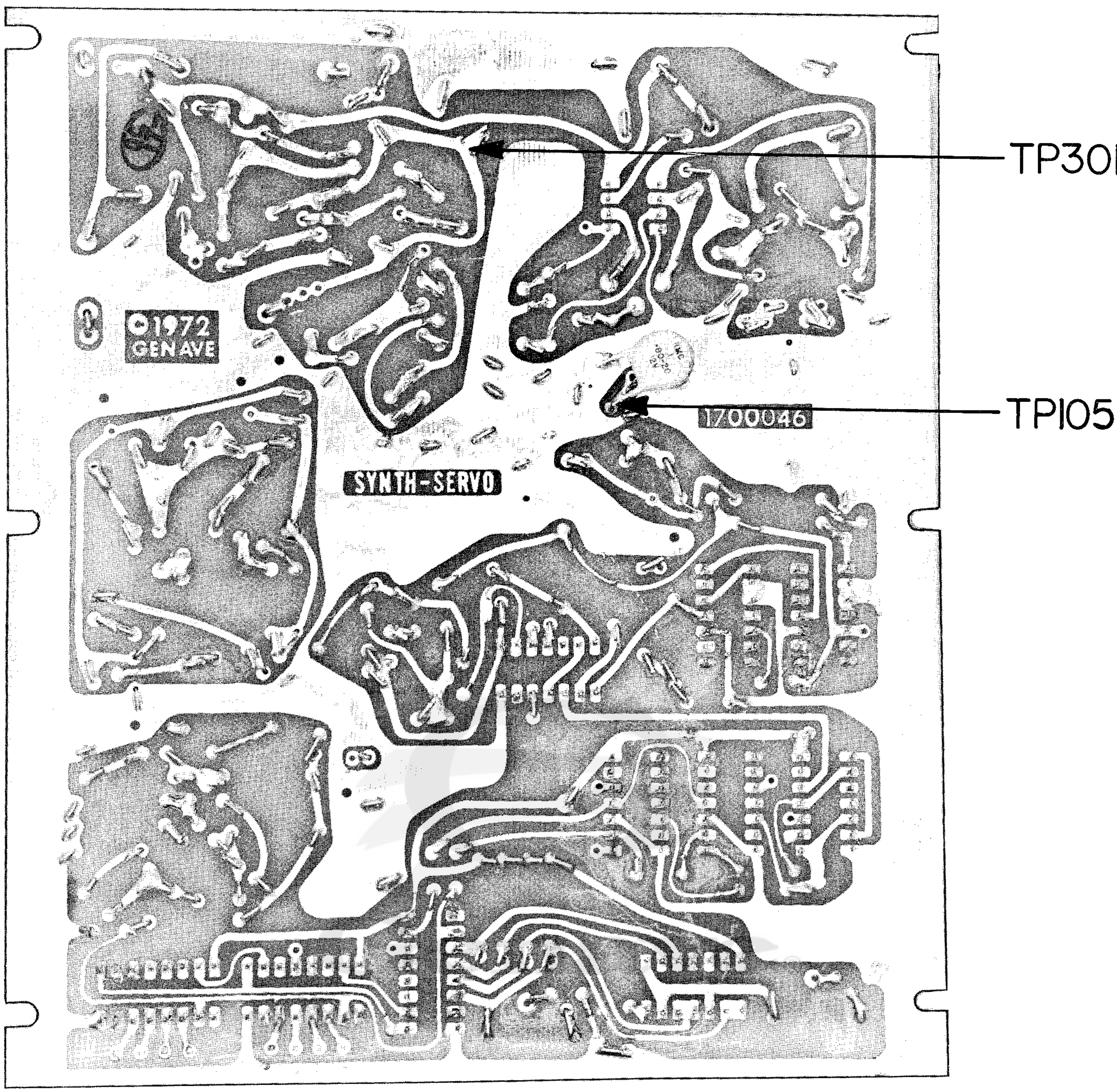

Figure 4-4-13
SYNTHESIZER/SERVO BOARD TEST POINTS

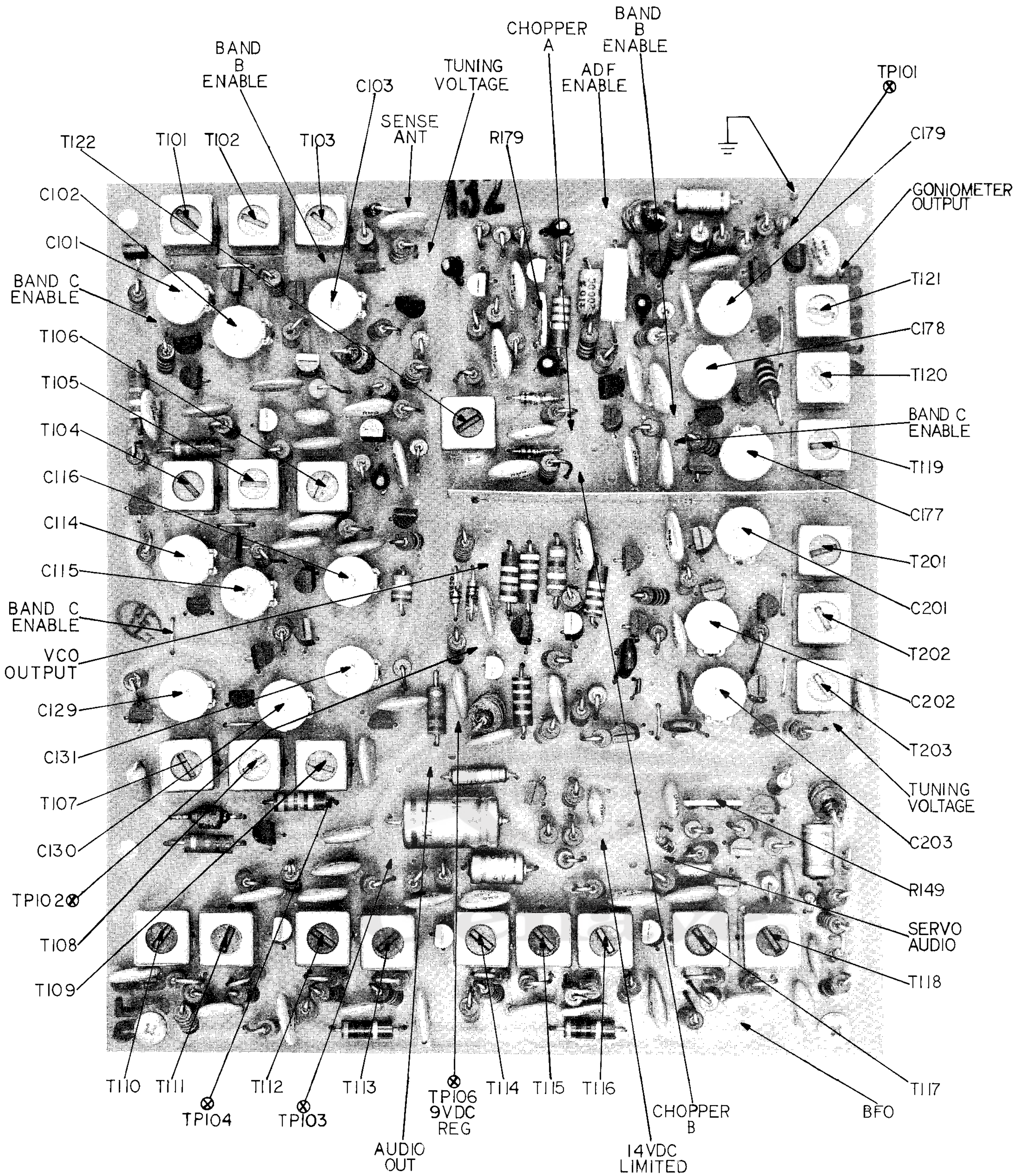

Figure 4-4-14.
RECEIVER BOARD
ALIGNMENT ADJUSTMENTS

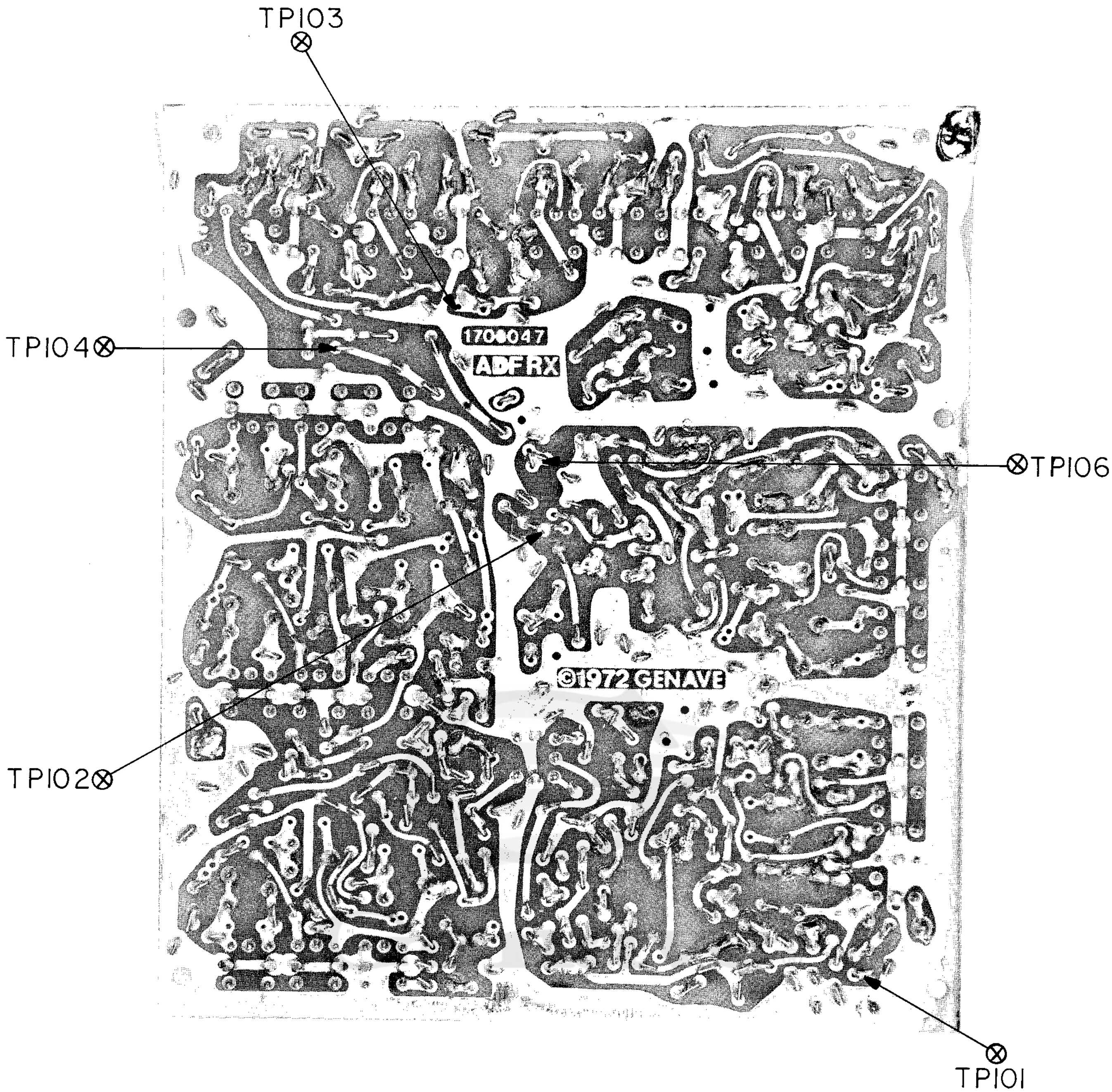

Figure 4-4-15
RECEIVER BOARD
TEST POINTS

Model: SIGMA/1500

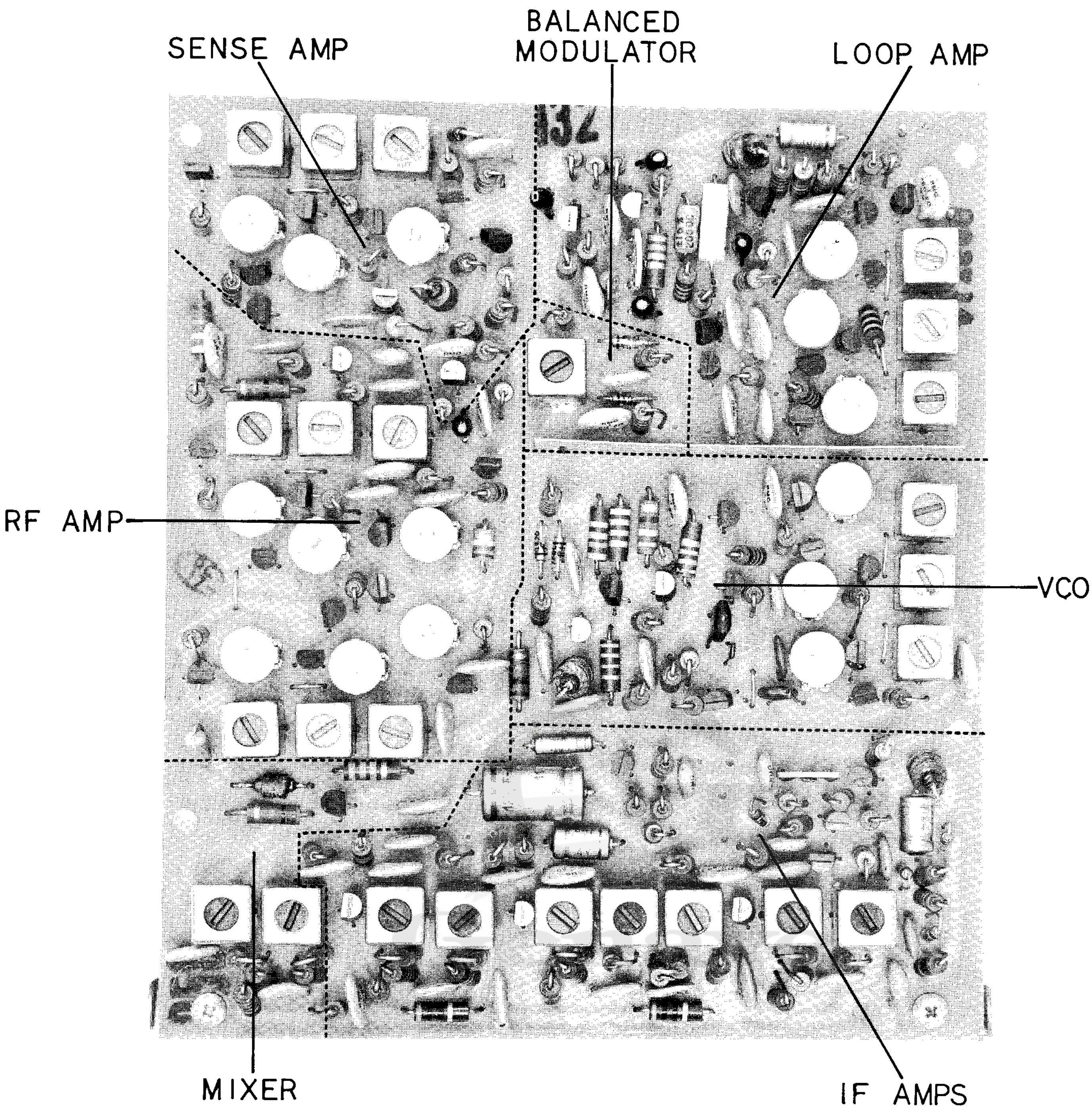

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Figure 4-4-16
RECEIVER BOARD
CIRCUIT SECTION LOCATION

