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# A GUIDE TO CONSTRUCTION OF INEXPENSIVE AUTOMATIC PICTURE-TRANSMISSION GROUND STATIONS

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GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

X-730-67-240

# A GUIDE TO CONSTRUCTION OF INEXPENSIVE AUTOMATIC PICTURE-TRANSMISSION GROUND STATIONS

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Greenbelt, Maryland

# PREFACE

Weather satellites, together with communications satellites, are among the products of space research of most practical benefit to mankind. The capability of satellites to observe conditions in the earth's atmosphere rapidly and comprehensively was recognized early as a tool with which to cope with global weather forecasting.

In order to obtain global weather data quickly at a central point for study, designers adopted data-storage readout procedures for the early weather satellites. Later, with the addition to the satellites of the continuous broadcasting feature of the Automatic Picture Transmission (APT) System, information can be transmitted immediately directly to local weather stations. APT enables the remotest site to receive instant weather information.

When designed in 1960, APT used state-of-the-art components to meet its requirements. Some of those did not permit portable or low-cost equipment to be built. The recent advent of less expensive high quality electronic components, together with the use of advanced electronic design experience, has made possible the creation of equipment which can easily be built in most parts of the world. Contained herein is a guide to the construction of an economical, useful APT weather instrument for the direct reception of cloud-cover pictures from satellites.

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ILLUSTRATIONS (Continued)

# A GUIDE TO CONSTRUCTION OF INEXPENSIVE AUTOMATIC PICTURE-TRANSMISSION GROUND STATIONS

## INTRODUCTION

The automatic picture-transmission (APT) system developed by the U. S. National Aeronautics and Space Administration (NASA) is a unique television system enabling a weather satellite to take cloudcover pictures over wide areas and transmit them to simple and inexpensive ground stations anywhere on earth.

The first APT-equipped satellite was TIROS VIII, an experimental version, launched December 21, 1963. Two APT-equipped experimental Nimbus satellites, launched August 28, 1964 and May 15, 1966, successfully demonstrated the APT system by transmitting thousands of APT pictures directly to receiving stations all over the world. The later TIROS operational satellites, named ESSA when they achieve orbit, will provide continuous APT coverage on a regular operational basis. These satellites are built and launched under the technical direction of the NASA Goddard Space Flight Center and are operated by the U. S. Environmental Science Services Administration (ESSA).

Simplicity, direct reception and "instant" pictures make the APT system particularly useful to meteorologists, weather services, commercial organizations, government agencies, and educational institutions. For instance, meteorologists at weather offices and TV stations can receive daily pictorial displays of the local cloudcover in less time than it would take to dial a telephone and get a complete weather forecast. A weather picture from a typical APT-equipped satellite is complete within about 200 seconds. Pictures of cloud patterns signifying weather conditions are thus immediately observable. Utility companies can keep an eye on weather changes affecting power and water consumption. Individual weather services can provide detailed data on local conditions. The universally available cloudcover pictures can also provide weather data to encourage accurate meteorological interpretation to localities not normally served by weather bureas.

The APT system has been described in considerable detail in articles by Goldshlak (1963), by Holmes and Hunter (1964), by Hunter (1962), by Stampfl and Press (1962), and by Stampfl and Stroud (1963).* This document therefore

*See the Bibliography.

contains only the information and instructions required to construct an APT ground station that is practical, economical, reliable, and easily operated to provide high-quality cloudcover pictures for weather office, commerical and individual users.

## FUNCTIONS OF AN APT-EQUIPPED SATELLITE

The operation of the APT system, now carried by ESSA and Nimbus satellites, can be compared, in its final results, to regular television operation. While these weather satellites cross the day portion of the globe in their near-polar orbits, their special television - camera tube (vidicon) is pointed at the earth below. The system is completely automatic and requires no ground commands for operation. In the daylight portion of the revolution, an internal sequence timer exposes the vidicon and begins the read-out process a few seconds later. This process is accomplished by scanning the stored picture from the face of the vidicon. This picture is scanned 800 times, resulting in 800 lines of picture information.* The excess and the deficiency of electrons stored on the face of the picture, which correspond to the shades of grey in the picture, are detected by the electron beam in the vidicon. The resulting current beam is used to amplitude modulate a 2400-Hz carrier and is sent to the APT transmitter for relay to waiting ground stations (Figure 1).

The weather satellite will pass within range of any ground station two or three times during daytime. A receiving station can receive weather pictures taken over regions 2000 miles distant. For example, the station in Greenbelt, Maryland, can receive pictures from Central America to Greenland. Local weather is of primary interest, however, and the ESSA and Nimbus satellites will pass almost directly overhead once daily. Each picture covers an area measuring approximately 1200 miles square (NIMBUS) or 1700 miles square (ESSA); a pair of successive pictures overlap about 30 percent on the ESSA satellite and 50 percent on Nimbus II. (Figures 2 and 3.)

The satellite radiates approximately 5 watts of power. The power received on the ground within the area of reception (Figure 3) is sufficient for clear pictures if the station has the proper receiving equipment. (See Figures 4 and 5 for an idea of the distance pictures may be transmitted and remain useful.) The area of reception increases proportionately with the altitude increase of the satellite (e.g. 1400 km for ESSA IV, 1200 km for Nimbus II). Each station should be able to acquire the satellite at about 5 degrees in elevation, which is an approximate distance of 3500 miles (see Figure 4 for good local reception).

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*TN D 1915 thoroughly explains the satellite system theory (See Bibliography).