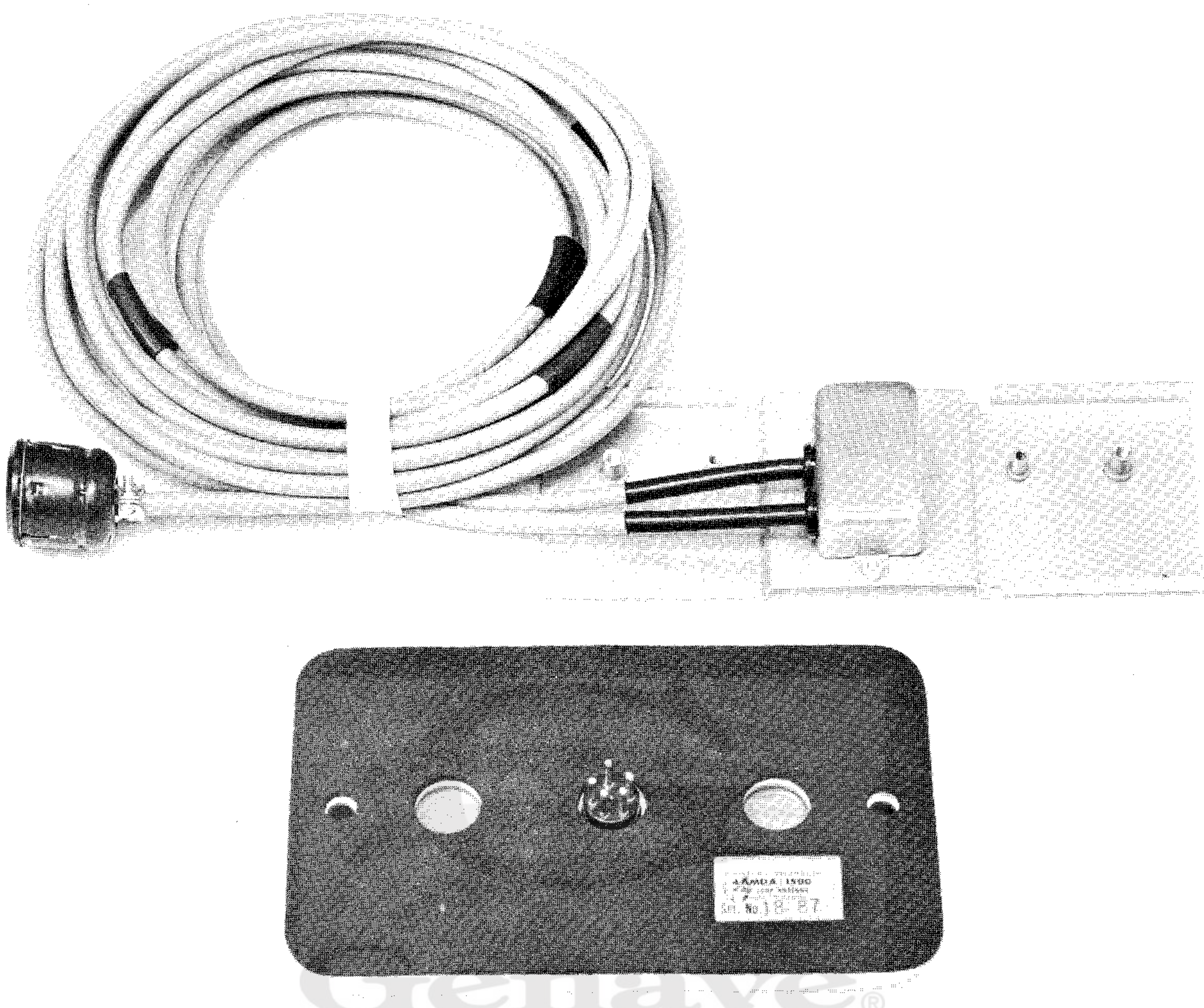

Figure 4-4-17
LOOP ANTENNA
LAMBDA/1500

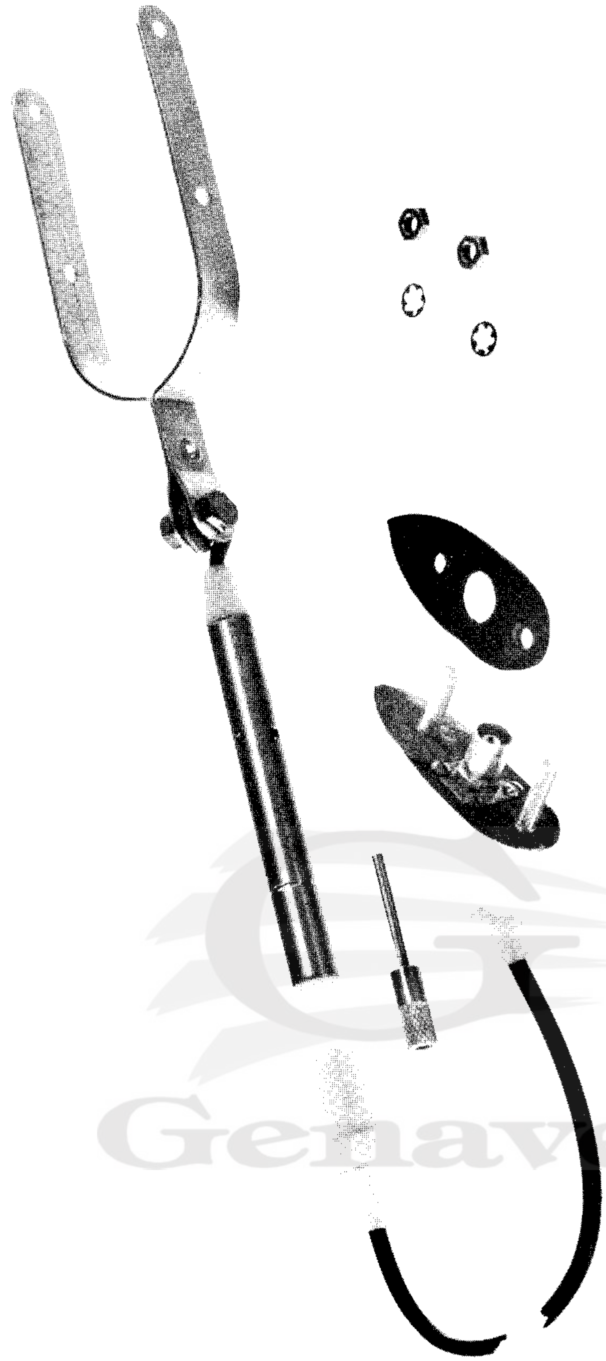

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Figure 4-4-18
SENSE ANTENNA
LAMBDA/50

4-5. TROUBLESHOOTING INFORMATION

I. General

It is assumed that the technician performing any troubleshooting or repair work on this unit is familiar with the principles of aviation electronics and the procedures of troubleshooting electronic equipment. It is further assumed that he has a working knowledge of transistorized circuitry and the use of all the normal test equipment found in the field.

The primary aids to troubleshooting the receiver are the DC Voltage Measurements given in Figure 4-5-1, the DC Bandswitching Voltages of Figure 4-5-2, the Synthesizer/Servo Waveforms (Figures 4-5-3 through 4-5-14), the Receiver Schematics (Figures 4-5-15 through 4-5-18), the Parts/Track Maps (Figures 4-5-19 and 4-5-20), and the Component Location Diagrams (Figures 4-5-21 and 4-5-22).

The above aids should help to locate any problem area and facilitate its repair. The Specialized Procedures of Section 4-6 should prove helpful in some cases requiring mechanical disassembly of the system components. The Parts List of Section V contains the information necessary for selecting replacement parts.

II. Table of Figures

Figure 4-5-1
DC VOLTAGE MEASUREMENTS

All voltages shown in this table must be measured with a VTVM. The input voltage to the radio should be set at 13.75 VDC and the 9.0 VDC line should be adjusted to 9.00 VDC. A variation of ±20% of the measured voltage from those listed may be considered normal.

Ref. No.	Setting Control	No Signal Condition			ADF Function 300 KHz signal at 100 uv/m			Notes
		E(S)	B(G)	C(D)	E(S)	B(G)	C(D)	
Q103		8.4	0	1.8	8.4	0	1.8	
Q105		0.4	1.0	8.9	0.3	0.9	8.9	
Q110		1.0	0	8.0	1.0	0	8.0	
Q111		0.6	1.2	7.0	0.3	1.0	7.6	
Q112		0.6	1.2	7.0	0.3	1.0	7.6	
Q113		1.9	2.6	8.0	1.9	2.6	8.0	
Q114		3.2	2.6	0	2.8	2.2	0	
Q115		2.6	3.2	8.5	2.2	2.8	8.5	
Q116		1.7	2.2	8.5	1.3	1.8	8.5	
Q117	Vol CCW	0	1.1	6.0	0	1.0	6.0	1 KHz, 30% Modulation
	Vol CW	0	1.0	6.0	0	1.0	6.0	1 KHz, 30% Modulation
Q120		1.0	0	8.6	1.0	0	8.6	
Q121		0.1	0.7	7.2	0.1	0.7	7.2	
Q122		0.7	0	0	0.7	0	0	
Q125		0.7	0	0	1.0	1.7	7.6	
Q201		1.0	0	8.4	1.0	0	8.4	
Q206		0.4	1.1	7.0	0.5	1.1	7.0	
Q207		7.6	7.0	2.0	7.6	6.9	2.2	
Q301		0	0.1	3.0	0	0.1	3.0	
Q302		0	0.1	3.0	0	0.1	2.8	
Q303		3.4	2.8	0	3.0	2.3	0	Indicator "Locked-On"
Q304		3.4	3.8	3.3	3.0	3.4	3.0	Indicator "Locked-On"
Q305		3.4	3.8	3.3	3.0	3.4	3.0	Indicator "Locked-On"
Q313		—	—	—	—	—	—	Indicator "Locked-On"
		—	—	—	—	—	—	Test Button Depressed
Q314		—	—	0	—	—	0	Indicator "Locked-On"
		—	—	0	—	—	0	Test Button Depressed
Q315		—	—	—	—	—	—	Indicator "Locked-On"
		—	—	—	—	—	—	Test Button Depressed
Q316		—	—	0	—	—	0	Indicator "Locked-On"
		—	—	0	—	—	0	Test Button Depressed
Q317		13.5	13.1	12.6	13.5	13.2	12.6	
Q318		13.1	12.6	9.0	13.2	12.6	9.0	
Q319		5.1	5.7	12.6	5.1	5.7	12.6	
Q320		5.1	5.7	9.0	5.1	5.7	9.0	
Q321		5.0	5.7	8.8	5.0	5.7	9.0	
Q322		3.4	4.0	9.0	3.4		9.0	
Q323		2.6	3.4	2.6	2.6	3.3	2.6	
Q324		0	0.4	4.2	0	0.4	4.2	
Q325		0	0	2.9	0	0	3.0	
		0	0.6	0	0	0.6	0	Freq. Selectors Set to 199 KHz

Figure 4-5-1
DC VOLTAGE MEASUREMENTS

Q326	0	0	0	0	0	0	
	0	0.6	0	0	0.6	0	Freq. Selectors Set to 1700 KHz
Q327	0.1	0	5.0	0.1	0	5.0	
Q328	0	0.8	2.0	0	0.8	2.0	
Q329	1.3	1.7	9.0	1.3	1.7	9.0	

IC Voltage Measurements

Ref. No.	IC Pin No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
IC301		1.6	4.2	1.2	0	0	1.1	1.6	0	3.4	1.5	.9	1.6	1.6	2.0	.5	5.0
IC302		1.5	4.1	1.1	0	0	1.1	1.3	0	3.4	.5	.7	1.2	1.8	2.2	.2	5.0
IC303		1.6	4.1	5.0	0	0	2.9	.7	0	3.4	.1	.1	.1	.1	1.4	.2	5.0
IC304		2.9	2.9	.1	0	0	.1	0	.1	0	5.0	.1	2.0	2.0	5.0	—	—
IC305		.1	4.4	1.7	1.7	3.4	.1	0	3.4	1.2	1.4	4.4	3.6	.6	5.0	—	—
IC306		.3	1.6	0	0	3.4	0	0	4.4	4.1	0	.1	0	.2	5.0	—	—
IC307		1.3	1.7	4.4	1.3	3.4	.2	0	4.4	4.1	0	.1	1.3	1.3	5.0	—	—
IC308		2.0	0	0	0	5.0	0	0	1.9	1.9	0	1.8	3.4	0	2.1	—	—
IC309		1.9	0	0	0	5.0	0	0	1.9	1.9	0	1.7	1.9	0	1.8	—	—
IC310		1.7	.4	3.6	3.7	2.2	2.0	0	.8	1.6	2.2	.4	4.0	3.7	5.0	—	—
IC311		.6	8.7	2.1	0	.1	8.7	.6	13.7	—	—	—	—	—	—	—	—

Figure 4-5-2
DC BANDSWITCHING VOLTAGES

All voltages shown in this table must be measured with a VTVM. The input voltage to the radio should be set at 13.75 VDC and the 9.0 VDC line should be adjusted to 9.00 VDC. All voltages taken with no signal input. A variation of ± 20% of the measured voltage from those listed may be considered normal.

Ref. No.	Band A (200-399 KHz)			Band B (400-799 KHz)			Band C (800-1699 KHz)			Notes
	E(S)	B(G)	C(D)	E(S)	B(G)	C(D)	E(S)	B(G)	C(D)	
Q101	0	0	0	0	0	0	0	0.7	0	
Q102	0	0	0	0	0.7	0	0	0.7	0	
Q107	0	0	0	0	0.7	0	0	0.7	0	
Q108	0	0	0	0	0.7	0	0	0.7	0	
Q109	0	0	0	0	0	0	0	0.7	0	
Q118	0	0	0	0	0	0	0	0.7	0	
Q119	0	0	0	0	0.7	0	0	0.7	0	
Q122	0.7	0	0	8.5	8.9	0	8.7	8.8	0	
Q123	0.7	0	0	0.7	0	0	8.7	8.8	0	
Q129	0	0	0	0	8.8	0	0	8.8	0	
Q130	0	0	0	0	0	0	0	8.8	0	
Q131	0	0	0	0	8.8	0	0	8.8	0	
Q132	0	0	0	0	8.8	0	0	8.8	0	
Q133	0	0	0	0	0	0	0	8.8	0	
Q135	0	0	0	0	8.8	0	0	8.8	0	
Q137	0	0	0	0	8.8	0	0	8.8	0	
Q138	0.7	0	0	0.7	0	0	8.7	8.8	0	
Q139	0.7	0	0	8.5	8.9	0	8.7	8.8	0	
Q202	0	0	0	0	0	0	0	0.7	0	
Q203	0	0	0	0	0.7	0	0	0.7	0	
Q204	0	0	8.5	0	0	8.2	0	0.7	0	
Q205	0	0	8.5	0	0.7	0	0	0.7	0	
Q106	0	0	0	0	0	0	0	0.7	0	

NOTE: If one of the bandswitching transistors or FET's is suspected as being bad and the bandswitching voltage listed above appears correct, the following method will help to verify the semiconductor's condition.

1. Connect the receiver to the loop alignment setup of Figure 4-4-9.
2. Tune the receiver to the band in which the suspected transistor is to be "turned-on".
3. Apply a low level test signal to the receiver on the selected test frequency.
4. Jumper from emitter to collector, for transistors, or from source to drain, for FET's with a 0.1 Mfd capacitor. If an increase in receiver sensitivity is noted, failure of the suspected semiconductor is indicated.

SYNTHESIZER/SERVO WAVEFORMS

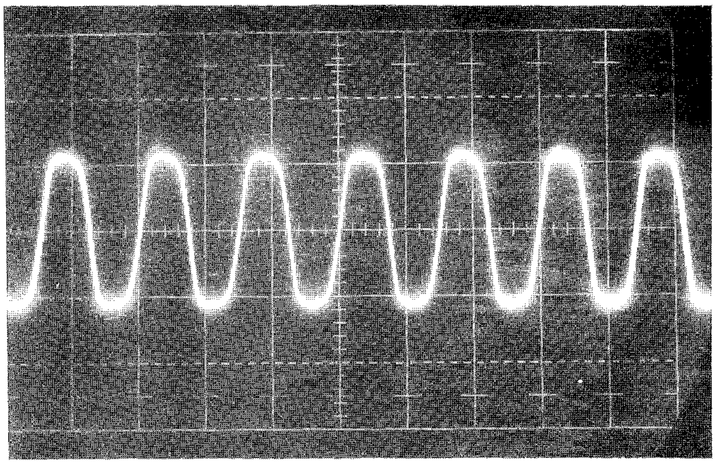


Figure 4-5-3
VCO OUTPUT LINE

Vert. = .5 V/div.
Horiz. = .01 msec./div.
Sync. to IC305 Pin 12
Rec. Freq. = 200 KHz

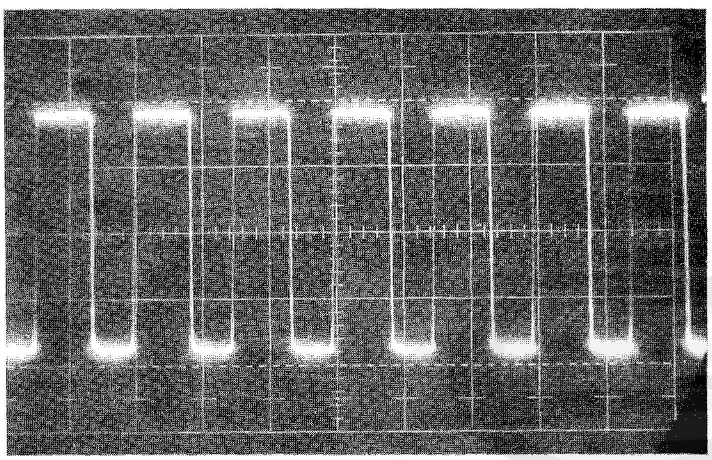


Figure 4-5-4
CLOCK OUTPUT

Vert. = 1 V/div.
Horiz. = .01 msec./div.
Sync. to IC305 Pin 12
Rec. Freq. = 200 KHz

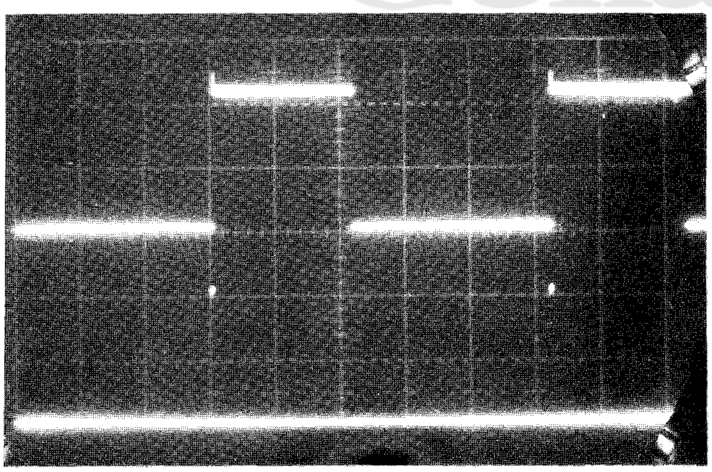


Figure 4-5-5
RESET ENABLE, IC307 Pin 8
TERMINAL COUNT, IC303 Pin 15

Vert. = 2 V/div.
Horiz. = .2 msec./div.
Sync. to IC305 Pin 12
Rec. Freq. = 200 KHz

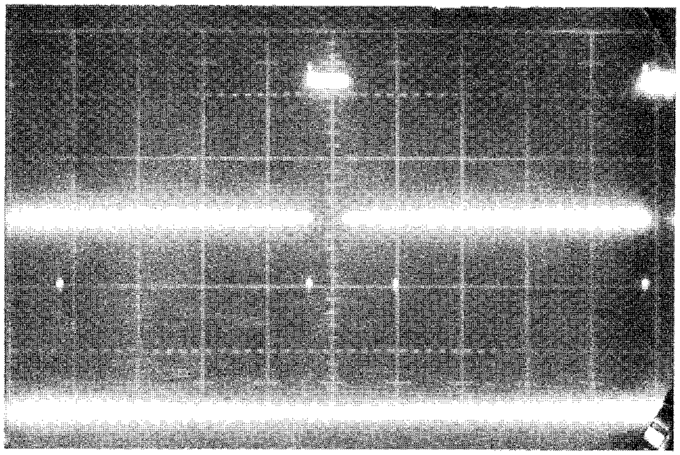


Figure 4-5-6
RESET ENABLE, IC307 Pin 8
TERMINAL COUNT, IC303 Pin 15

Vert. = 2 V/div.
Horiz. = .2 msec./div.
Sync. to IC305 Pin 12
Rec. Freq. = 1200 KHz