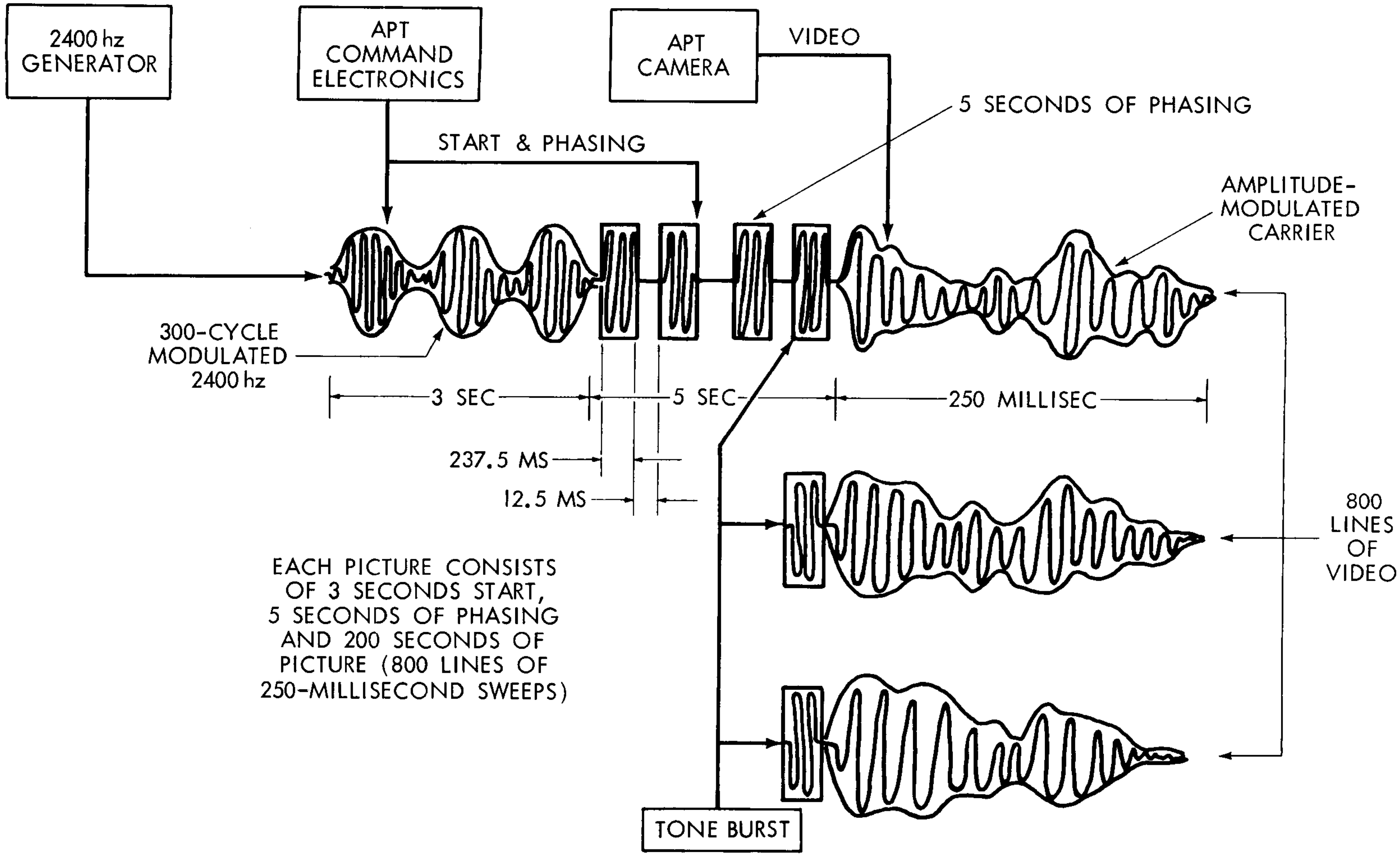


Figure 1—Carrier Analysis

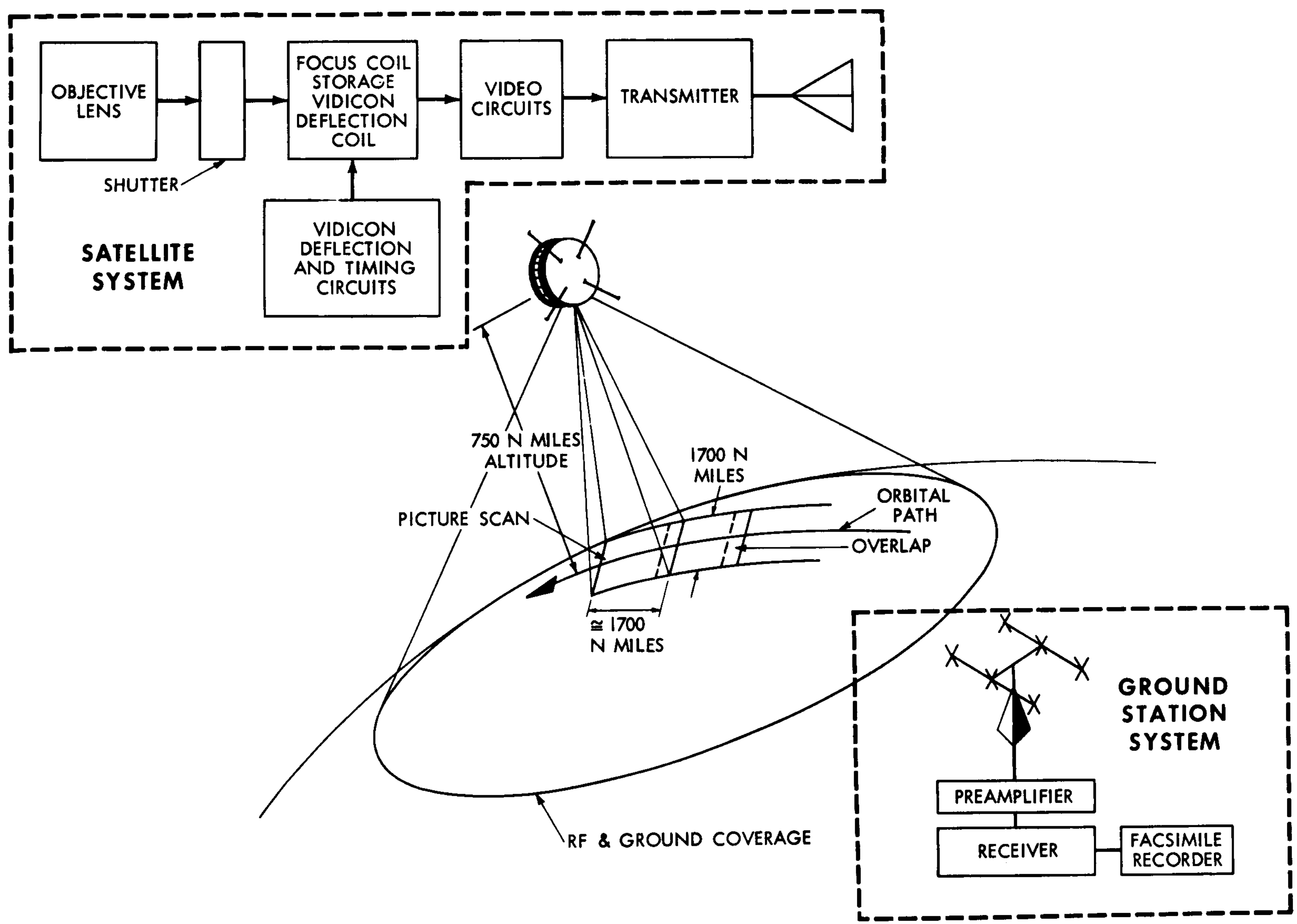


Figure 2–Automatic Picture-Transmission System

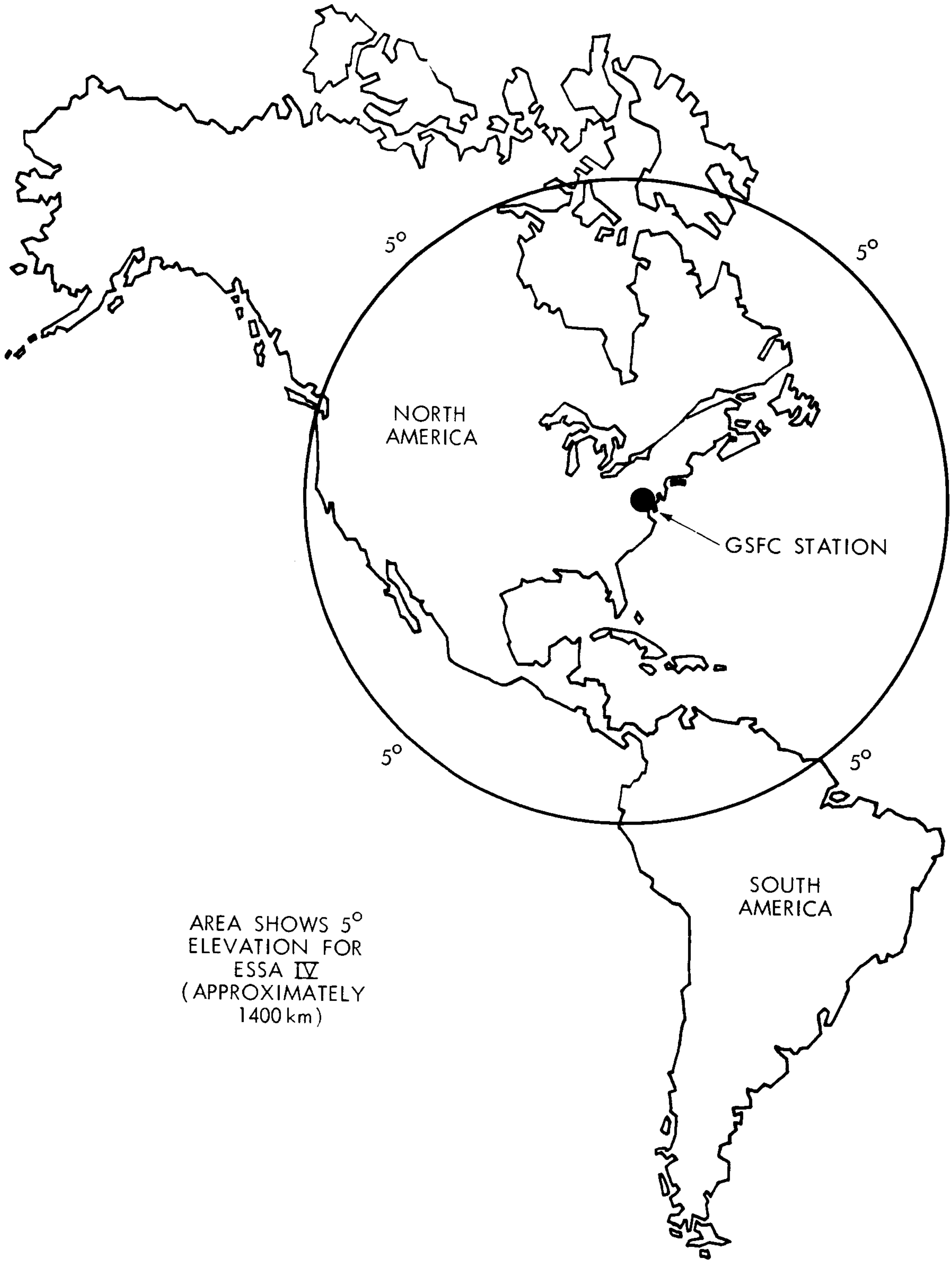


Figure 3–Area of Possible Reception

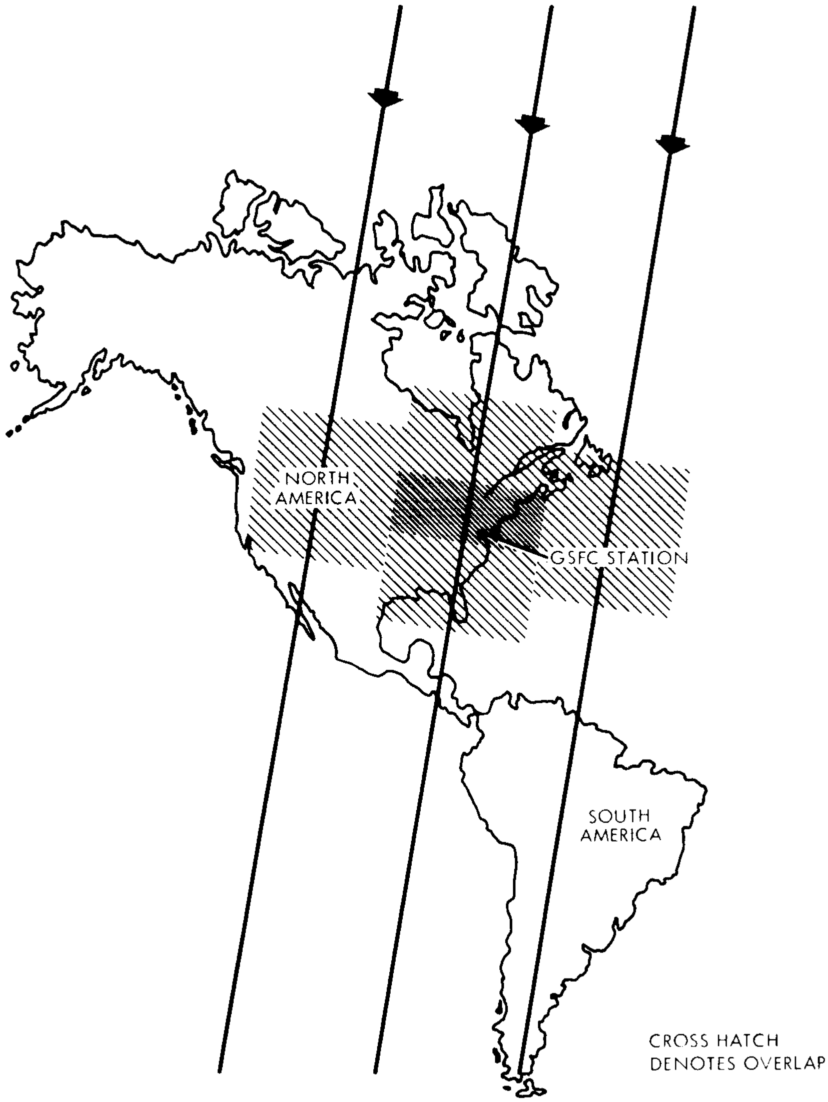


Figure 4–Area of Local Reception

## HOW THE APT GROUND STATION WORKS

Once the satellite is in range, the video signal can be heard in the receiver output. The first picture transmitted is of littel value because:

- It is usually "noisy."
- It is not of the local area.
- The station did not receive start and phase.

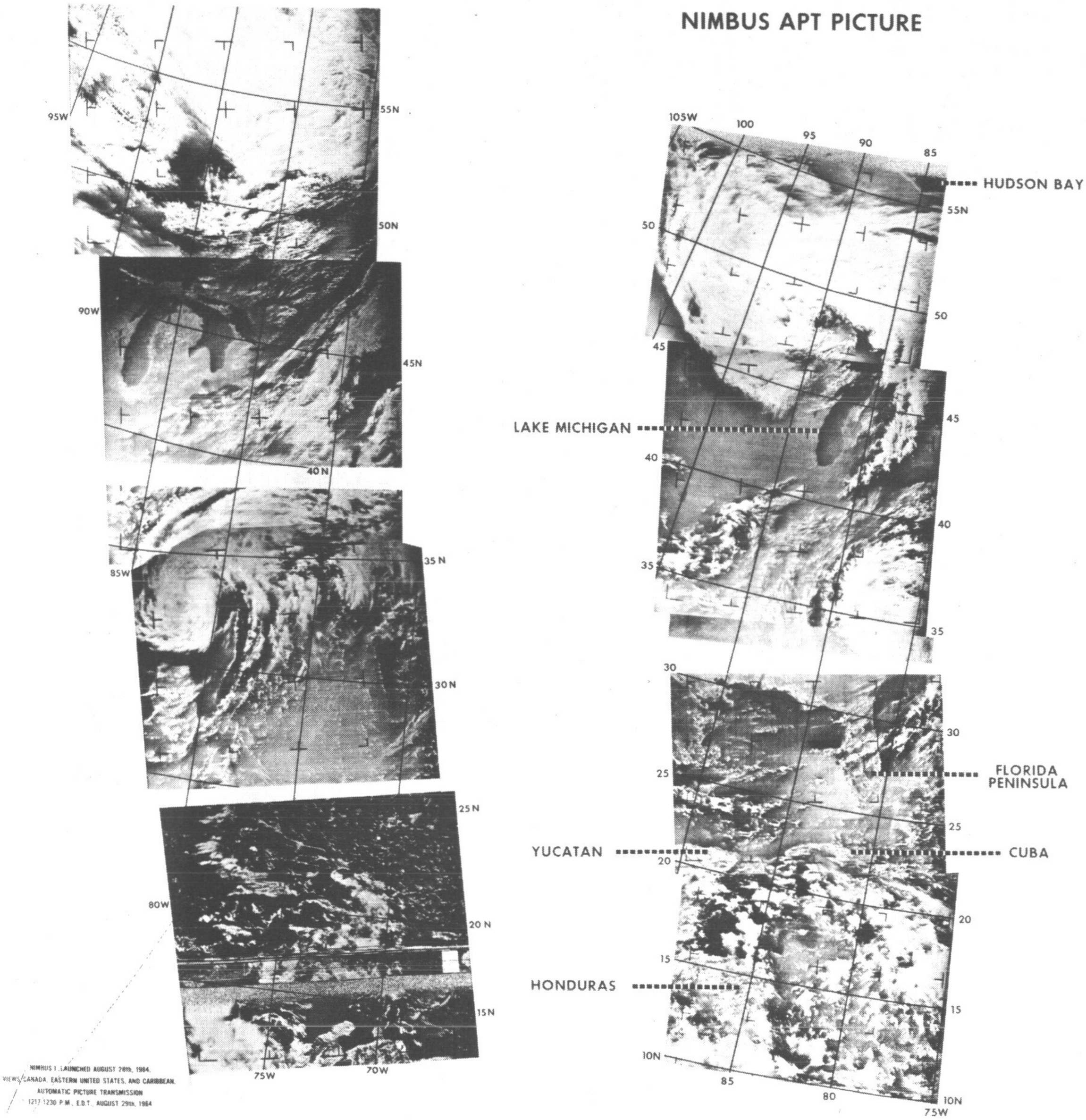


Figure 5–Nimbus APT Pictures

This is a good time to tune in the receiver and make a last-minute check of the station to verify its readiness to receive the first useful picture. The antenna operator tracks the satellite with the orbital predict data he has calculated, using the information he has received from the National Weather Satellite Center by mail or teletype.* (The APT User's Guide, a requirement for all APT stations, explains satellite tracking in detail.)** By the time the first local picture is transmitted, the station will have a good clear signal, indicated by a "buzzing" sound that interrupts the normal "beep" tone. This is the 300-cycle start, followed by the phasing signal (refer to Figure 1). Together these take 8 seconds. The 800 lines of picture information that immediately follow take 200 seconds to be transmitted and received. The ESSA spacecraft, which, in its rolling-wheel stabilization, revolves at a 10 RPM rate, will not take another picture until it is again in proper position. This operation takes about 140 seconds, during which the spacecraft transmits no picture information, only a steady 2400-Hz tone. After the satellite senses that it is in position, another picture will be taken and transmitted.

The Nimbus spacecraft is different from the ESSA spacecraft because it is an earth-oriented satellite always pointing towards the earth; there is no time lapse between the end of one picture and the start of another.

Twenty minutes are required to track an overhead pass from horizon to horizon. Each satellite will yield up to five good pictures for such a pass.

## BUILDING YOUR OWN APT GROUND STATION

Figure 6 is a simplified block diagram of the station whose construction is described in this document. The builder should take every precaution to wire to prevent mistakes. Since some parts may be faulty when procured, the operability of each component should be checked before it is used. The material needed for building a station is expensive; care in this early stage of construction will save time and money later.

The following circuit descriptions are straightforward, and assume only that the builder has a good background in electronics and a facility for testing.

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*For all material and predict data needed to calculate orbital information, write to: APT Coordinator; United States Department of Commerce; Environmental Science Services Administration; National Environmental Satellite Center; Washington, D. C., 20233. USA.

**The APT Users Guide. National Weather Satellite Center, Environment Science Services Administration. Washington, D.C. August 1965. (Available as GPO Document C52.8 from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402, USA, $1.00).