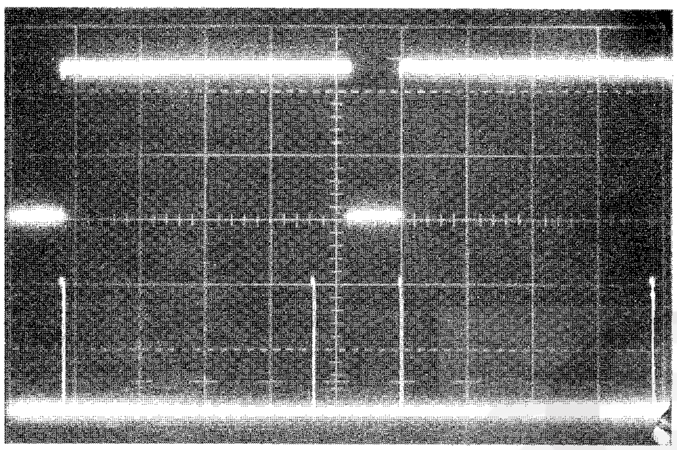


Figure 4-5-7
1 MHz ENABLE, IC306 Pin 8
TERMINAL COUNT, IC303 Pin 15

Vert. = 2 V/div.
Horiz. = .2 msec./div.
Sync. to IC305 Pin 12
Rec. Freq. = 1200 KHz

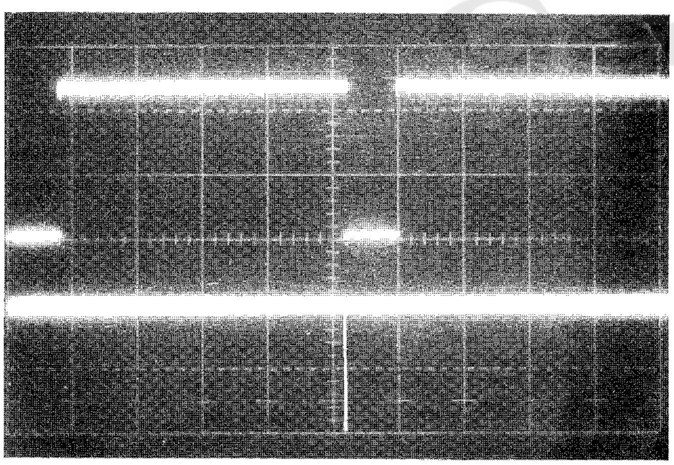


Figure 4-5-8
1 MHz ENABLE, IC306 Pin 8
RESET LINE, IC305 Pin 8

Vert. = 2 V/div.
Horiz. = .2 msec./div.
Sync. to IC305 Pin 12
Rec. Freq. = 1200 KHz

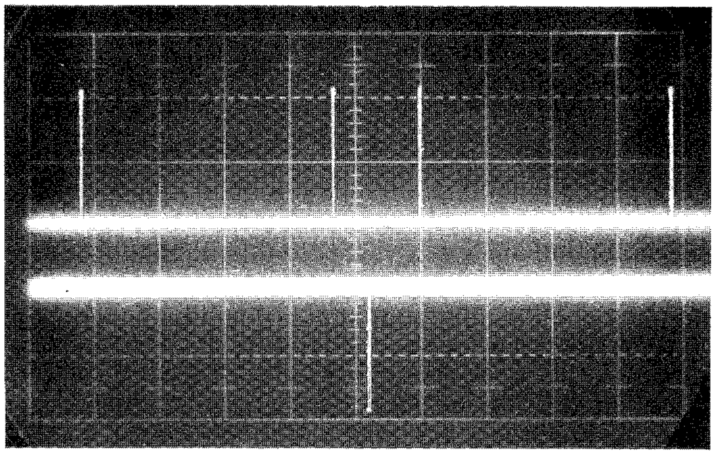


Figure 4-5-9
TERMINAL COUNT, IC303 Pin 15
RESET LINE, IC305 Pin 8

Vert. = 2 V/div.
Horiz. = .2 msec./div.
Sync. to IC305 Pin 12
Rec. Freq. = 1200 KHz

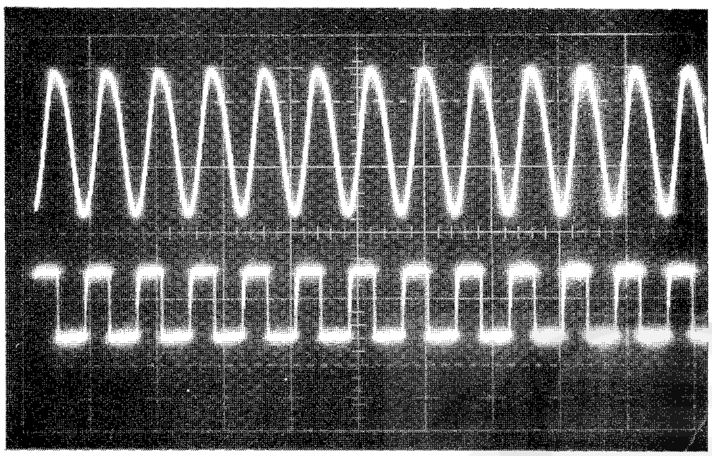


Figure 4-5-10
128 KHz OSCILLATOR
GATE, Q327
COLLECTOR, Q328

Vert. = 5V/div.
Horiz. = 10 usec/div.
Internal Sync.

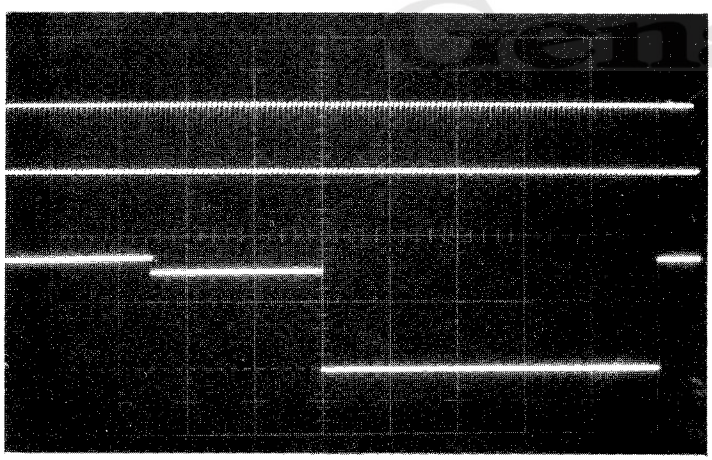


Figure 4-5-11
128 KHz OSC. OUTPUT, COLLECTOR Q328
128 DIVIDER OUTPUT, IC309 Pin 11

Vert. = 5V/div.
Horiz. = .1 msec/div.
Internal Sync.

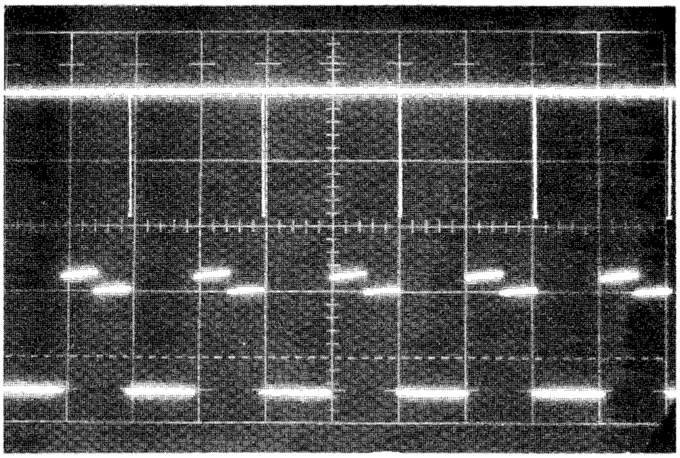


Figure 4-5-12
PHASE DETECTOR INPUTS
IC310 Pin 1
IC310 Pin 3

Vert. = 2 V/div.
Horiz. = .5 msec./div.
Internal Sync.

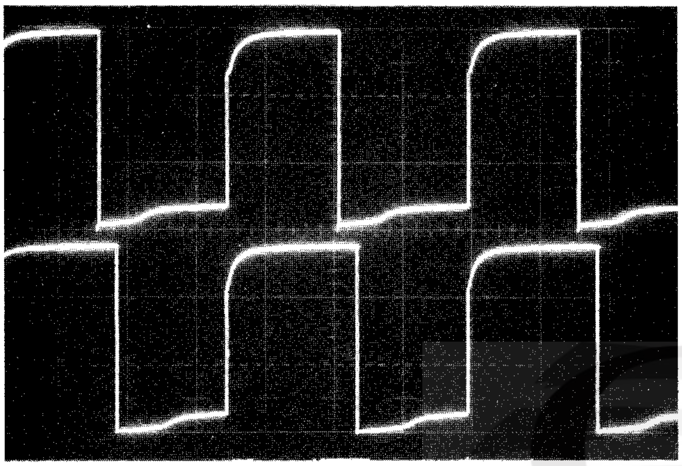


Figure 4-5-13
CHOPPER OUTPUTS
COLLECTOR, Q301
COLLECTOR, Q302

Vert. = 2 V/div.
Horiz. = .5 msec./div.
Internal Sync.

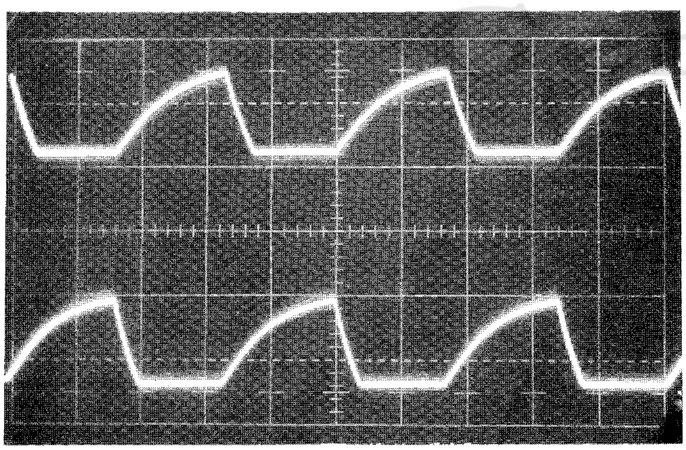


Figure 4-5-14
SERVO AMP. SWITCHING
BASE, Q304
BASE, Q305

Vert. = 2 V/div.
Horiz. = .5 msec./div.
Internal Sync.

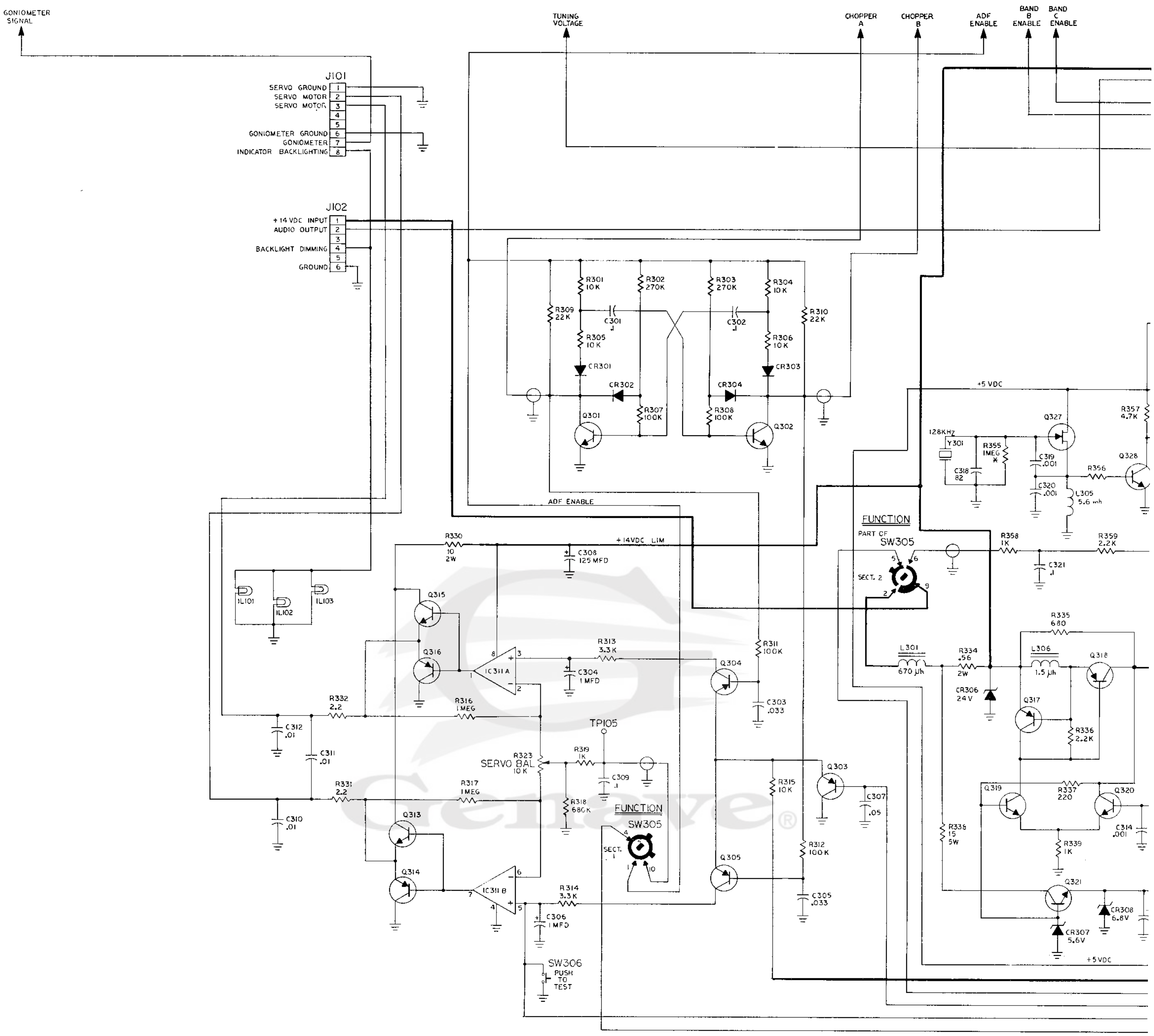
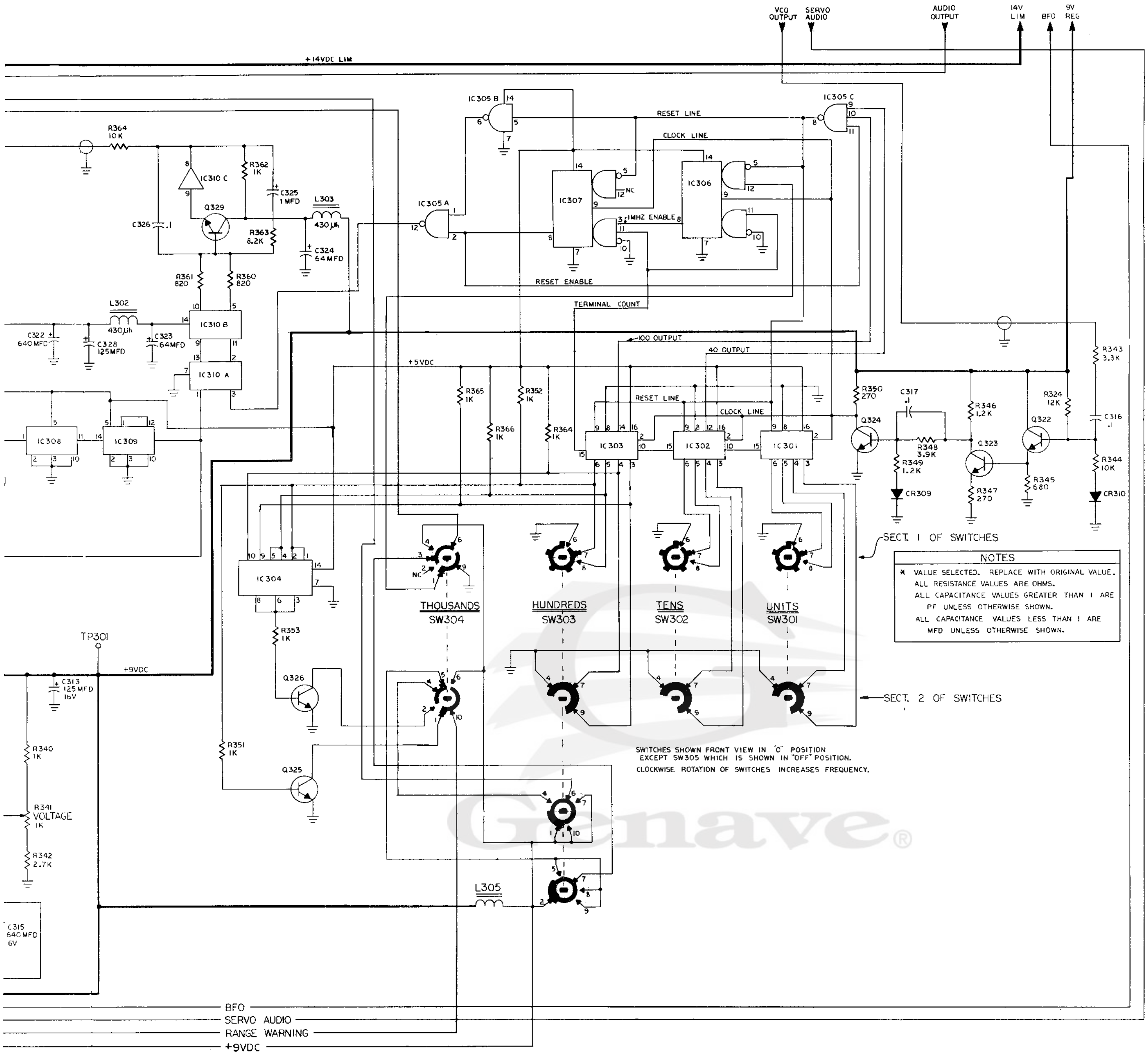
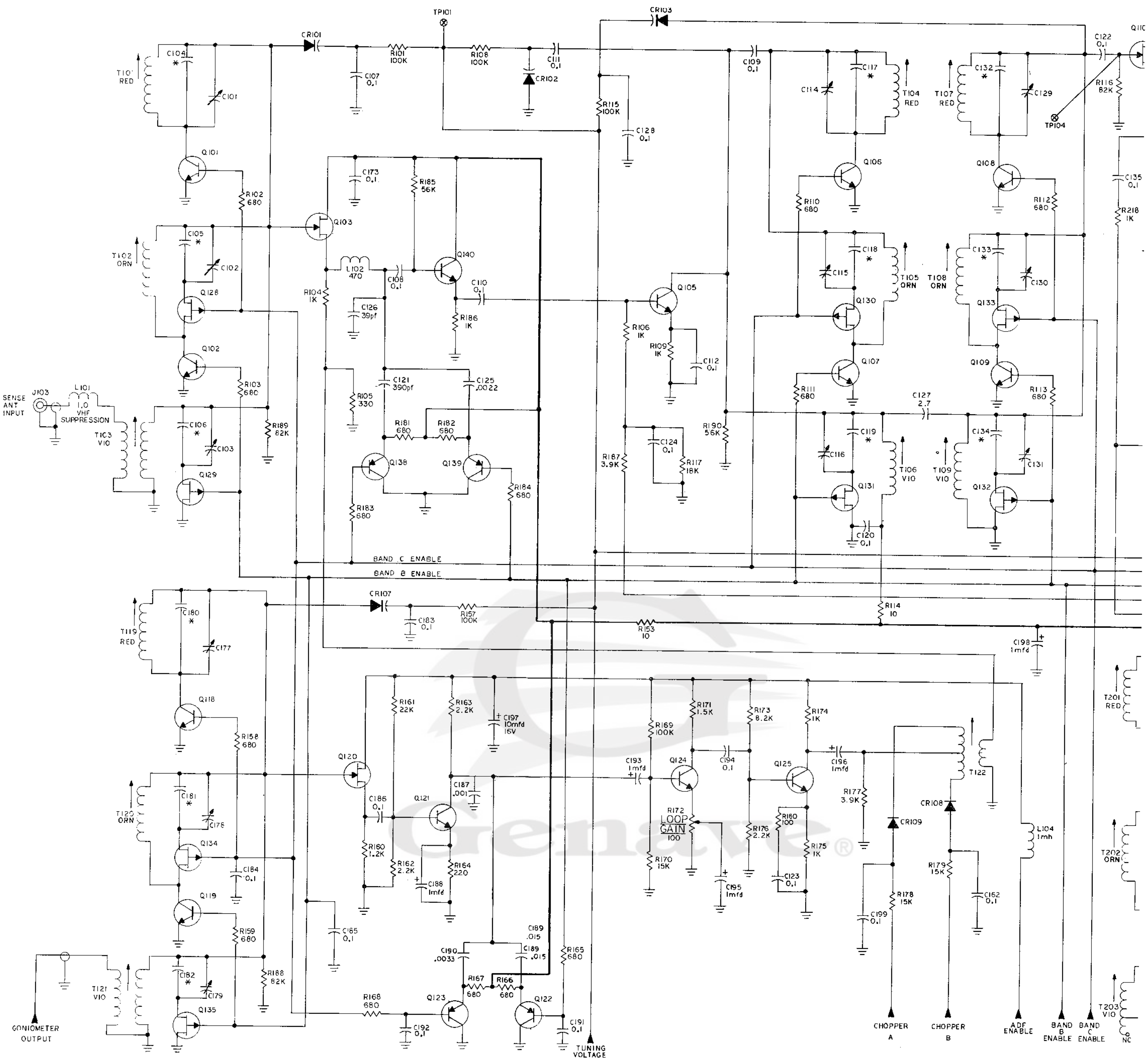


Figure 4-5-16
SCHEMATIC
SYNTHESIZER/SERVO CIRCUIT BOARD



Model: SIGMA/1500


SENSE ANT INPUT
J103
L101 1.0 VHF SUPPRESSION
CR101
TP101
R101 100K
R108 100K
CR102
C111 0.1
CR103
C109 0.1
C122 0.1
R116 82K
TP104
R115 100K
C128 0.1
Q101
Q102
Q103
Q105
Q106
Q107
Q108
Q109
Q128
Q129
Q130
Q131
Q132
Q133
Q138
Q139
Q140
L102 470
C126 39pf
C121 390pf
C125 .0022
R105 330
R181 680
R182 680
R183 680
R184 680
R189 82K
R190 56K
R187 3.9K
R117 18K
C127 2.7
C120 0.1
C135 0.1
R218 1K
BAND C ENABLE
BAND B ENABLE
CR107
R157 100K
R153 10
R114 10
C198 1mfd
Q118
Q119
Q120
Q121
Q122
Q123
Q124
Q125
Q134
Q135
C197 10mfd 16V
R172 LOOP GAIN 100
C193 1mfd
C194 0.1
C195 1mfd
C196 1mfd
T122
CR108
CR109
L104 1mh
R177 3.9K
R178 15K
R179 15K
C162 0.1
C199 0.1
R168 680
R167 680
R166 680
C190 .0033
C189 .015
R165 680
R188 82K
GONIOMETER OUTPUT
TUNING VOLTAGE
CHOPPER A
CHOPPER B
ADF ENABLE
BAND B ENABLE
BAND C ENABLE
T201 RED
T202 ORN
T203 VIO