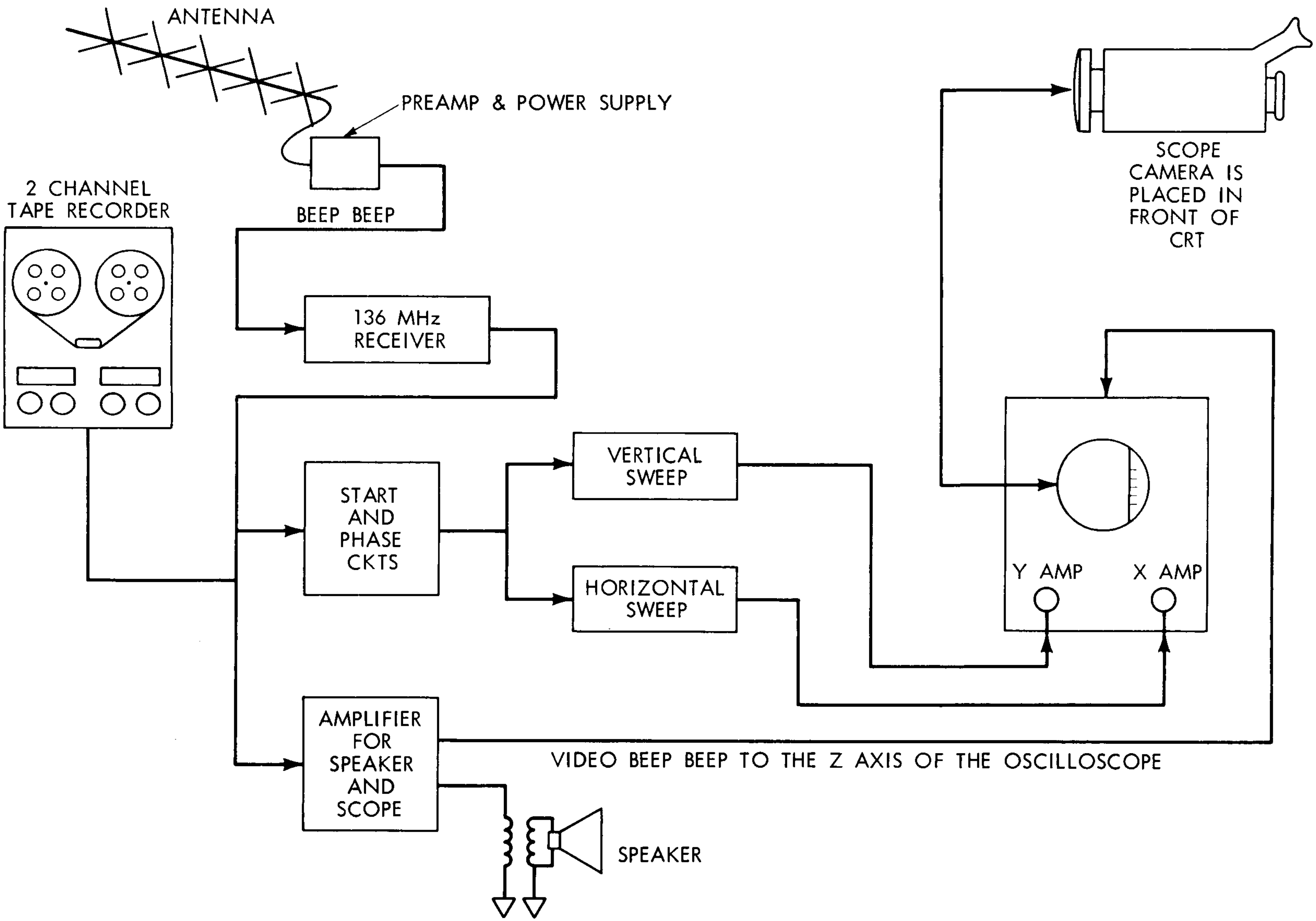



Figure 6–Block Diagram of the Low-Cost Station

ANTENNA

The antenna, apart from its pedestal, is a critical component of the system. However, it can easily be built to the following specifications or may be purchased for about $250.00 (at U. S. prices).

The antennas pictures in Figures 7 and 8 are made by TACO.* Whether purchased or handmade, the antenna must have the following characteristics:

Desired antenna gain: at least 11 db for elevations from 5 to 90 to 5 degrees (approximately 7000 mi dia).

Acceptable antenna gain: at least 9 db for elevations from 15 to 90 to 15 degrees (approximately 5000 mi dia). Nine db still insure local coverage.

Beamwidth: 45± 5 degrees. This is wide enough to provide easy tracking, yet narrow enough to yield sufficient gain.

Frequency: 130 to 140 MHz.

Polarization: right-hand circular.

If the proper facilities are available, the builder can make the antenna by following Figures 9 and 10. Figure 11 shows how to support the elements and the finished antenna. The elements are held in place by antenna-mast couplers and supported by nylon guy ropes. To connect the antenna cable to the antenna, a "gamma match" is needed.† The lengths of coaxial cable are connected with coax "TEE" connectors (Figure 10). The specified coax switches are needed to permit optimum polarization as the signal comes in. As the signal begins to fade, the switch settings must be alerted to compensate for the change.

Antenna Positioning

The antenna should be mounted so that it can be positioned in azimuth and elevation. The motors used for this purpose are CDE HAM-M rotators, selling for $120.00 each.†† They are sold with a control box which may be used in controlling them from the station.

*Scientific Atlanta, Hi Gain, Textran and other antenna manufacturers are equally satisfactory.

†Radio Amateurs Handbook. American Radio Relay League, Hartford, Connecticut. Latest edition: $3.50.
VHF Handbook. Radio Publications, Wilton Connecticut. Latest edition: $2.95.

††Other types of motors similar to the CDE HAM-M rotators can also be used.

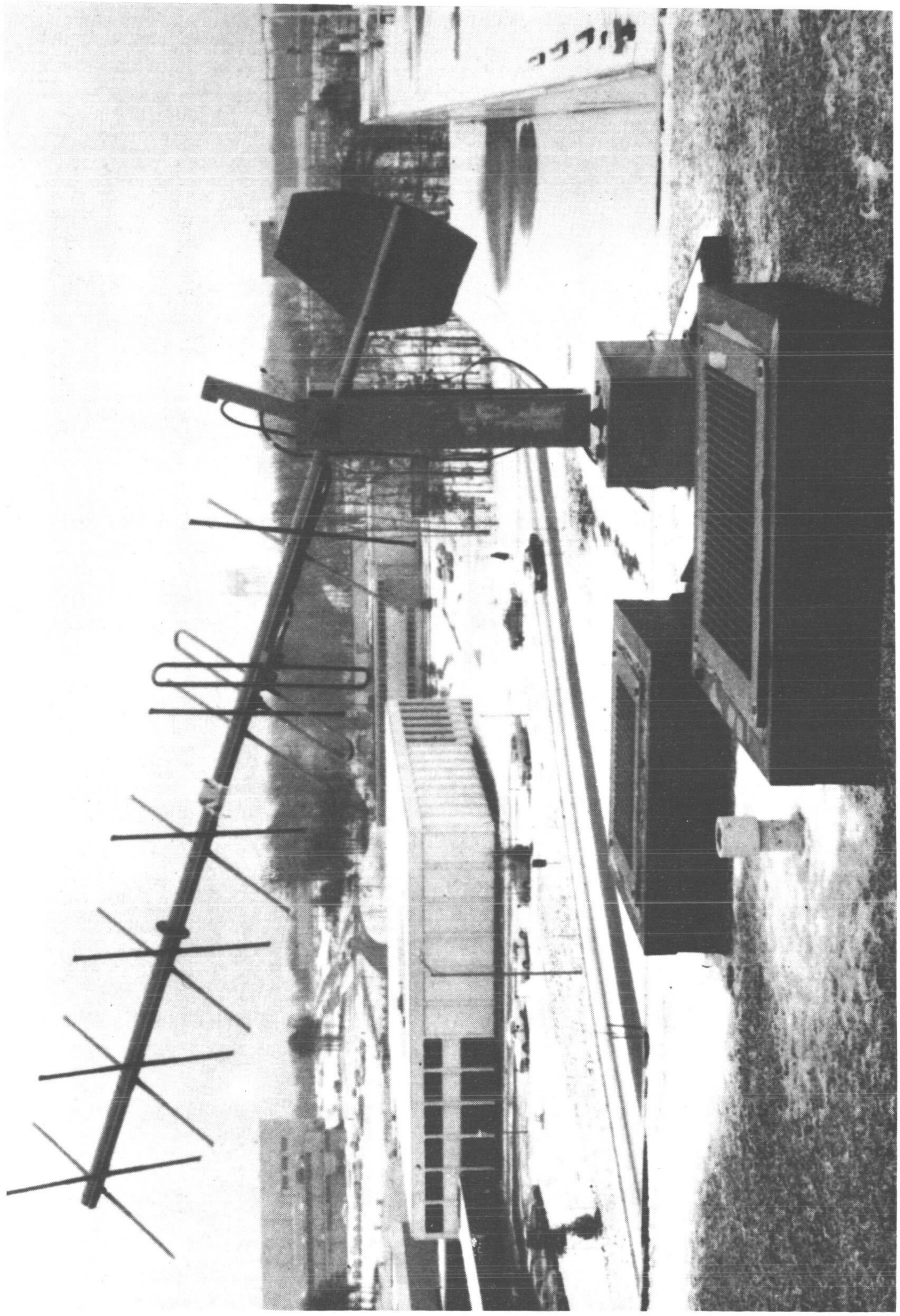


Figure 7—Dual-Axis/Single-Boom Crossed Yagi

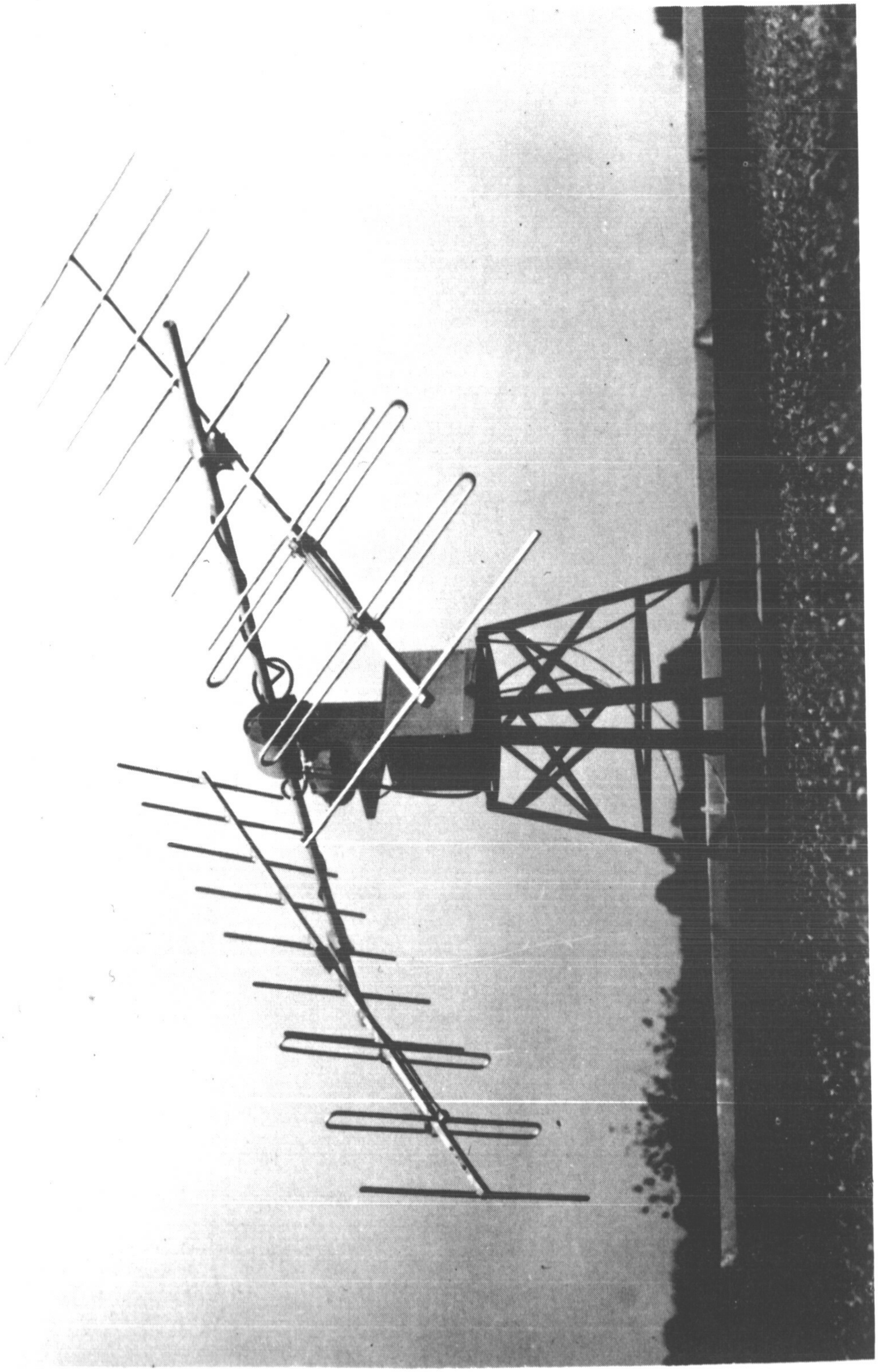


Figure 8—Dual-Axis/Double-Boom Crossed Yagi

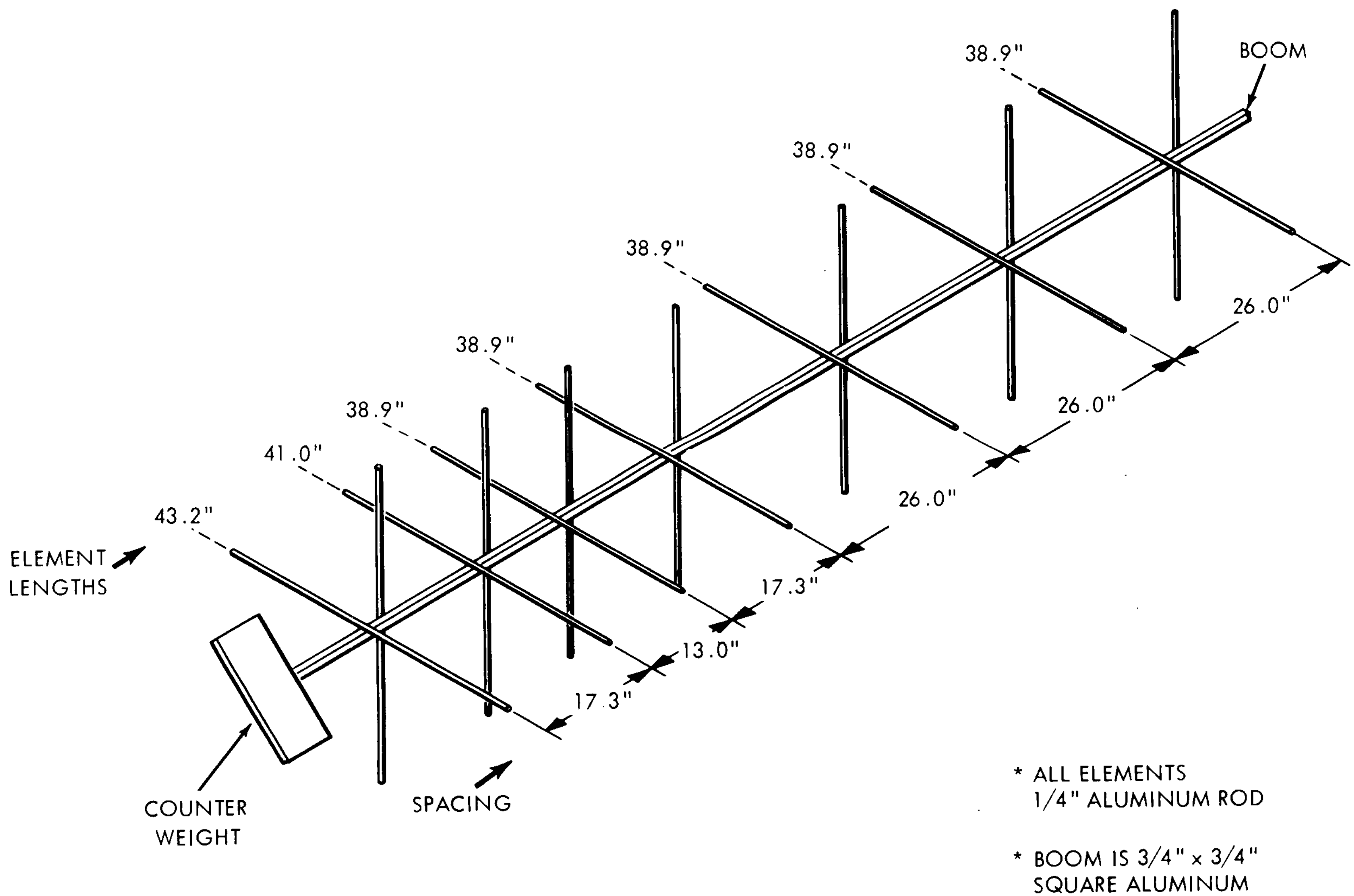
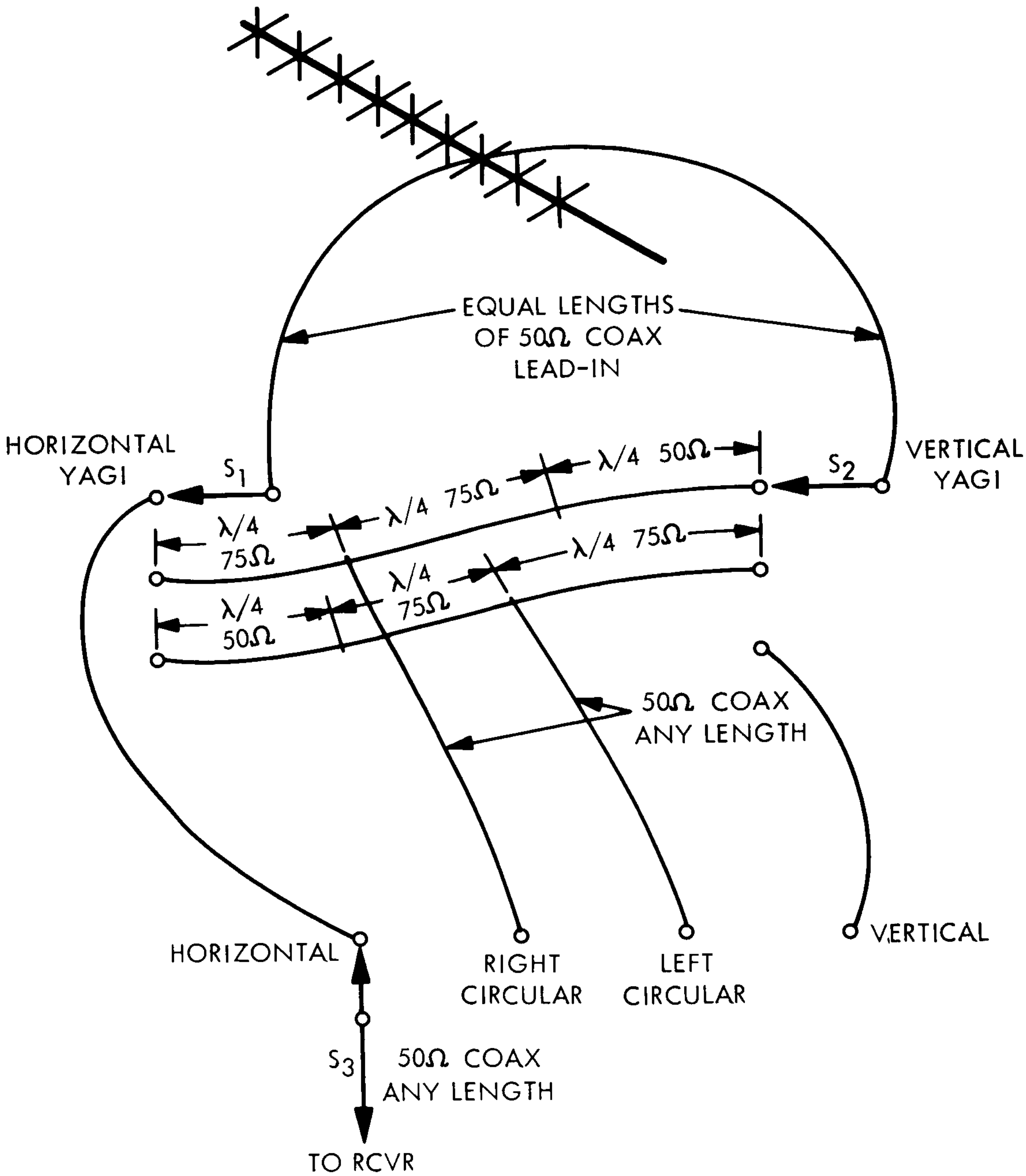