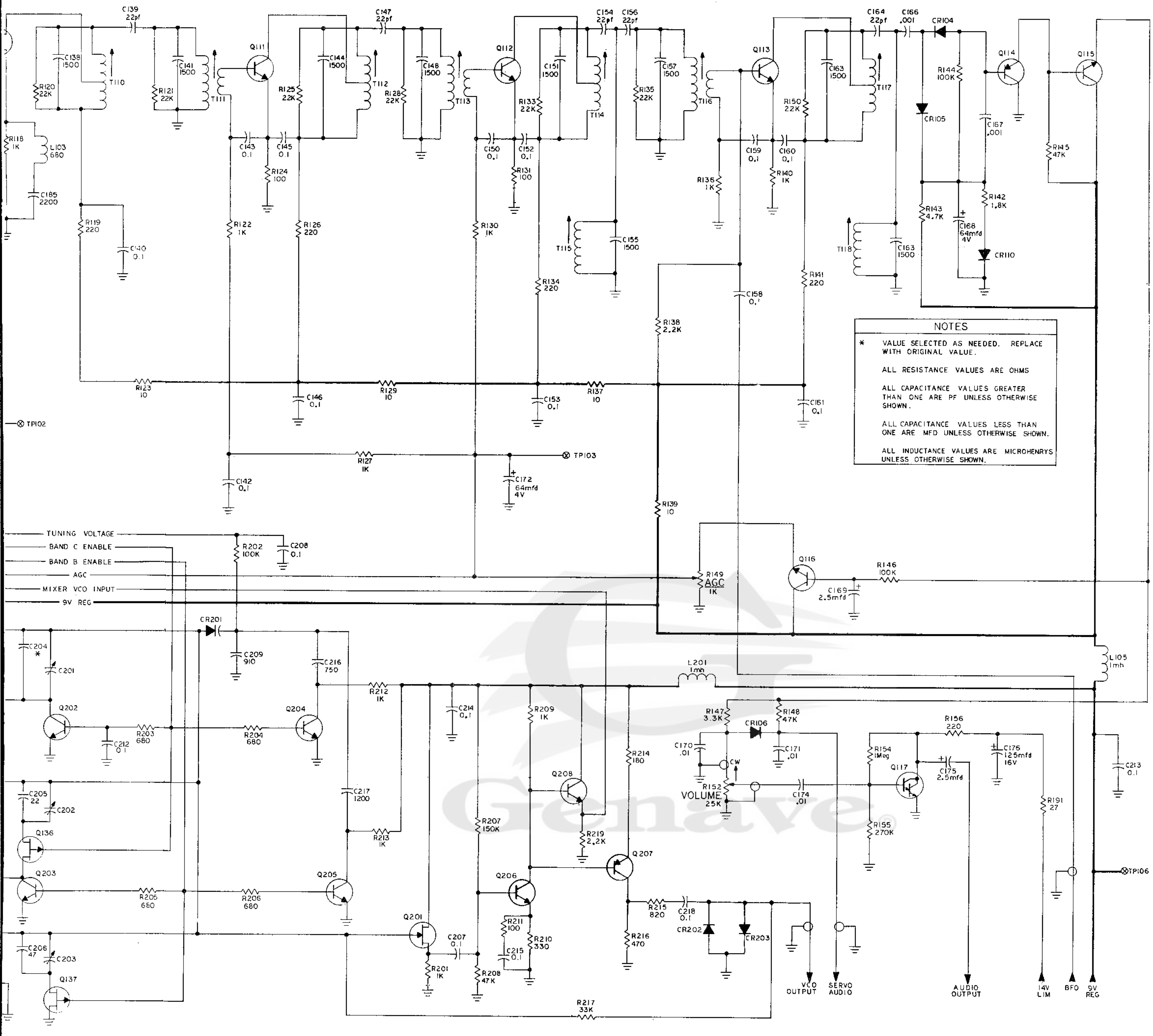


Figure 4-5-15
SCHEMATIC
RECEIVER CIRCUIT BOARD

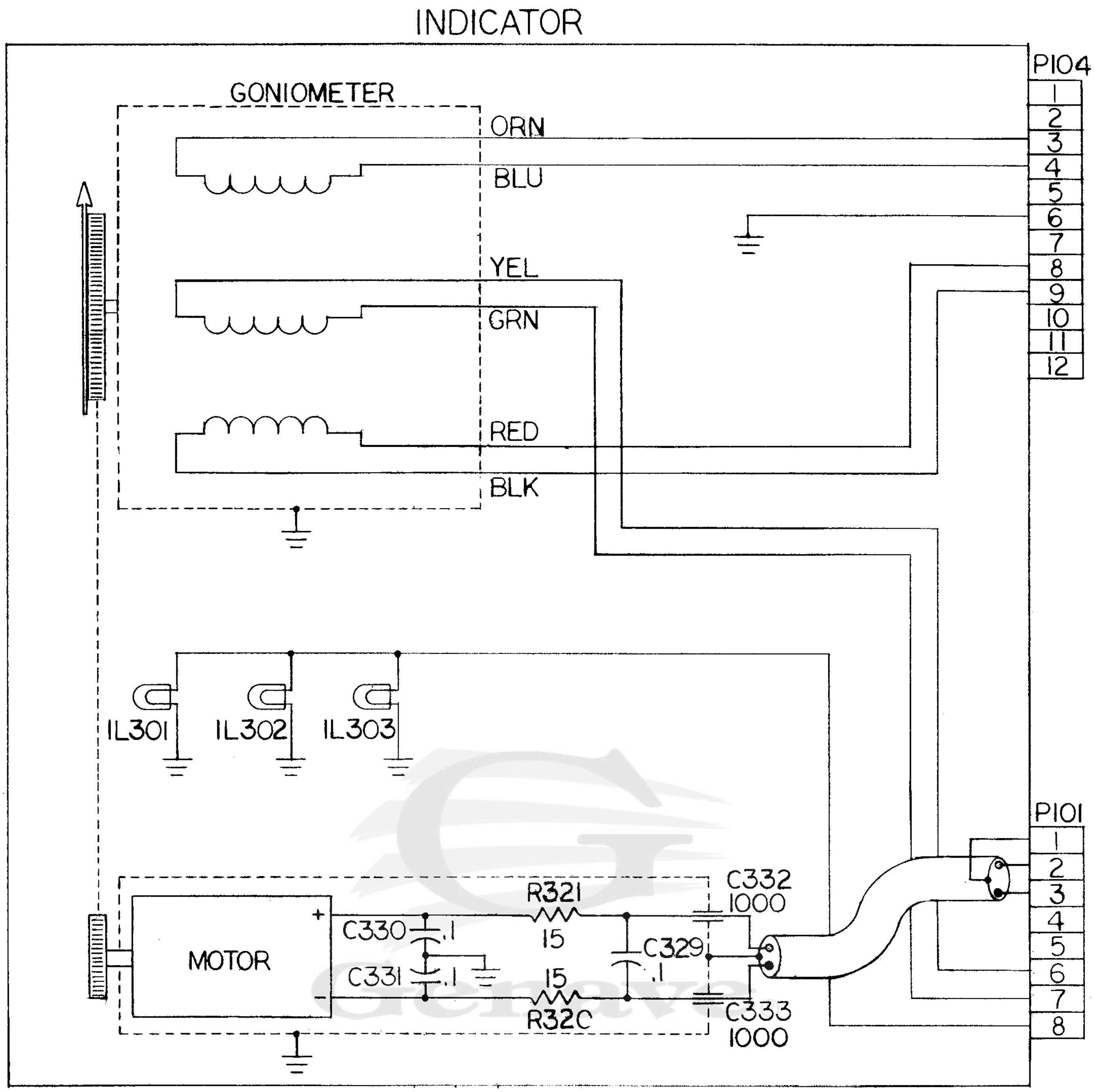


Figure 4-5-17
SCHEMATIC
INDICATOR

LAMBDA/1500 LOOP ASSEMBLY

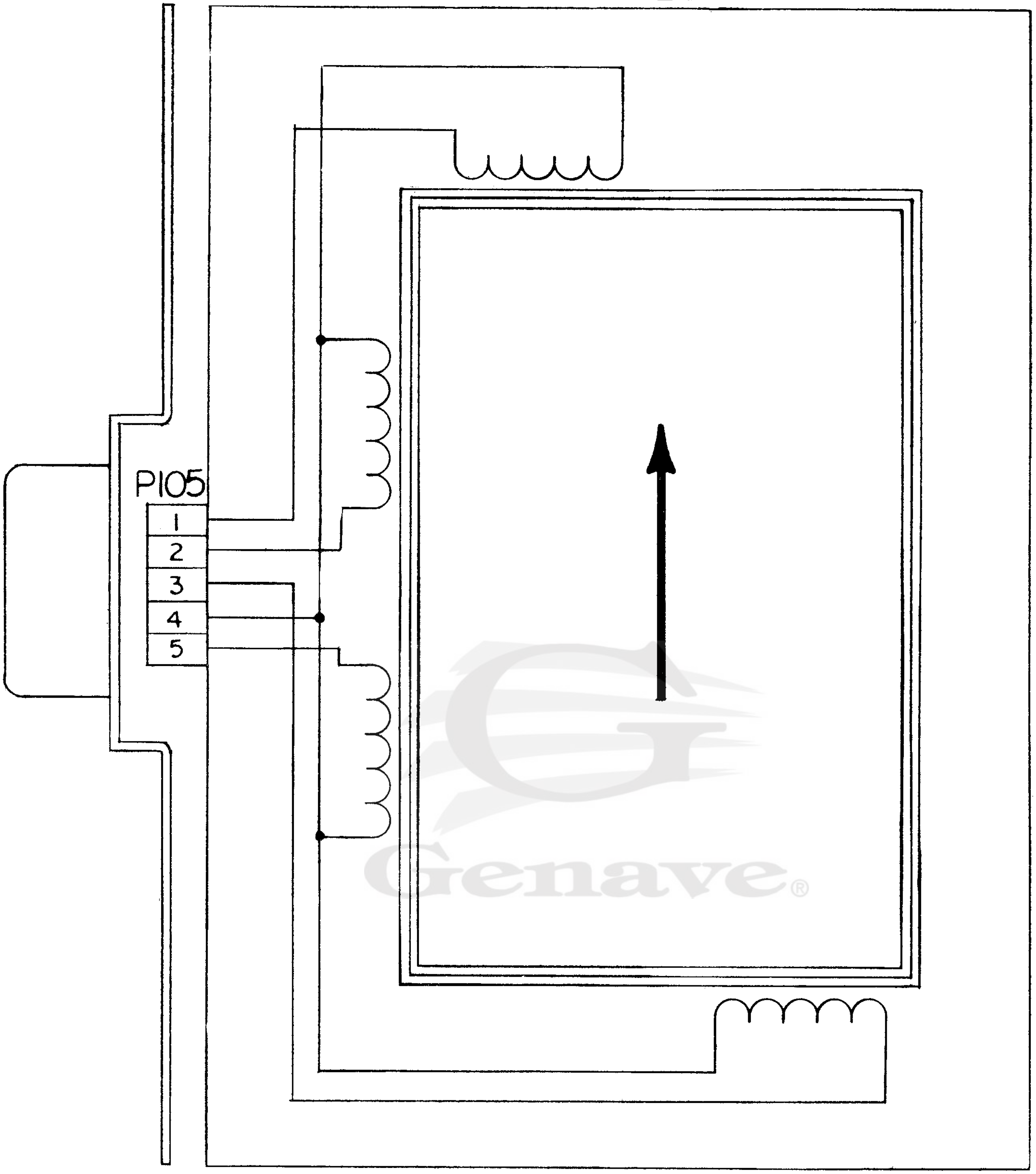


Figure 4-5-18
SCHEMATIC
LOOP ANTENNA

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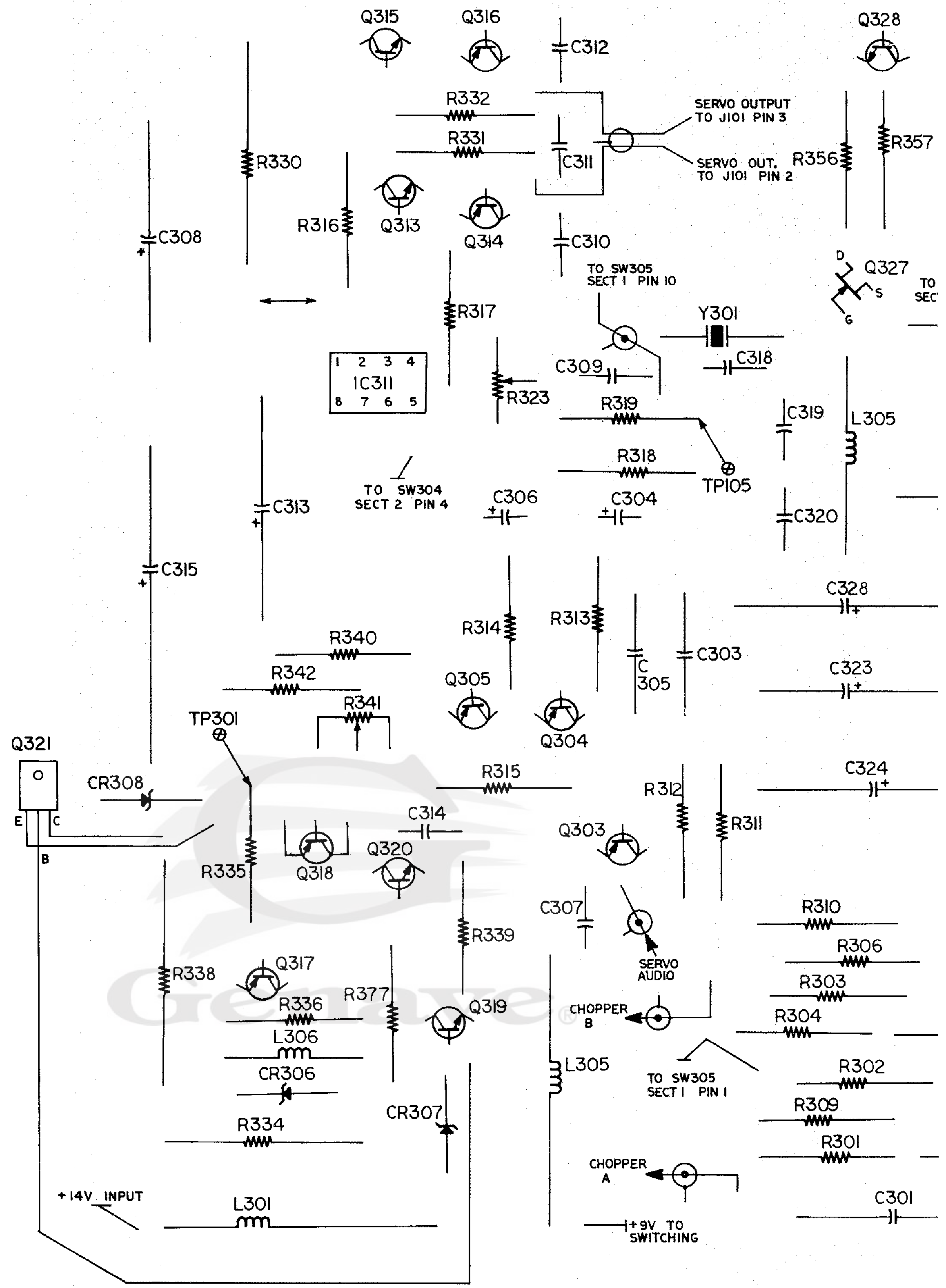
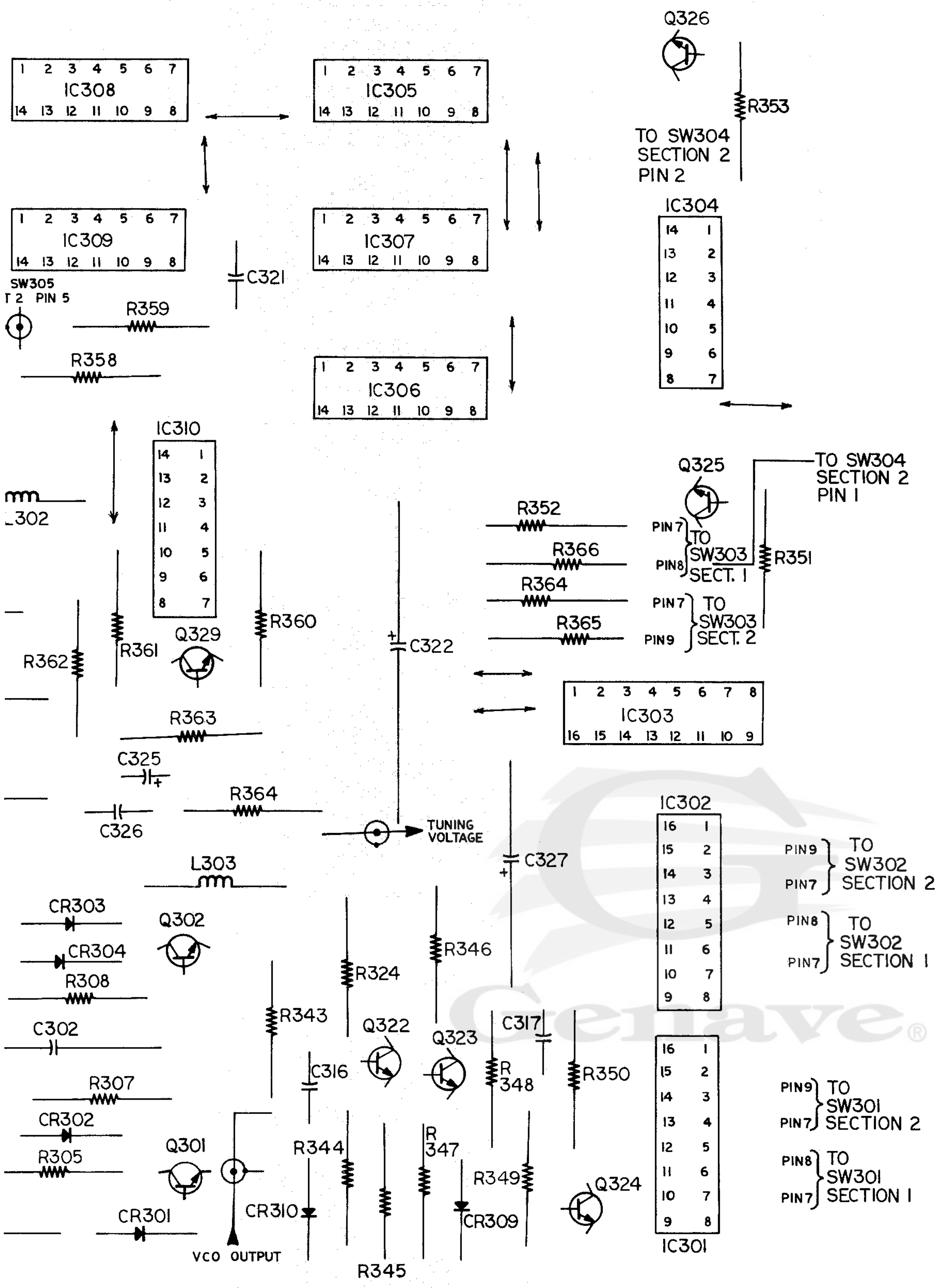
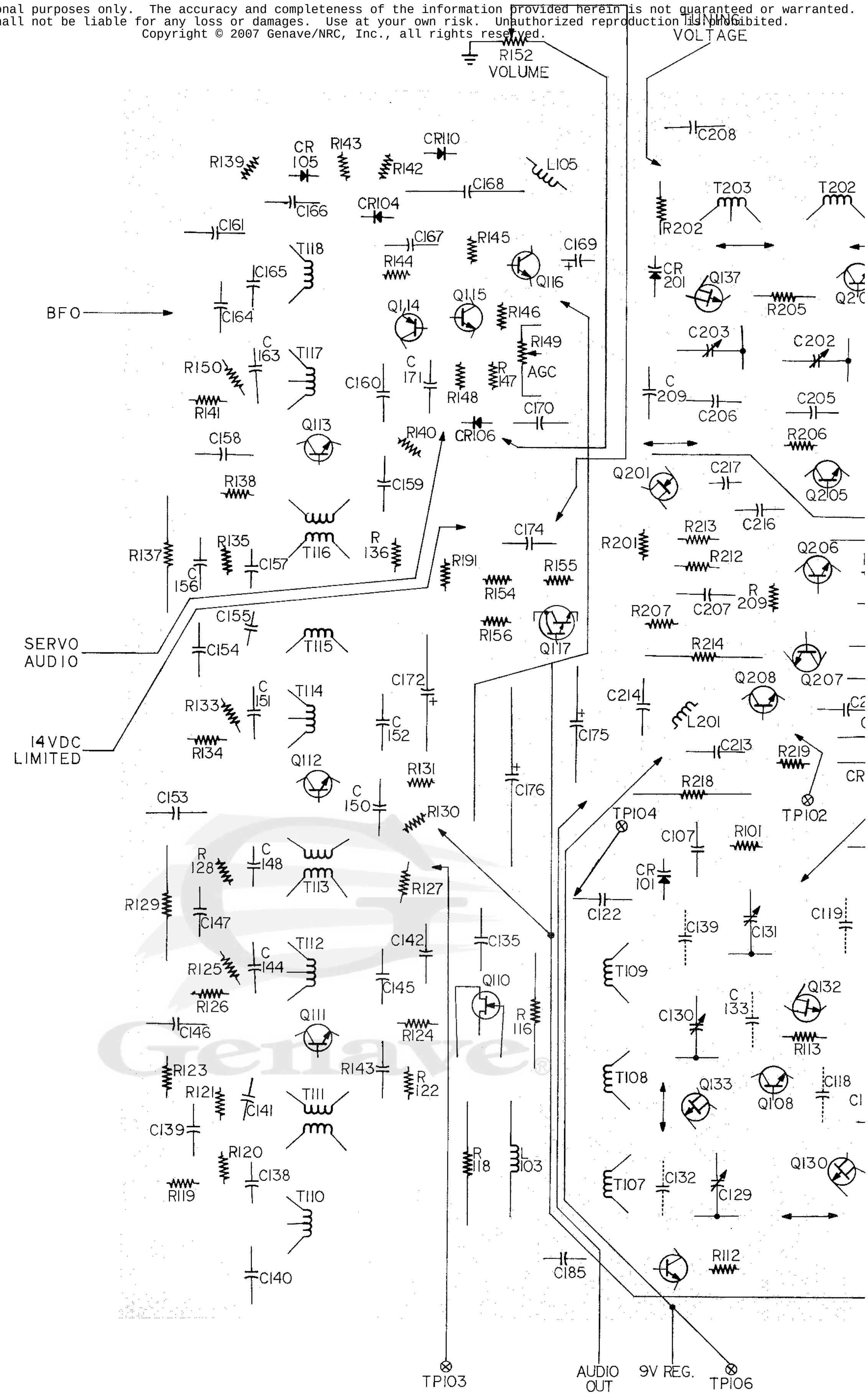
Model: SIGMA/1500



SYNTH-SERVO BOARD AS VIEWED FROM FOIL SIDE OF PRINTED CIRCUIT BOARD

Figure 4-5-20
PARTS/TRACK MAP
SYNTHESIZER/SERVO CIRCUIT BOARD


Q326
R353
TO SW304
SECTION 2
PIN 2
IC308
IC305
IC309
IC307
IC304
C321
SW305
T 2 PIN 5
R359
R358
IC306
IC310
Q325
TO SW304
SECTION 2
PIN 1
L302
R352
R366
R364
R365
PIN 7
PIN 8
TO
SW303
SECT. 1
R351
PIN 7
PIN 9
TO
SW303
SECT. 2
R360
R361
R362
Q329
C322
IC303
R363
C325
C326
R364
TUNING
VOLTAGE
IC302
C327
PIN 9
PIN 7
TO
SW302
SECTION 2
PIN 8
PIN 7
TO
SW302
SECTION 1
L303
CR303
CR304
Q302
R308
R324
R346
R343
C302
Q322
Q323
C317
C316
R348
R350
R307
CR302
R305
Q301
R344
R347
R349
Q324
CR310
CR309
CR301
VCO OUTPUT
R345
IC301
PIN 9
PIN 7
TO
SW301
SECTION 2
PIN 8
PIN 7
TO
SW301
SECTION 1