Figure 9–Antenna Element-Spacing Diagram




NOTE: 50Ω COAX IS RG8/U

75Ω COAX IS RG11/U

COAX SWITCHES
$S_1$, $S_2$, $S_3$ ARE B & W 550A

Figure 10—Antenna-Phasing Diagram

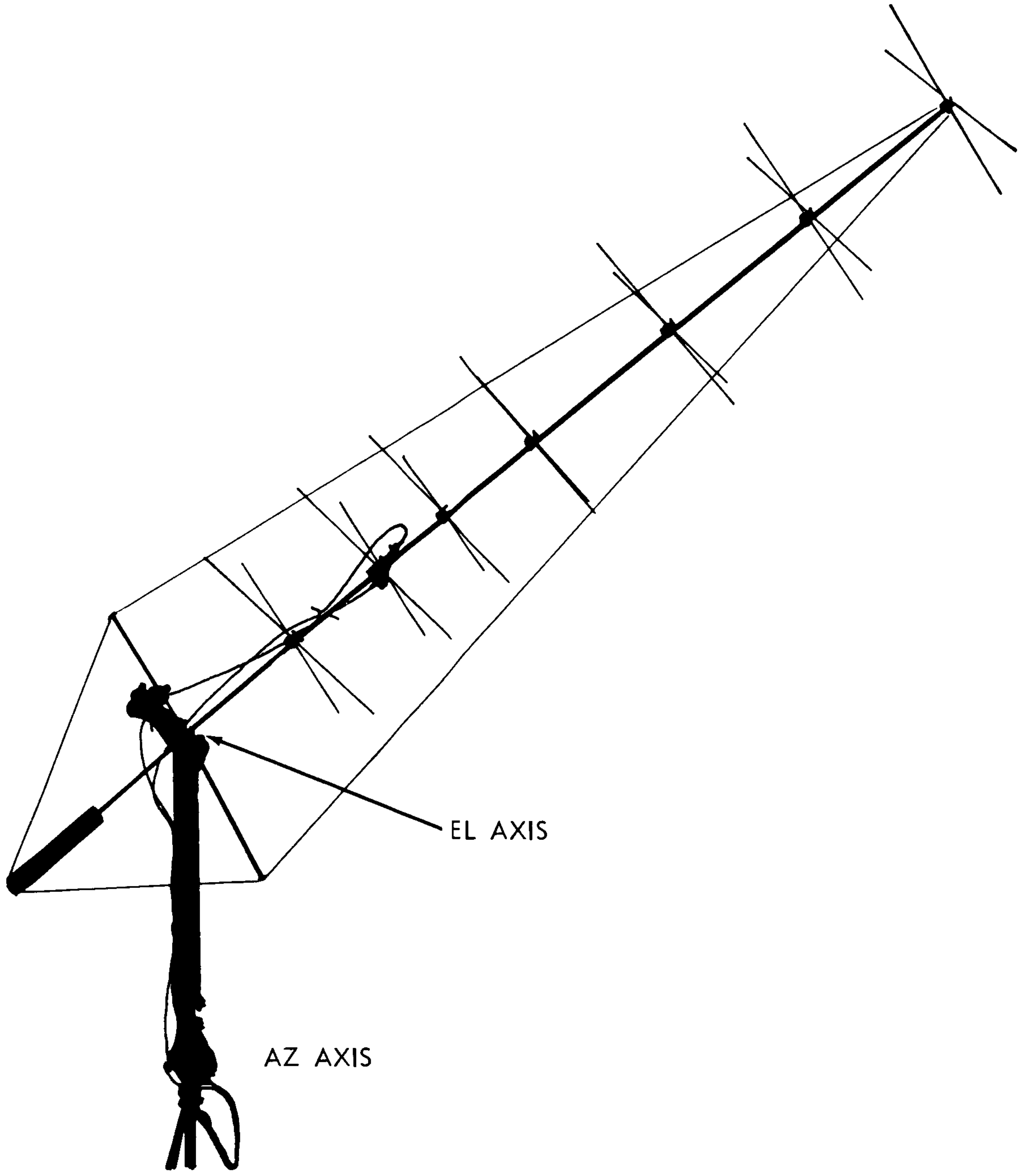



Figure 11–Assembled Yagi Boom Support

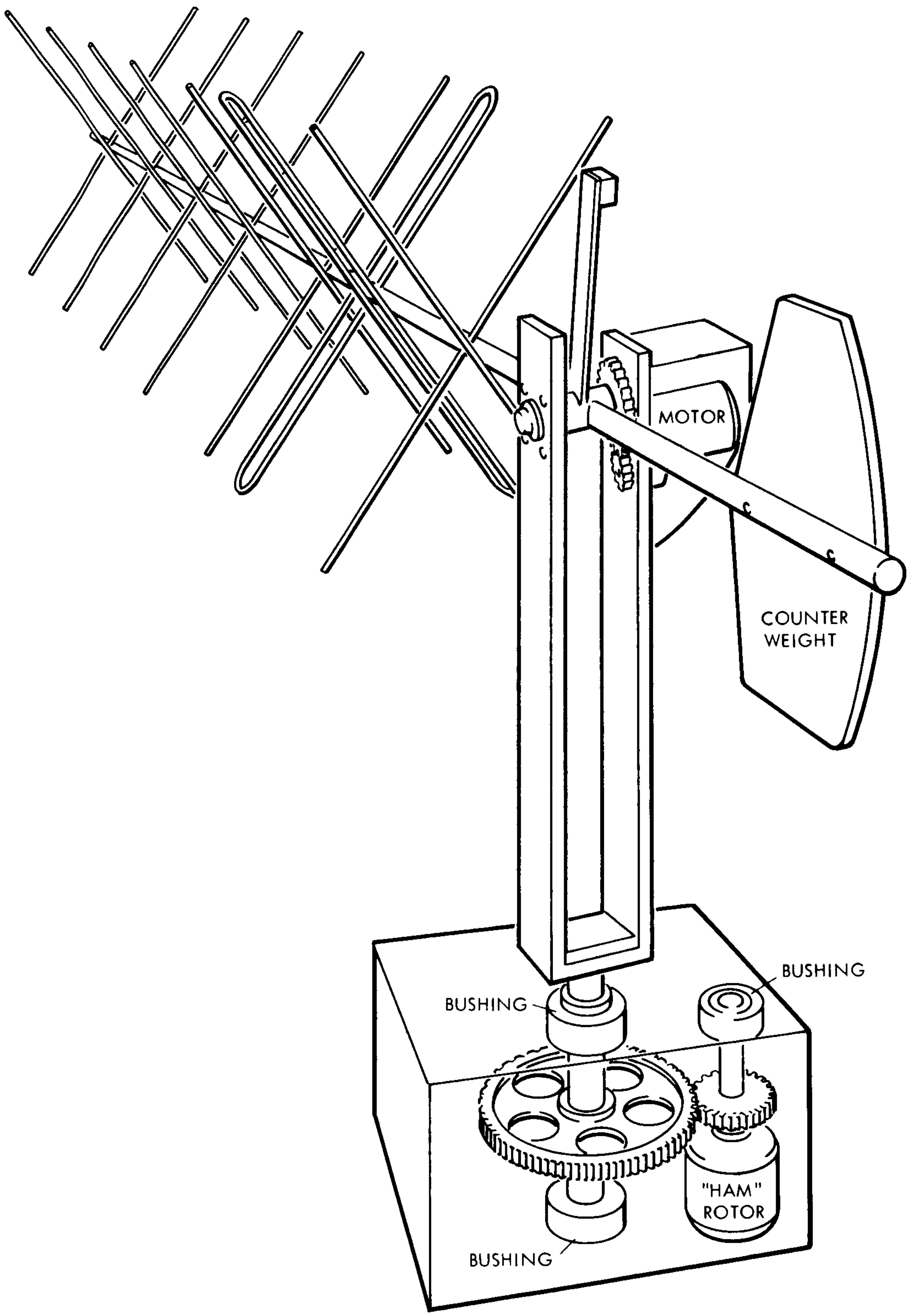


Figure 12–Mechanical Assembly of Antenna Pedestal

The motor shafts must be drilled and pinned with the gears proper for rotation. Select large "cast" gears for strength.* They must be at least 1 inch thick and of sufficient radius to give a 2-to-1 speed reduction. This will yield the proper speed and torque needed to move an antenna of the size mentioned. Refer to Figures 12 and 13, a mechanical guide for the pedestal and motor mounting.