Model: SIGMA/1500

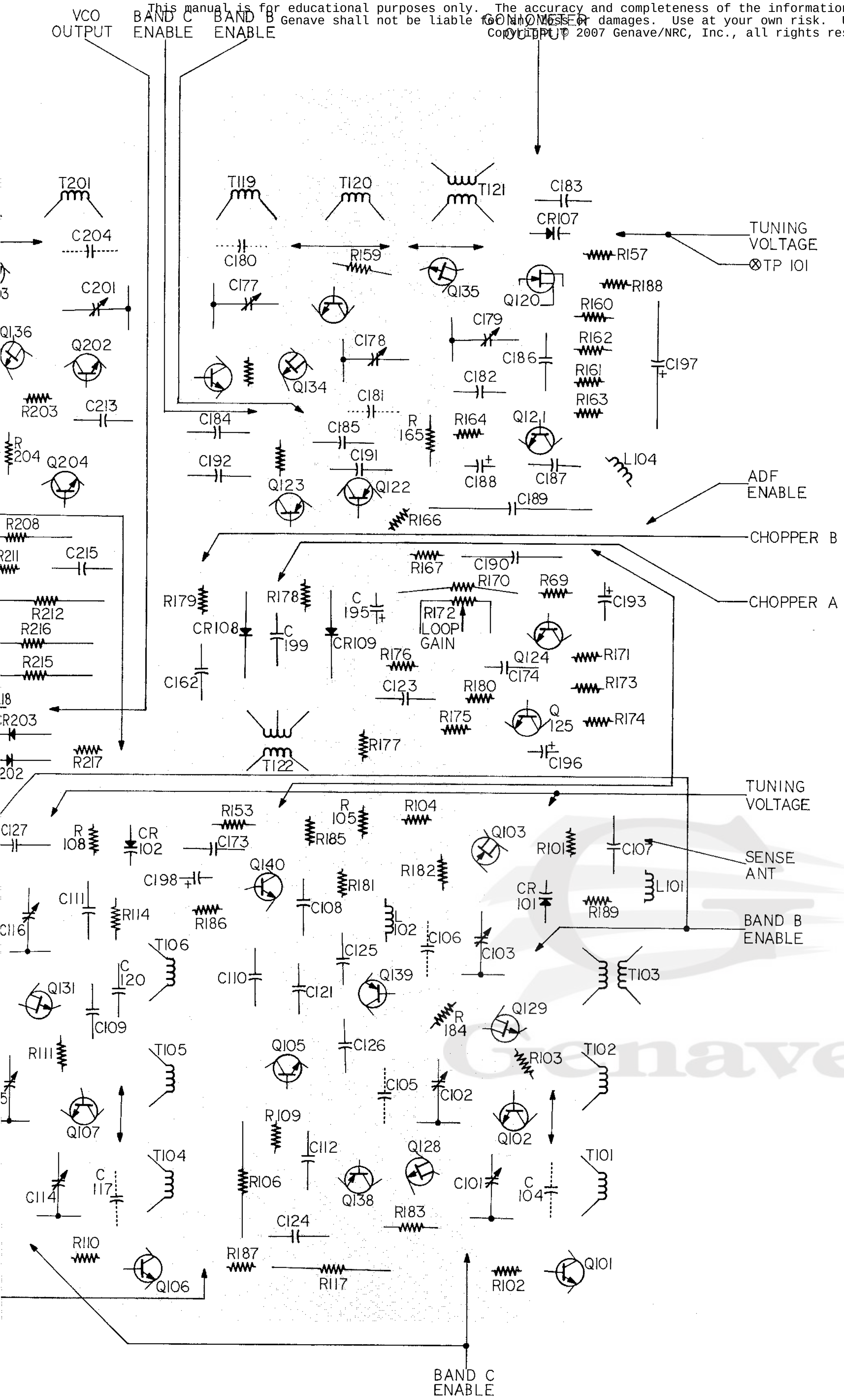


Figure 4-5-19
PARTS/TRACK MAP
RECEIVER CIRCUIT BOARD

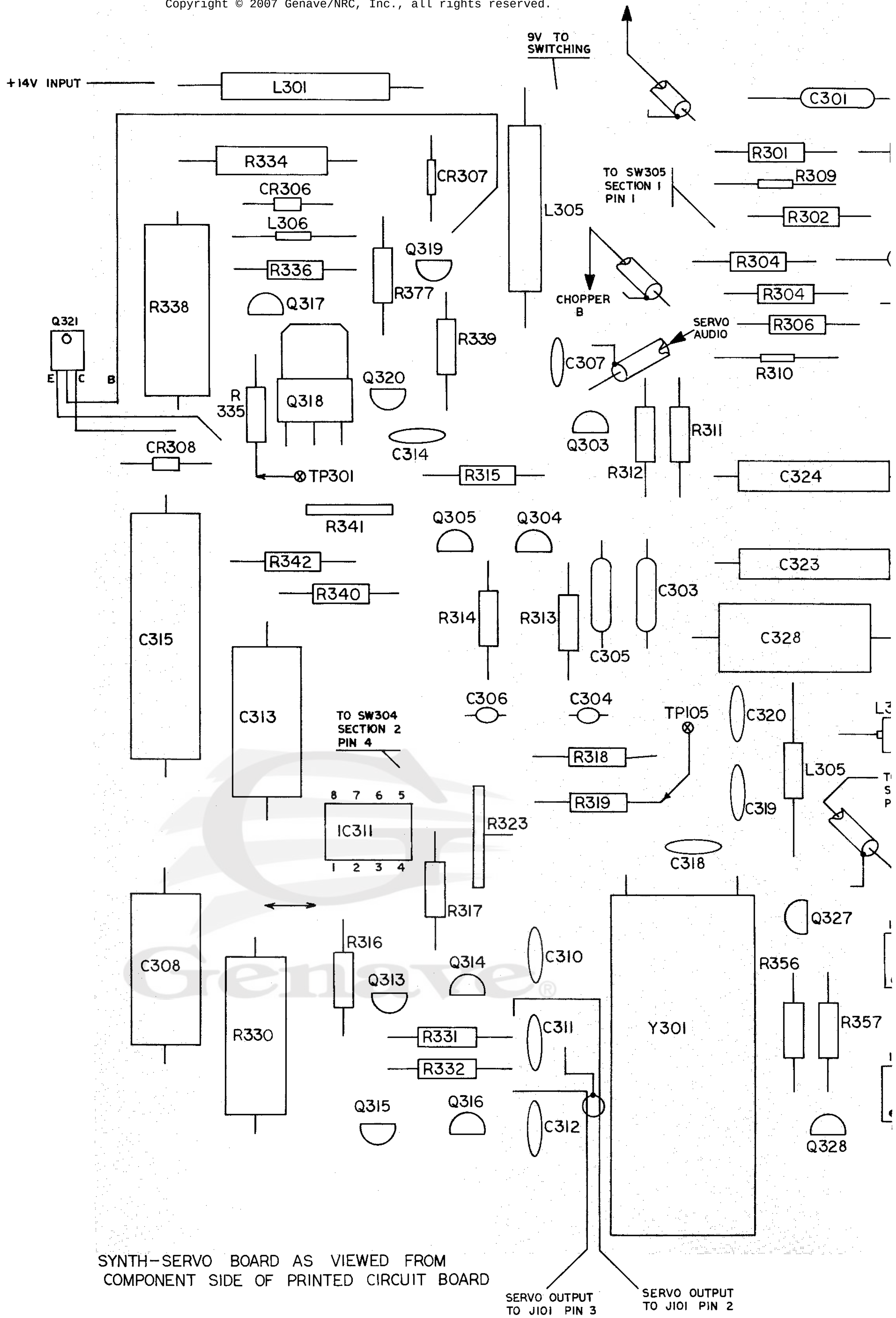
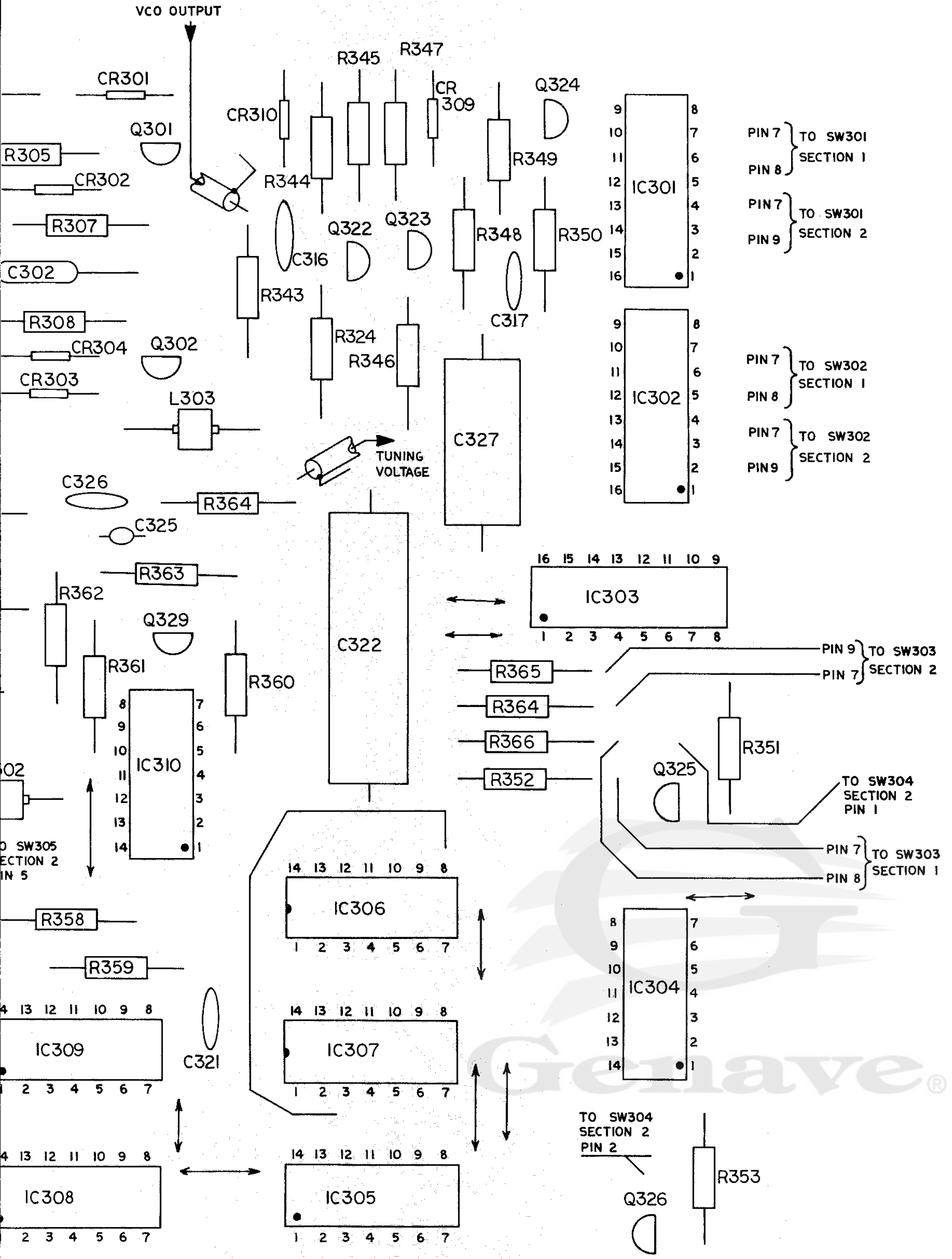
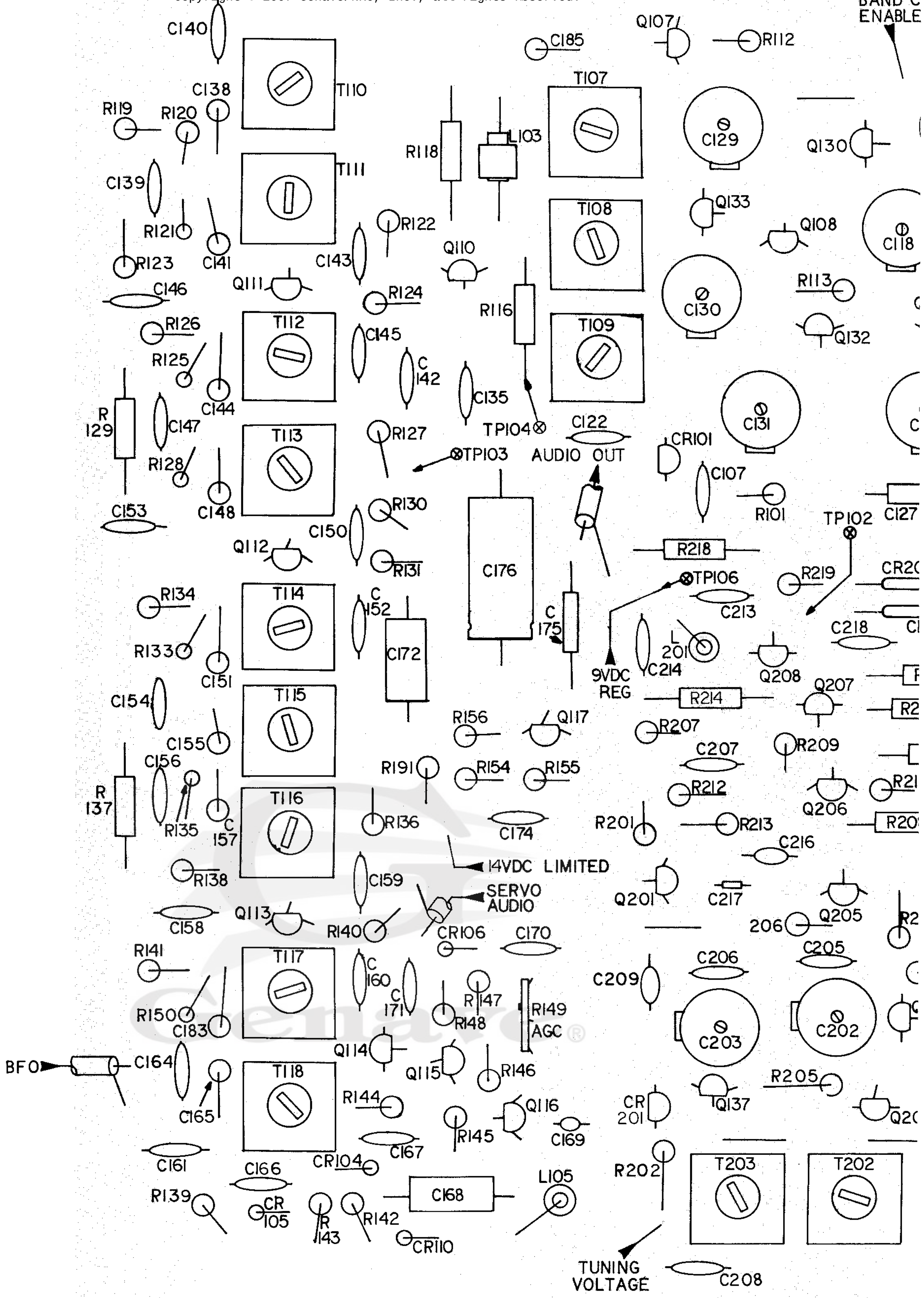


Figure 4-5-22
COMPONENT LOCATION DIAGRAM SYNTHESIZER/SERVO CIRCUIT BOARD



Model: SIGMA/1500



RECEIVER CIRCUIT BOARD AS VIEWED FROM COMPONENT SIDE OF CIRCUIT BOARD

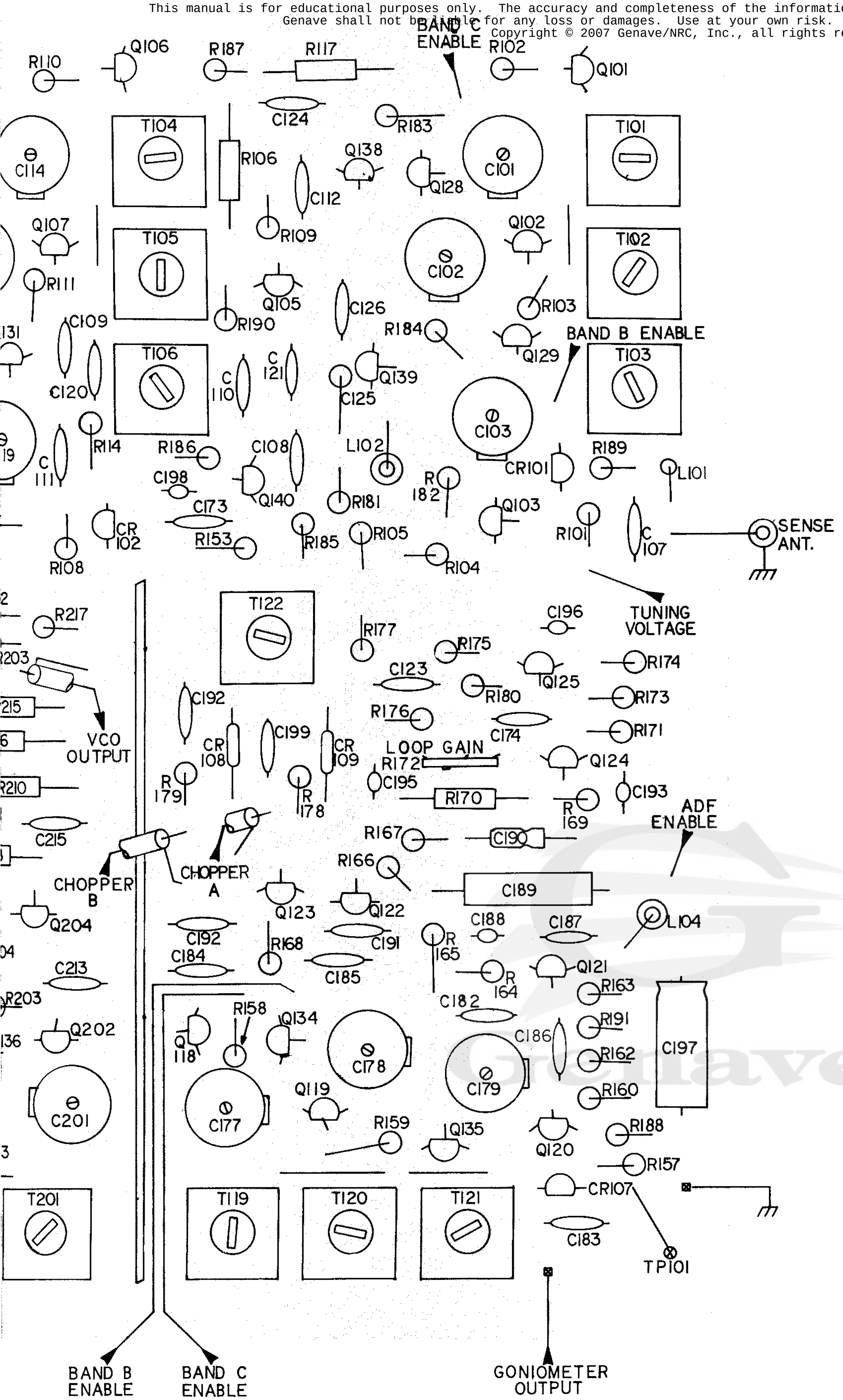


Figure 4-5-21
COMPONENT LOCATION DIAGRAM
RECEIVER CIRCUIT BOARD

SPECIALIZED PROCEDURES

4-6. SPECIALIZED PROCEDURES

A. *Receiver Front Panel Removal*

Removing the receiver front panel (trim panel) allows access to the backlighting lamps, test pushbutton cap, function selector dial, and frequency selector dials.

1. Using a 1/16″ allen wrench remove the function selector knob and the frequency selector knobs.
2. Using a .035″ (across flats) allen wrench remove the volume control knob.
3. Remove the four (4) Phillips head trim panel mounting screws.
4. Remove the trim panel being careful to catch the test pushbutton cap which will be released.
5. Remove the frequency selector and function selector dials using a .035″ (across flats) allen wrench.
6. To reassemble reverse the above steps.

B. *Switch Mounting Panel Removal*

The following procedure is used to gain access to the frequency selector switch, test switch, and the volume control potentiometer.

1. Perform the front panel removal described in Part A above.
2. Remove the 9″ long retaining screw.
3. Remove the four (4) #6 screws securing the switch mounting panel.
4. The switches can be removed from the switch mounting panel using a ½″ wrench.
5. To reassemble reverse the above steps.

C. *Indicator Cover Removal*

This allows access to the electrical connections and mechanical drive setscrews.

1. Remove the top cover panel by removing the three (3) #6 screws from the top panel and the two (2) #6 screws from the left cover panel.
2. Remove the bottom cover panel using the same procedure outlined in step 1 above.
3. To reassemble reverse the above steps.

D. *Indicator Drive System Disassembly*

This procedure allows access to the pointer disc, azimuth dial card, drive gears, backlighting lamps, goniometer, motor, and azimuth drive shaft.

1. Perform the cover removal described in Part C above.
2. Remove the azimuth knob using a 1/16″ allen wrench.
3. Remove the four (4) #6 screws from the front of the side panels (2 screws on each side) and remove the front panel assembly from the unit.
4. Remove the #2-56 screw from the pointer disc and remove the pointer disc.
5. Using a soft lead pencil mark the azimuth drive hub and azimuth dial card to facilitate exact reassembly.

NOTE: If it should be necessary to replace the azimuth drive hub or azimuth dial card, both must be replaced. These parts are available from the factory in matched sets only.

6. Remove the two (2) #0-80 screws securing the azimuth dial card to the azimuth drive hub and remove the azimuth dial card.
7. Remove the azimuth drive "O" ring.
8. Remove the two (2) #6 screws from the rear of the side panels and pull the rear panel free of the side covers.
9. Free the goniometer drive coupler by using a 1/16″ allen wrench to loosen the two setscrews.
10. Loosen the goniometer mounting bracket and remove the goniometer.

NOTE: If the goniometer is removed the Goniometer Pointer Adjustment outlined in Section 4-2, Part J must be performed. When reordering a replacement goniometer state whether the original unit has a metal or plastic case.

11. Remove the nuts and lockwashers from the three (3) idler gear shafts and remove the idler gears and shafts. The idler gears can be replaced by removing the clips and washers securing them to the shafts.
12. Remove the azimuth drive hub and goniometer drive shaft all together, from the gear mounting bracket.
13. To remove the motor withdraw the three (3) #4 machine screws from the gear mounting bracket and remove the brass motor drive gear.

NOTE: When replacing the motor, the entire motor assembly must be replaced due to shielded cover considerations. When ordering replacement parts the entire motor assembly will be supplied.

14. To remove the azimuth drive shaft, remove the clip at the rear of the shaft and slide shaft from bearings.
15. To reassemble, reverse the above steps.