## Antenna Control Orientation

After the antenna is assembled and working properly, it must be oriented. Since the satellite is not in a true polar orbit, the pedestal must be positioned so that it does not hit the azimuth stops during tracking (Figure 14). Set the antenna so that it will rotate from 350 degrees to 170 degrees with 0 degrees at TRUE NORTH (Figure 15). To rotate the antenna from 170 degrees through 350 degrees, the elevation must be run all the way to the other side, the antenna placed in the western sector. The antenna will track the satellite from horizon to horizon even though the satellite pass is at maximum elevation angle.

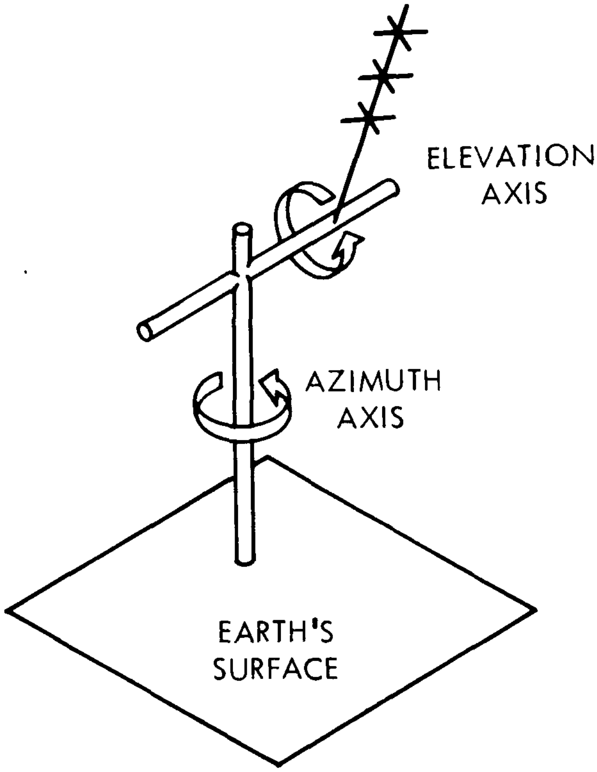
Bolt the antenna base to a solid level surface. This will help damp any oscillation and prevent the pedestal from blowing over in a storm. To bolt the base, pour a solid cement foundation in the ground, anchoring large bolts in the cement before it has hardened. Fasten the antenna base to these bolts after the cement dries. The antenna may be placed on a structure such as a roof or tower if the structure can support its weight (typical weight: 500 pounds).

## Antenna Control Boxes

The position boxes are packed with the motors. Refer to the CDE manual (or other, if used) to calibrate the antenna position so that it reads the same as the meter indication. The scales must be removed and scribed, as shown in Figure 16. This may require the services of a draftsman, since these scales are an important part of the console.

Personnel having sheet-metal facilities may wish to remove the az/el control boxes from their plastic houses, make one narrow, two-window console and paint it an attractive color. This makes the apparatus look more professional. If another housing is made for the two boxes, the ac power should be wired to an ON/OFF switch.

*Those made by Boston, American Gear or equivalent manufacturers will be satisfactory.




AZ-EL MOUNT

Figure 13–Simplified Antenna Positioning

Antenna Preamplifier

The antenna's direct signal is given off at a level too low for reception. This condition becomes more severe as the distance is increased between the antenna and the receiver. The level must be boosted by a pre-amplifier on the antenna pedestal. Of the two versions of the preamplifier discussed here, version 1 is the easiest to build and can be used with any type of receiver. Version 2 can only be used with the receiver described in this document since its preamp receives power from that receiver.

Preamp Version 1 – Figure 17 shows the schematic and coil construction data for preamp version 1. When this design is used, it is recommended that two preamps be fabricated and placed in series to improve the signal level. The two units may be placed in a single box, which must be rigid aluminum and completely weatherproof. The B+ can be fed in through a hold, if the hole is epoxy-sealed. Type-N connectors are used for input and output.

The number of turns in L3 does not appear to be critical, but can be adjusted at 136 MHz for the best noise figure. In order to keep distributed capacity to a minimum, the transistors were wired into the circuit and soldered directly to the leads. Leads should be as short as possible; all critical components must be subjected to heat-sink. This is accomplished by placing a metal clamp between the soldering connection and the component body while heat is applied.

Tuning is not critical, but in order to peak at 136 MHz, a weak signal should be induced in the receiving antenna and all tuning adjustments made. The bandwidth will be several MHz wide. Optimum tuning can be accomplished with

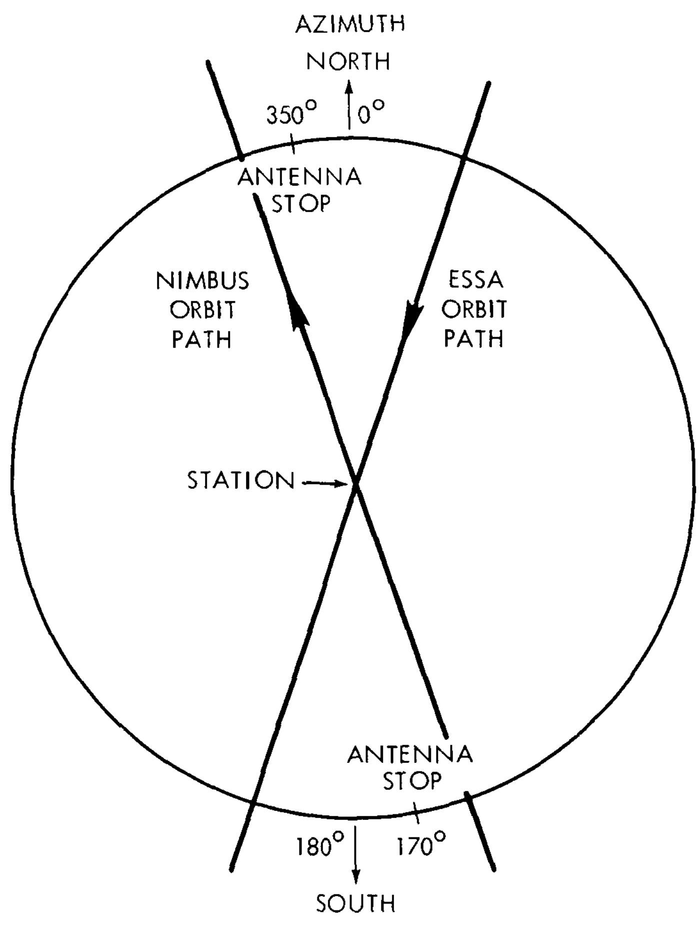



Figure 14–Antenna Orientation

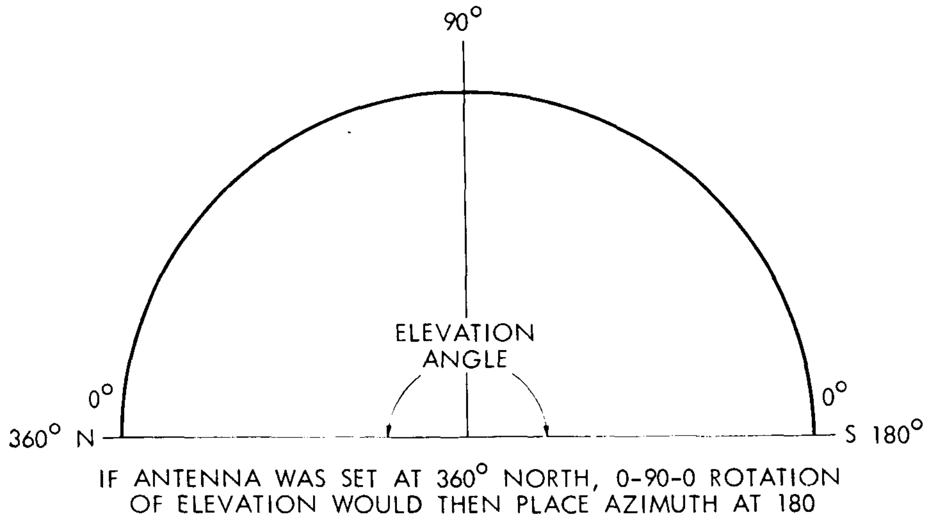



Figure 15–Limits of Antenna Orientation

a noise figure generator.* When transmission line lengths are changed, amplifier circuits will probably need retuning.

The 2-8 pf capacitors used are the miniature type, about 3/8 inch in diameter. These capacitors should be soldered directly to the coil lugs. The adjustable capacitors across the input and output tank circuits are best set to near-resonance with the coil slug at its mid position. Fine tuning can be done from the top of the chassis.