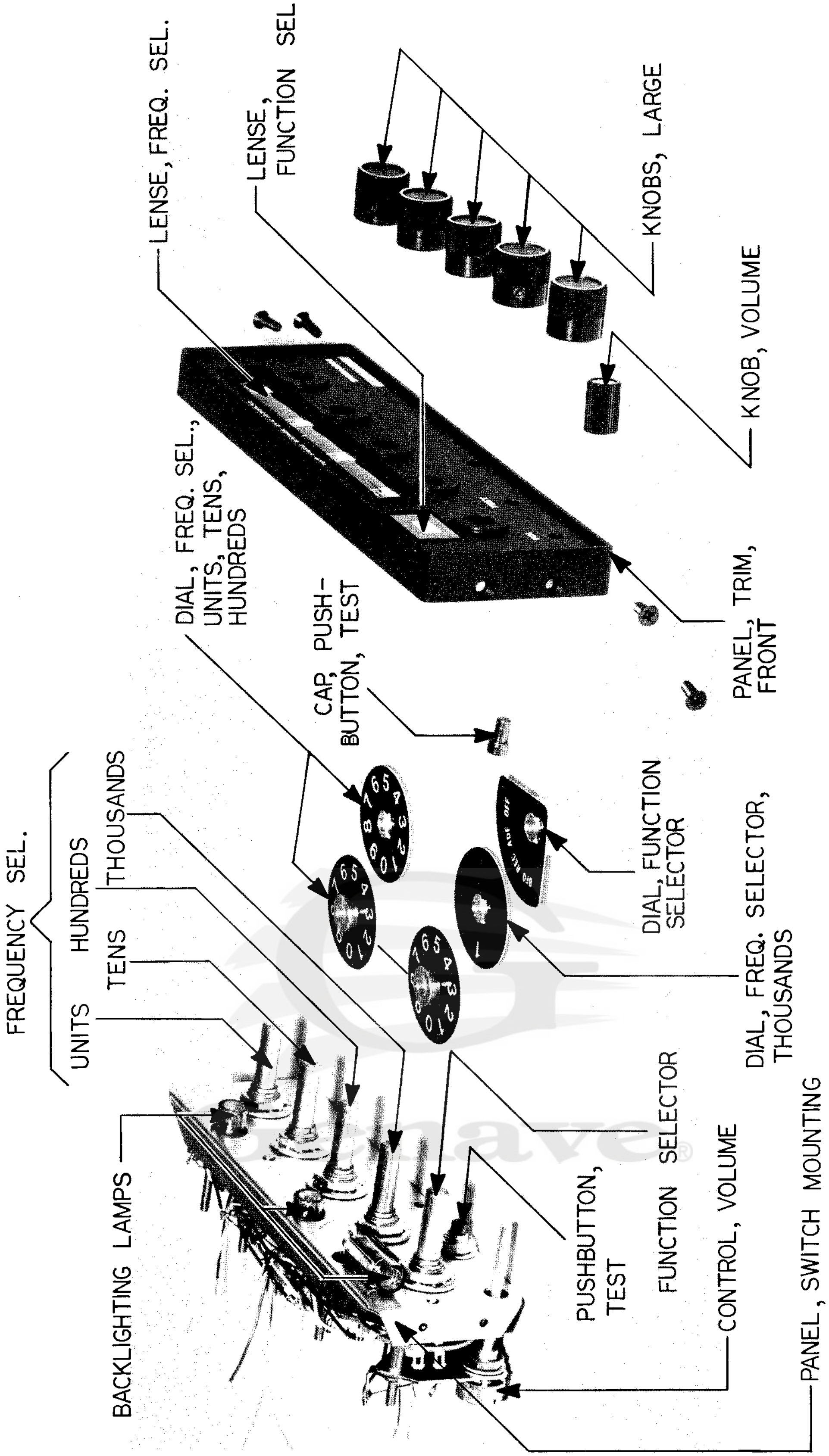


Figure 4-6-1
EXPANDED VIEW RECEIVER

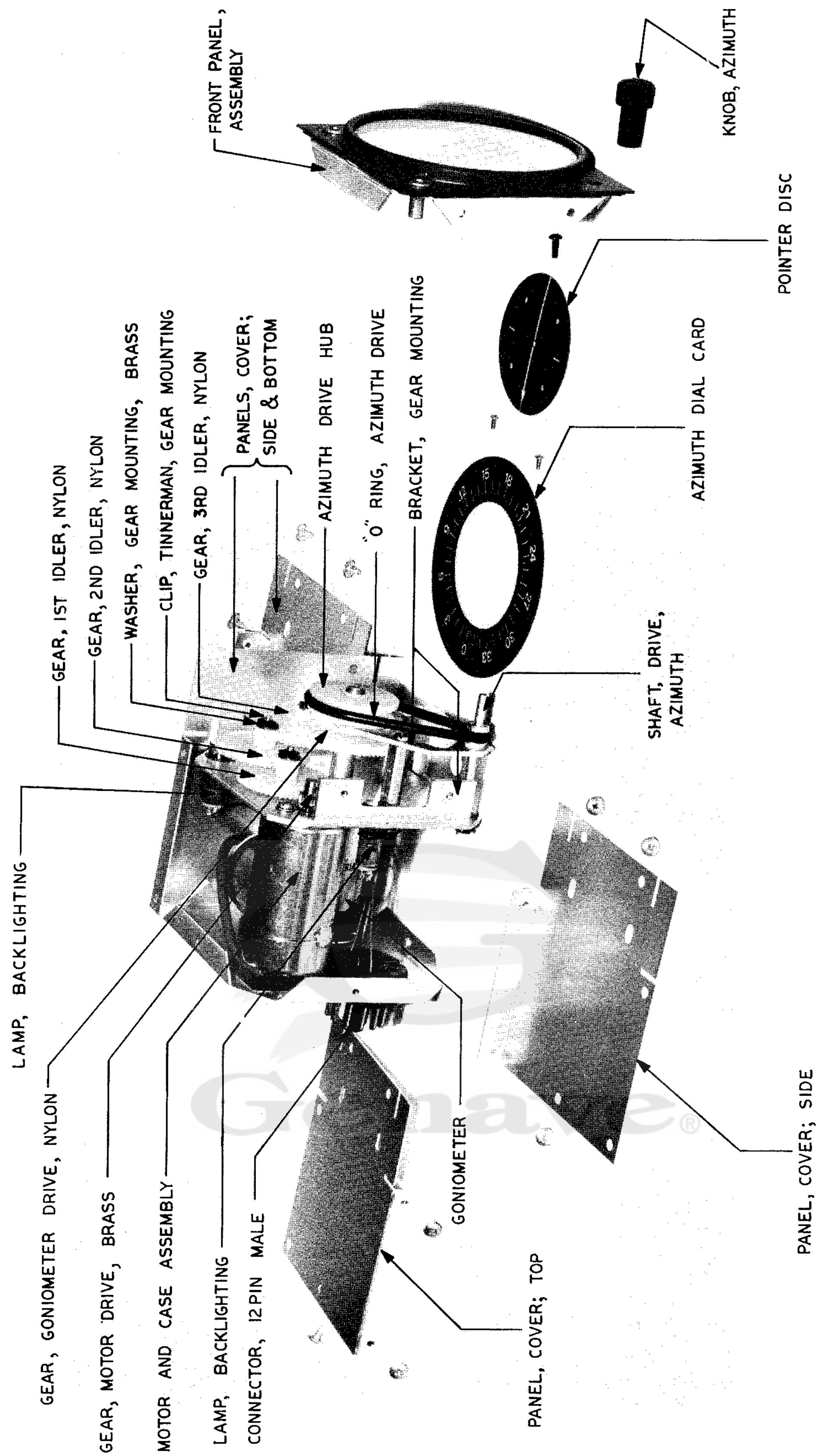


Figure 4-6-2
EXPANDED VIEW
INDICATOR

SECTION V
SIGMA/1500 RECEIVER PARTS LIST

Ref. No.	Genave Part No.	DESCRIPTION
		CAPACITORS
C101	1580000	Trimmer, 5.5-60 pfd
C102	1580000	Trimmer, 5.5-60 pfd
C103	1580000	Trimmer, 5.5-60 pfd
C104		Unassigned
C105		Unassigned
C106		Unassigned
C107	1520055	Disc, .1 mfd, +80 −20%, 12V
C108	1520055	Disc, .1 mfd, +80 −20%, 12V
C109	1520055	Disc, .1 mfd, +80 −20%, 12V
C110	1520055	Disc, .1 mfd, +80 −20%, 12V
C111	1520055	Disc, .1 mfd, +80 −20%, 12V
C112	1520055	Disc, .1 mfd, +80 −20%, 12V
C113		Unassigned
C114	1580000	Trimmer, 5.5-60 pfd
C115	1580000	Trimmer, 5.5-60 pfd
C116	1580000	Trimmer, 5.5-60 pfd
C117		Unassigned
C118		Unassigned
C119		Unassigned
C120	1520055	Disc, .1 mfd, +80 −20%, 12V
C121	1520039	Y5E Disc, 390 pfd, 10%
C122	1520055	Disc, .1 mfd, +80 −20%, 12V
C123	1520055	Disc, .1 mfd, +80 −20%, 12V
C124	1520055	Disc, .1 mfd, +80 −20%, 12V
C125	1500007	Mylar, .0022 mfd, 10%
C126	1520014	NPO Disc, 39 pfd, 10%
C127	1510016	Gimmick, NPO, 2.7 pfd, 10%
C128	1520055	Disc, .1 mfd, +80 −20%, 12V
C129	1580000	Trimmer, 5.5-60 pfd
C130	1580000	Trimmer, 5.5-60 pfd
C131	1580000	Trimmer, 5.5-60 pfd
C132		Unassigned
C133		Unassigned
C134		Unassigned
C135	1520055	Disc, .1 mfd, +80 −20%, 12V
C136	1520055	Disc, .1 mfd, +80 −20%, 12V
C137	1520055	Disc, .1 mfd, +80 −20%, 12V
C138	1500076	N200 Poly, 1500 pfd, 10%
C139	1520011	NPO Disc, 22 pfd, 10%
C140	1520055	Disc, .1 mfd, +80 −20%, 12V
C141	1500076	N200 Poly, 1500 pfd, 10%
C142	1520055	Disc, .1 mfd, +80 −20%, 12V
C143	1520055	Disc, .1 mfd, +80 −20%, 12V
C144	1500076	N200 Poly, 1500 pfd, 10%
C145	1520055	Disc, .1 mfd, +80 −20%, 12V
C146	1520055	Disc, .1 mfd, +80 −20%, 12V
C147	1520011	NPO Disc, 22 pfd, 10%
C148	1500076	N200 Poly, 1500 pfd, 10%
C149	1520055	Disc, .1 mfd, +80 −20%, 12V
C150	1520055	Disc, .1 mfd, +80 −20%, 12V
C151	1500076	N200 Poly, 1500 pfd, 10%
C152	1520055	Disc, .1 mfd, +80 −20%, 12V
C153	1520055	Disc, .1 mfd, +80 −20%, 12V
C154	1520011	NPO Disc, 22 pfd, 10%
C155	1500076	N200 Poly, 1500 pfd, 10%
C156	1520011	NPO Disc, 22 pfd, 10%
C157	1500076	N200 Poly, 1500 pfd, 10%
C158	1520055	Disc, .1 mfd, +80 −20%, 12V
C159	1520055	Disc, .1 mfd, +80 −20%, 12V
C160	1520055	Disc, .1 mfd, +80 −20%, 12V
C161	1520055	Disc, .1 mfd, +80 −20%, 12V
C162	1520055	Disc, .1 mfd, +80 −20%, 12V
C163	1500076	N200 Poly, 1500 pfd, 10%
C164	1520011	NPO Disc, 22 pfd, 10%
C165	1500076	N200 Poly, 1500 pfd, 10%
C166	1520048	Z5P Disc, .001 mfd, 10%
C167	1520048	Z5P Disc, .001 mfd, 10%
C168	1540021	Electrolytic, 64 mfd, 4V
C169	1540004	Electrolytic, 2.5 mfd, 16V
C170	1520051	Disc, .01 mfd, 20%, 25V
C171	1520051	Disc, .01 mfd, 20%, 25V
C172	1540021	Electrolytic, 64 mfd, 4V
C173	1520055	Disc, .1 mfd, +80 −20%, 12V
C174	1520051	Disc, .01 mfd, 20%, 25V
C175	1540004	Electrolytic, 2.5 mfd, 16V
C176	1540024	Electrolytic, 125 mfd, 16V
C177	1580000	Trimmer, 5.5-60 pfd
C178	1580000	Trimmer, 5.5-60 pfd
C179	1580000	Trimmer, 5.5-60 pfd
C180		Unassigned
C181	1520014	NPO Disc, 39 pfd, 10%
C182		Unassigned
C183	1520055	Disc, .1 mfd, +80 −20%, 12V
C184	1520055	Disc, .1 mfd, +80 −20%, 12V
C185	1500007	Mylar, .0022 mfd, 10%
C186	1520055	Disc, .1 mfd, +80 −20%, 12V
C187	1520048	Z5P Disc, .001 mfd, 10%
C188	1550002	Tantalum, .1 mfd, 20%, 35V
C189	1500020	Mylar, .015 mfd, 10%, 200V
C190	1500009	Mylar, .0033 mfd, 10%, 200V
C191	1520055	Disc, .1 mfd, +80 −20%, 12V
C192	1520055	Disc, .1 mfd, +80 −20%, 12V
C193	1550002	Tantalum, .1 mfd, 20%, 35V
C194	1520055	Disc, .1 mfd, +80 −20%, 12V
C195	1550002	Tantalum, .1 mfd, 20%, 35V
C196	1550002	Tantalum, .1 mfd, 20%, 35V
C197	1540014	Electrolytic, 10 mfd, 16V
C198	1550002	Tantalum, 1 mfd, 20%, 25V
C199	1520055	Disc, .1 mfd, +80 −20%, 12V
C200		Unassigned
C201	1580000	Trimmer, 5.5-60 pfd
C202	1580000	Trimmer, 5.5-60 pfd
C203	1580000	Trimmer, 5.5-60 pfd
C204		Unassigned
C205		Unassigned
C206		Unassigned
C207	1520055	Disc, .1 mfd, +80 −20%, 12V
C208	1520055	Disc, .1 mfd, +80 −20%, 12V
C209	1530009	Silver Mica, 910 pfd, 10%
C210		Unassigned
C211		Unassigned
C212	1520055	Disc, .1 mfd, +80 −20%, 12V
C213	1520055	Disc, .1 mfd, +80 −20%, 12V
C214	1520055	Disc, .1 mfd, +80 −20%, 12V
C215	1520055	Disc, .1 mfd, +80 −20%, 12V
C216	1530008	Silver Mica, 750 pfd, 10%
C217	1530011	Silver Mica, .0012 mfd, 10%
C218	1520055	Disc, .1 mfd, +80 −20%, 12V
C219		Unassigned
C220		Unassigned
C301	1500033	Tubular Mylar, .1 mfd, 5%, 200V
C302	1500033	Tubular Mylar, .1 mfd, 5%, 200V
C303	1500026	Mylar, .033 mfd, 10%, 100V
C304	1550002	Tantalum. .1 mfd, 20%, 35V
C305	1500026	Mylar, .033 mfd, 10%, 100V
C306	1550002	Tantalum, .1 mfd, 20%, 35V
C307	1520054	.05 mfd, +80 −20%
C308	1540024	Electrolytic, 125 mfd, 16V
C309	1520055	Disc, .1 mfd, +80 −20%, 12V
C310	1520051	Disc, .01 mfd, 20%, 25V
C311	1520051	Disc, .01 mfd, 20%, 25V
C312	1520051	Disc, .01 mfd, 20%, 25V
C313	1540024	Electrolytic, 125 mfd, 16V
C314	1520048	Z5P Disc, .001 mfd, 10%, 1000V
C315	1540035	Electrolytic, 640 mfd, 6.4V
C316	1520055	Disc, .1 mfd, +80 −20%, 12V
C317	1520055	Disc, .1 mfd, +80 −20%, 12V
C318	1520020	NPO Disc, 82 pfd, 10%
C319	1520048	Z5P Disc, .001 mfd, 10%, 1000V
C320	1520048	Z5P Disc, .001 mfd, 10%, 1000V
C321	1520055	Disc, .1 mfd, +80 −20%, 12V
C322	1540035	Electrolytic, 640 mfd, 6.4V
C323	1540022	Electrolytic, 64 mfd, 10V
C324	1540022	Electrolytic, 64 mfd, 10V
C325	1550002	Tantalum, .1 mfd, 20%, 35V
C326	1520055	Disc, .1 mfd, +80 −20%, 12V
C327	1540022	Electrolytic, 64 mfd, 10V
C328	1540024	Electrolytic, 125 mfd, 16V
C329	1520055	Disc, .1 mfd, +80 −20%, 12V
C330	1520055	Disc, .1 mfd, +80 −20%, 12V
C331	1520055	Disc, .1 mfd, +80 −20%, 12V
C332	1520061	Feedthrough, .001 mfd
C333	1520061	Feedthrough, .001 mfd
C334		Unassigned
C335		Unassigned
		COILS
L101	1800350	1 μHy
L102	1800351	470 μHy
L103	1800353	680 μHy
L104	1800354	1 mHy
L105	1800354	1 mHy
L106		Unassigned
L201	1800354	1 mHy
L202		Unassigned
L301	1800352	670 μHy
L302	1800028	430 μHy
L303	1800028	430 μHy
L304	1800352	670 μHy
L305	1800208	5.6 mHy, 10%
L306	1800067	1.5 μHy
L307		Unassigned
		DIODES
CR101	4811115	Varicap, Matched, SMV-1115, Available in sets of 5 only
CR102	4811115	Varicap, Matched, SMV-1115, Available in sets of 5 only
CR103	4811115	Varicap, Matched, SMV-1115, Available in sets of 5 only
CR104	4810019	Hot Carrier, FH1100
CR105	4810019	Hot Carrier, FH1100
CR106	4810017	Silicon, High Speed Switching, FD1936
CR107	4811115	Varicap, Matched, SMV-1115, Available in sets of 5 only
CR108	4810017	Silicon, High Speed Switching, FD1936
CR109	4810017	Silicon, High Speed Switching, FD1936
CR110	4810017	Silicon, High Speed Switching, FD1936
CR111		Unassigned
CR201	4811115	Varicap, Matched, SMV-1115, Available in sets of 5 only
CR202	4810017	Silicon, High Speed Switching, FD1936

Ref. No.	Genave Part No.	DESCRIPTION
CR203	4810017	Silicon, High Speed Switching, FD1936
CR204		Unassigned
CR301	4810017	Silicon, High Speed Switching, FD1936
CR302	4810017	Silicon, High Speed Switching, FD1936
CR303	4810017	Silicon, High Speed Switching, FD1936
CR304	4810017	Silicon, High Speed Switching, FD1936
CR305		Unassigned
CR306	4810011	Zener, 24V, 10%, 1W, ZS24A
CR307	4810005	Zener, 5.6V, 5%, ½W, ZS5.6B
CR308	4810007	Zener, 6.8V, 10%, ZS6.8A
CR309	4810017	Silicon, High Speed Switching, FD1936
CR310	4810017	Silicon, High Speed Switching, FD1936

INTEGRATED CIRCUITS

Ref. No.	Genave Part No.	DESCRIPTION
IC301	3138310	TTL, Programable Decade Counter, MC8310P
IC302	3138310	TTL, Programable Decade Counter, MC8310P
IC303	3138310	TTL, Programable Decade Counter, MC8310P
IC304	3130008	DTL, Quad 2-Input "Nand" Gate, MC846P-6K
IC305	3137410	TTL, Triple 3-Input "Nand" Gate, MC7410P
IC306	3133061	TTL, Single J-K Flip-Flop, 9001
IC307	3133061	TTL, Single J-K Flip-Flop, 9001
IC308	3137493	TTL, 4-bit Binary Counter, MC7493P
IC309	3137493	TTL, 4-bit Binary Counter, MC7493P
IC310	3134044	TTL, Phase-Frequency Detector, MC4044P
IC311	3130012	Dual Op-Amp, N5558 or MC1458CP1

RESISTORS

Ref. No.	Genave Part No.	DESCRIPTION
R101	4700049	100K, 10%, ½W
R102	4700023	680 ohm, 10%, ½W
R103	4700023	680 ohm, 10%, ½W
R104	4700025	1K, 10%, ½W
R105	4700020	390 ohm, 10%, ½W
R106	4700025	1K, 10%, ½W
R107		Unassigned
R108	4700049	100K, 10%, ½W
R109	4700025	1K, 10%, ½W
R110	4700023	680 ohm, 10%, ½W
R111	4700023	680 ohm, 10%, ½W
R112	4700023	680 ohm, 10%, ½W
R113	4700023	680 ohm, 10%, ½W
R114	4700003	10 ohm, 10%, ½W
R115	4700049	100K, 10%, ½W
R116	4700048	82K, 10%, ½W
R117	4700040	18K, 10%, ½W
R118	4700025	1K, 10%, ½W
R119	4700017	220 ohm, 10%, ½W
R120	4700041	22K, 10%, ½W
R121	4700041	22K, 10%, ½W
R122	4700025	1K, 10%, ½W
R123	4700003	10 ohm, 10%, ½W
R124	4700013	100 ohm, 10%, ½W
R125	4700041	22K, 10%, ½W
R126	4700017	220 ohm, 10%, ½W
R127	4700025	1K, 10%, ½W
R128	4700041	22K, 10%, ½W
R129	4700003	10 ohm, 10%, ½W
R130	4700025	1K, 10%, ½W
R131	4700013	100 ohm, 10%, ½W
R132	4700025	1K, 10%, ½W
R133	4700041	22K, 10%, ½W
R134	4700017	220 ohm, 10%, ½W
R135	4700041	22K, 10%, ½W
R136		Unassigned
R137	4700003	10 ohm, 10%, ½W
R138	4700029	2.2K, 10%, ½W
R139	4700003	10 ohm, 10%, ½W
R140	4700025	1K, 10%, ½W
R141	4700017	220 ohm, 10%, ½W
R142	4700028	1.8K, 10%, ½W
R143	4700033	4.7K, 10%, ½W
R144	4700049	100K, 10%, ½W
R145	4700045	47K, 10%, ½W
R146	4700049	100K, 10%, ½W
R147	4700033	3.3K, 10%, ½W
R148	4700045	47K, 10%, ½W
R149	4760005	Variable, 1K
R150	4700032	3.9K, 10%, ½W
R151		Unassigned
R152	4760028A	Potentiometer, 25K, 10%, ¼W
R153	4700003	10 ohm, 10%, ½W
R154	4700058	1M, 10%, ½W
R155	4700054	270K, 10%, ½W
R156	4700017	220 ohm, 10%, ½W
R157	4700049	100K, 10%, ½W
R158	4700023	680 ohm, 10%, ½W
R159	4700023	680 ohm, 10%, ½W
R160	4700026	1.2K ohm, 10%, ½W
R161	4700041	22K, 10%, ½W
R162	4700029	2.2K, 10%, ½W
R163	4700029	2.2K, 10%, ½W
R164	4700017	220 ohm, 10%, ½W
R165	4700023	680 ohm, 10%, ½W
R166	4700023	680 ohm, 10%, ½W
R167	4700023	680 ohm, 10%, ½W
R168	4700023	680 ohm, 10%, ½W
R169	4700049	100K, 10%, ½W
R170	4700039	15K, 10%, ½W
R171	4700027	1.5K, 10%, ½W
R172	4760027	Variable, 100 ohm
R173	4700036	8.2K, 10%, ½W
R174	4700025	1K, 10%, ½W
R175	4700025	1K, 10%, ½W
R176	4700029	2.2K, 10%, ½W
R177	4700032	3.9K, 10%, ½W
R178	4700039	15K, 10%, ½W
R179	4700039	15K, 10%, ½W
R180	4700013	100 ohm, 10%, ½W
R181	4700023	680 ohm, 10%, ½W
R182	4700023	680 ohm, 10%, ½W
R183	4700023	680 ohm, 10%, ½W
R184	4700023	680 ohm, 10%, ½W
R185	4700046	56K, 10%, ½W
R186		Unassigned
R187	4700032	3.9K, 10%, ½W
R188	4700048	82K, 10%, ½W
R189	4700048	82K, 10%, ½W
R190	4700046	56K, 10%, ½W
R191	4700007	27 ohm, 10%, ½W
R192		Unassigned
R193		Unassigned
R201	4700025	1K, 10%, ½W
R202	4700049	100K, 10%, ½W
R203	4700023	680 ohm, 10%, ½W
R204	4700023	680 ohm, 10%, ½W
R205	4700023	680 ohm, 10%, ½W
R206	4700023	680 ohm, 10%, ½W
R207	4700051	150K, 10%, ½W
R208	4700045	47K, 10%, ½W
R209	4700025	1K, 10%, ½W
R210	4700019	330 ohm, 10%, ½W
R211	4700013	100 ohm, 10%, ½W
R212	4700025	1K, 10%, ½W
R213	4700025	1K, 10%, ½W
R214	4700016	180 ohm, 10%, ½W
R215	4700024	820 ohm, 10%, ½W
R216	4700021	470 ohm, 10%, ½W
R217	4700043	33K, 10%, ½W
R218		Unassigned
R219	4700029	2.2K, 10%, ½W
R220		Unassigned
R221		Unassigned
R301	4700037	10K, 10%, ½W
R302	4700054	270K, 10%, ½W
R303	4700054	270K, 10%, ½W
R304	4700037	10K, 10%, ½W
R305	4700037	10K, 10%, ½W
R306	4700037	10K, 10%, ½W
R307	4700049	100K, 10%, ½W
R308	4700049	100K, 10%, ½W
R309	4700041	22K, 10%, ½W
R310	4700041	22K, 10%, ½W
R311	4700049	100K, 10%, ½W
R312	4700049	100K, 10%, ½W
R313	4700031	3.3K, 10%, ½W
R314	4700031	3.3K, 10%, ½W
R315	4700037	10K, 10%, ½W
R316	4700058	1M, 10%, ½W
R317	4700058	1M, 10%, ½W
R318	4700072	680K, 10%, ½W
R319	4700025	1K, 10%, ½W
R320	4700004	15 ohm, 10%, ½W
R321	4700004	15 ohm, 10%, ½W
R322		Unassigned
R323	4760006	Potentiometer, 10K, ±30%
R324	4700038	12K, 10%, ½W
R325		Unassigned
R326		Unassigned
R327		Unassigned
R328		Unassigned
R329		Unassigned
R330	4740003	10 ohm, 10%, 2W
R331	4700001	2.2 ohm, 10%, ½W
R332	4700001	2.2 ohm, 10%, ½W
R333	4740002	.56 ohm, 10%, 2W
R334	4740002	.56 ohm, 10%, 2W
R335	4700023	680 ohm, 10%, ½W
R336	4700029	2.2K, 10%, ½W
R337	4700017	220 ohm, 10%, ½W
R338	4740017	15 ohm, 10%, 5W
R339	4700025	1K, 10%, ½W
R340	4700025	1K, 10%, ½W
R341	4760005	Potentiometer, 1K, ±30%
R342	4700030	2.7K, 10%, ½W
R343	4700031	3.3K, 10%, ½W
R344	4700037	10K, 10%, ½W
R345	4700034	5.6K, 10%, ½W
R346	4700026	1.2K, 10%, ½W
R347	4700021	470 ohm, 10%, ½W
R348	4700032	3.9K, 10%, ½W
R349	4700026	1.2K, 10%, ½W
R350	4700017	220 ohm, 10%, ½W
R351	4700025	1K, 10%, ½W
R352	4700025	1K, 10%, ½W
R353	4700025	1K, 10%, ½W
R354	4700025	1K, 10%, ½W
R355	4700058	1M, 10%, ½W
R356	4700033	4.7K, 10%, ½W
R357	4700033	4.7K, 10%, ½W
R358	4700025	1K, 10%, ½W
R359	4700029	2.2K, 10%, ½W
R360	4700024	820 ohm, 10%, ½W
R361	4700024	820 ohm, 10%, ½W
R362	4700025	1K, 10%, ½W
R363	4700036	8.2K, 10%, ½W
R364	4700037	10K, 10%, ½W
R365	4700025	1K, 10%, ½W
R366	4700025	1K, 10%, ½W

TRANSFORMERS

Ref. No.	Genave Part No.	DESCRIPTION
T101	5610108	High Band, Red
T102	5610109	Middle Band, Orange
T103	5610174	Low Band, Purple
T104	5610108	High Band, Red
T105	5610109	Middle Band, Orange
T106	5610174	Low Band, Purple
T107	5610108	High Band, Red
T108	5610109	Middle Band, Orange
T109	5610174	Low Band, Purple
T110	5610094	IF, 141.5 KHz, Black

Ref. No.	Genave Part No.	DESCRIPTION
T111	5610094	IF, 141.5 KHz, Black
T112	5610094	IF, 141.5 KHz, Black
T113	5610094	IF, 141.5 KHz, Black
T114	5610094	IF, 141.5 KHz, Black
T115	5610094	IF, 141.5 KHz, Black
T116	5610094	IF, 141.5 KHz, Black
T117	5610094	IF, 141.5 KHz, Black
T118	5610094	IF, 141.5 KHz, Black
T119	5610108	High Band, Red
T120	5610109	Middle Band, Orange
T121	5610097	Loop, Low Band
T122	5610096	Balanced Modulator
T201	5610108	High Band, Red
T202	5610109	Middle Band, Orange
T203	5610174	Low Band, Purple
		TRANSISTORS
Q101	4800007	Silicon, NPN, 2N4264, Brown
Q102	4800007	Silicon, NPN, 2N4264, Brown
Q103	4805458	Silicon, J-FET, N-Channel, 2N5458
Q104		Unassigned
Q105	4800026	Silicon, NPN, MPS-3693S, White
Q106	4800007	Silicon, NPN, 2N4264, Brown
Q107	4800007	Silicon, NPN, 2N4264, Brown
Q108	4800007	Silicon, NPN, 2N4264, Brown
Q109	4800007	Silicon, NPN, 2N4264, Brown
Q110	4805458	Silicon, J-FET, N-Channel, 2N5458
Q111	4800026	Silicon, NPN, MPS-3693S, White
Q112	4800026	Silicon, NPN, MPS-3693S, White
Q113	4800026	Silicon, NPN, MPS-3693S, White
Q114	4800008	Silicon, PNP, Black, TN5086
Q115	4800028	Silicon, NPN, Red, MPS-6513S
Q116	4800028	Silicon, NPN, Red, MPS-6513S
Q117	4800051	Silicon, NPN, Darlington Pair, MPS-A13
Q118	4800007	Silicon, NPN, 2N4264, Brown
Q119	4800007	Silicon, NPN, 2N4264, Brown
Q120	4805458	Silicon, J-FET, N-Channel, 2N5458
Q121	4805089	Silicon, NPN, 2N5089
Q122	4800043	Silicon, PNP, 2N5227
Q123	4800043	Silicon, PNP, 2N5227
Q124	4800026	Silicon, NPN, MPS-3693S
Q125	4800026	Silicon, NPN, MPS-3693S, White
Q126		Unassigned
Q127		Unassigned
Q128	4805461	Silicon, J-FET, P-Channel, 2N5461
Q129	4805461	Silicon, J-FET, P-Channel, 2N5461
Q130	4805461	Silicon, J-FET, P-Channel, 2N5461
Q131	4805461	Silicon, J-FET, P-Channel, 2N5461
Q132	4805461	Silicon, J-FET, P-Channel, 2N5461
Q133	4805461	Silicon, J-FET, P-Channel, 2N5461
Q134	4805461	Silicon, J-FET, P-Channel, 2N5461
Q135	4805461	Silicon, J-FET, P-Channel, 2N5461
Q136	4805461	Silicon, J-FET, P-Channel, 2N5461
Q137	4805461	Silicon, J-FET, P-Channel, 2N5461
Q138	4800043	Silicon, PNP, 2N5227
Q139	4800043	Silicon, PNP, 2N5227
Q140	4800026	Silicon, NPN, MPS-3693S, White
Q141		Unassigned
Q201	4805458	Silicon, J-FET, N-Channel, 2N5458
Q202	4800007	Silicon, NPN, Brown, 2N4264
Q203	4800007	Silicon, NPN, Brown, 2N4264
Q204	4800007	Silicon, NPN, Brown, 2N4264
Q205	4800007	Silicon, NPN, Brown, 2N4264
Q206	4800026	Silicon, NPN, White, MPS-3693S
Q207	4800008	Silicon, PNP, Black, 2N5086
Q208	4800026	Silicon, NPN, White, MPS-3693S
Q209		Unassigned
Q301	4800033	Silicon, NPN, MPS-5172
Q302	4800033	Silicon, NPN, MPS-5172
Q303	4800043	Silicon, PNP, 2N5227
Q304	4800043	Silicon, PNP, 2N5227
Q305	4800043	Silicon, PNP, 2N5227
Q306		Unassigned
Q307		Unassigned
Q308		Unassigned
Q309		Unassigned
Q310		Unassigned

Ref. No.	Genave Part No.	DESCRIPTION
Q311		Unassigned
Q312		Unassigned
Q313	4806532	Silicon, NPN, MPS-6532
Q314	4806535	Silicon, PNP, MPS-6535
Q315	4806532	Silicon, NPN, MPS-6532
Q316	4806535	Silicon, PNP, MPS-6535
Q317	4800043	Silicon, PNP, 2N5227
Q318	4800022	Silicon, NPN, MPS-U51
Q319	4802015	Silicon, NPN, MPS-A10
Q320	4802015	Silicon, NPN, MPS-A10
Q321	4800013	Silicon, NPN, MJE-520
Q322	4800026	Silicon, NPN, White, MPS-3693S
Q323	4800002	Silicon, NPN, MPS-6531
Q324	4800002	Silicon, NPN, MPS-6531
Q325	4800007	Silicon, NPN, Brown, 2N4264
Q326	4800007	Silicon, NPN, Brown, 2N4264
Q327	4805458	Silicon, J-FET, N-Channel, 2N5458
Q328	4800026	Silicon, NPN, White, MPS-3693S
Q329	4805089	Silicon, NPN, 2N5089
Q330		Unassigned
		CRYSTALS
Y301	2303546	Wire Lead, 128 KHz
		LAMPS
IL101	3900003	Backlighting, Lunar White
IL102	3900003	Backlighting, Lunar White
IL103	3900003	Backlighting, Lunar White
		SWITCHES
SW301	5100057	Frequency Selector, Units, Short Spacer
SW302	5100058	Frequency Selector, Tens, Long Spacer
SW303	5100059	Frequency Selector, Hundreds, Dual Wafers
SW304	5100063	Frequency Selector, Thousands
SW305	5100054	Function Selector
SW306	5100045	Pushbutton, Test
		MISCELLANEOUS
J101	2100009	Connector, 8-Pin, Female
J102	2100015	Connector, 6-Pin, Female
P102	2100016	Connector, 6-Pin, Male
J103	2100021	Connector, Phono, Female
P103	2100022	Connector, Phono, Male
CV101	2100018	Cover for J102, P102, J102, & J104
		HARDWARE
	2503901D	Panel, Trim, Front
	2502411B	Lense, Frequency Selector, Dial
	2503432B	Lense, Function Selector, Dial
	2502641A	Insert, Logo
	2503692B	Knob, Large, Frequency & Function Selectors
	2800050	Set Screw, #6-32 x 1/8″, for above Knobs
	2800157	1 Screw, Trim Panel Mounting, #4-40 x 3/8″
	2503292	Knob, Volume
	2502771A	Insert, for above Knob
	2503452A	Cap, Pushbutton, Test, Red
	2503342A	Dial, Frequency Selector, Units, Tens, & Hundreds
	2503352A	Dial, Frequency Selector, Thousands
	2503991A	Dial, Function Selector
	2820010	Washer, Flat, Nylon, for frequency dials
	2500892C	Panel, Switch Mounting
	2502472B	Panel, Rear
	2502462C	Panel, Side, Left
	2502452C	Panel, Side, Right
	2502432C	Panel, Top
	2502442C	Shield, Divider, Circuit Board
	2503561A	Shield, Loop Circuitry
	2502482B	Bracket, Hinge, Circuit Board
	2501592A	Plate, Mounting, Dimmer Pot
	6070011	Clip, Lamp, Mounting
	2500461	Spacer, Hex, Chassis Bottom
	2830000	Spacer, Hex, Circuit Board Mounting
	2503842A	Screw, Retaining
	2503412A	Collar, Retaining Screw, Hex Head
	2505951	Sleeve, Retaining Screw
	2504082	Mounting Tray
	2810085	Clip, Tinnerman, Mounting Tray
	1090935	Manual, Installation
	1090936	Manual, Pilots Information

Specifications Subject To Change Without Notice

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INDICATOR PARTS LIST

Ref. No.	Genave Part No.	DESCRIPTION
IL301	3900003	Lamp, Backlighting, Lunar White
IL302	3900003	Lamp, Backlighting, Lunar White
IL303	3900003	Lamp, Backlighting, Lunar White
P101	2100012	Connector, 8-Pin, Male
P104	2100010	Connector, 12-Pin, Male
	2503602A	Knob, Azimuth
	2800005	Setscrew, #2-56, for above Knob
	2508390	Front Panel, Assembly
	250538-2A	Pointer Disc
	2508281-A	Pointer Mounting Washer
	250302-1A	Azimuth Drive Hub
	‡ 2508081-A	Bearing, Azimuth Drive Hub, Internal, Matched with card below
	‡ 250312-2A	Azimuth Dial Card, Matched with hub above
	250315-1	"O" Ring, Azimuth Drive
	250306-2A	Shaft, Drive, Azimuth
	3510000	Bearings, Azimuth Drive Shaft
	250304-2A	Shaft, Pointer
	2800056	Setscrew, #6-32, for above shaft
	2800081	Screw, #2-56, Pointer Disc Mounting
	2820025	Lock Washer, Internal Tooth, #2
	2503011	Gear, Goniometer Drive, Nylon
	250290-1A	Gear, Motor, Drive, Brass, w/Setscrew
	250300-1	Gear; 1st, 2nd, or 3rd Idler; Nylon
	250325-2A	Shaft, Gear, 1st Idler
	250324-2A	Shaft, Gear, 2nd Idler
	250326-2A	Shaft, Gear, 3rd Idler
	2506021-A	Washer, Gear Mounting, Brass
	6070057	Clip, Tinnerman, Gear Mounting
	2810065	Nut, Hex, #6-32, Idler Gear Shaft Mounting
	2820070	Lock Washer, Internal Tooth, #6
	250359-2C	Bracket, Gear Mounting
	2507611-A	Spacer, Hex, Gear Mounting Bracket
	2800155	Screw, #4-40, 3/8", for above
	6070060	Clip, Lamp Mounting
	250354-1A	Clamp, Goniometer Mounting
	250311-2B	Panels, Cover; Sides, Top, & Bottom
	250310-2B	Panel, Rear
	2850015	Retaining Ring, Connector
	2100047	Solder Lug, #4 x 1/4"
	2508821	Motor and Case Assembly
	* 2507840	Goniometer, State whether Metal or Plastic Case

Specifications Subject To Change Without Notice

‡ Replacement Azimuth Drive Hub and Azimuth Dial Card supplied in matched sets only.

* When ordering replacement goniometers state whether original unit was metal or plastic cased.