Proper setting of the bias pot is important because it affects both noise figure and gain. At zero bias, the circuit gain is at maximum and the amplifier is noisy. As the bias is increased, the noise output decreases exponentially. The bias control is properly set where both the gain and the noise decrease slowly. An exact value of bias cannot be given, because it varies with transistor characteristics.

Figure 18 shows a suitable power supply for the preamp version 1.

Preamp Version 2 – Figures 19, 20, 21, 22, and 23 show the schematic and construction details for preamp version 2. This preamp receives its dc operating

*If this equipment is not available, refer to:
Radio Amateur's Handbook. American Radio Relay League, Hartford, Connecticut. Latest edition: $3.50.
VHF Handbook. Radio Publications, Wilton, Connecticut. Latest edition: $2.95.

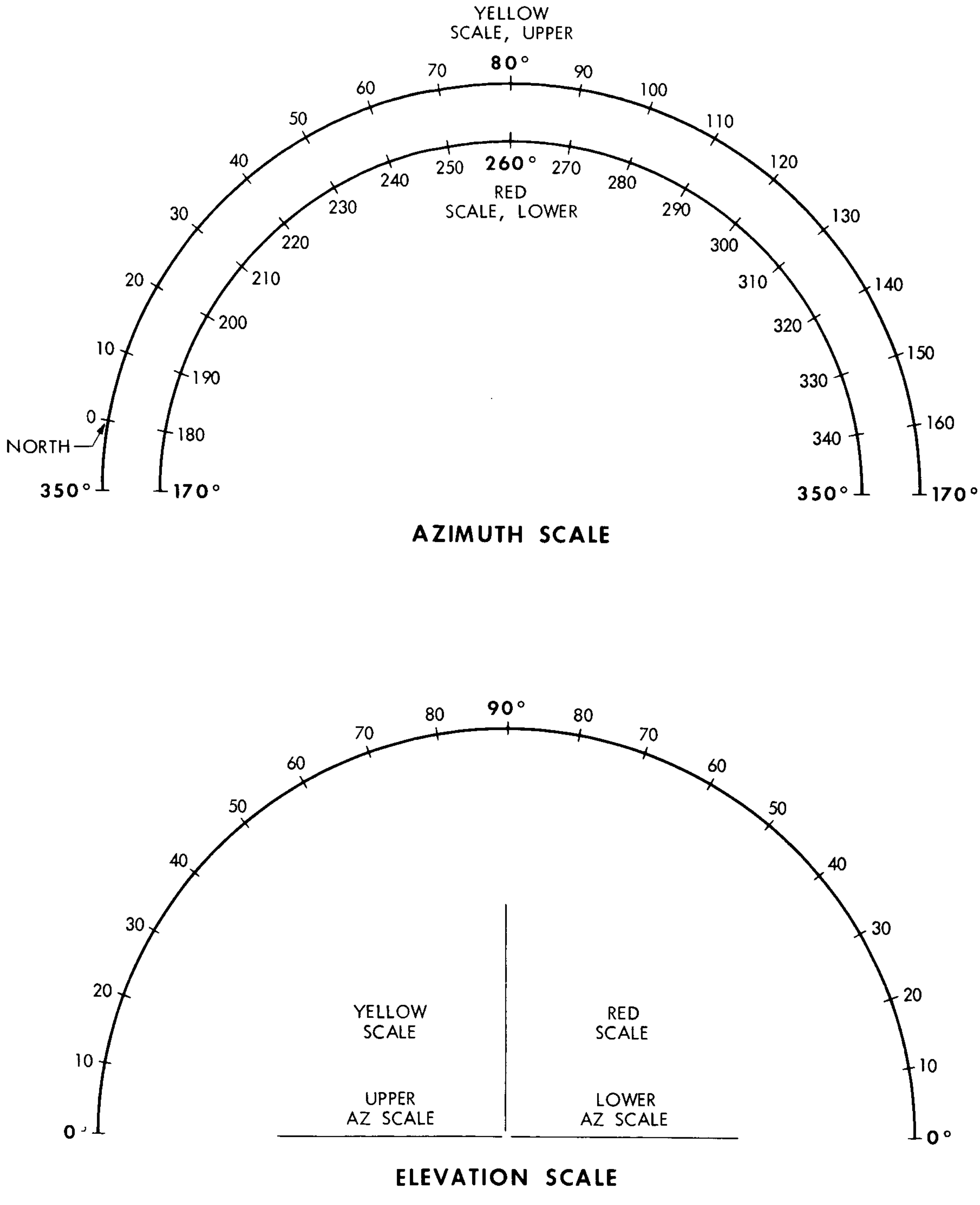
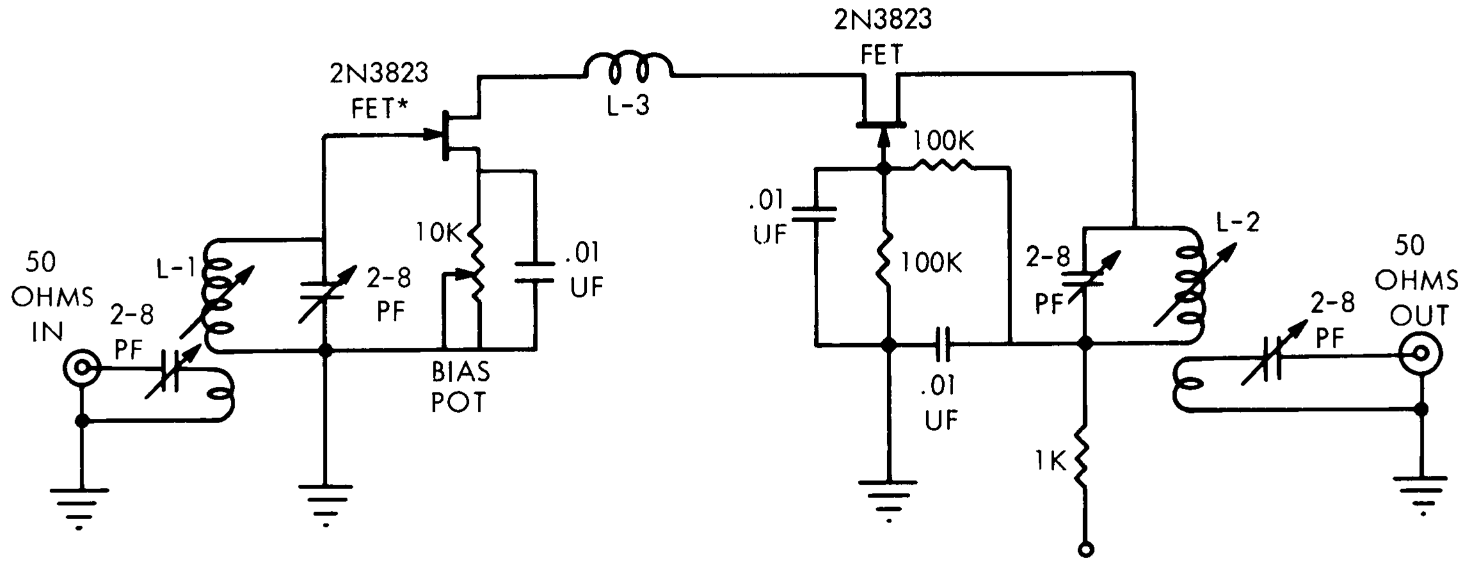



Figure 16–Recalibration of Antenna-Control Boxes




COIL DATA:
L-1; PRIMARY, TWO TURNS #22 PLASTIC-INSULATED WIRE, CLOSE WOUND OVER THE COLD END OF THE SECONDARY.
SECONDARY, SIX TURNS #22 WIRE SPACED TO FILL FORM.

L-2; PRIMARY, SIX TURNS #22 WIRE SPACED TO FILL FORM.
SECONDARY, ONE TURN #22 PLASTIC INSULATED WIRE, CLOSE WOUND OVER THE COLD END OF THE SECONDARY.

USE CAMBION COIL FORM, PART #1536-4-2.

L-3; THIRTEEN TURNS #26 ENAMEL-COATED WIRE, CLOSE WOUND ON 100K OHM 1/2W. RESISTOR AS CORE.

*FIELD - EFFECT TRANSISTOR (TEXAS INSTRUMENTS).

Figure 17–Antenna Preamplifier, Version 1, Schematic

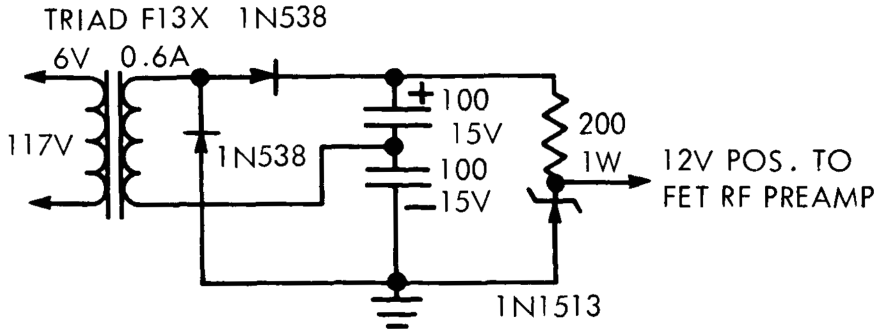



Figure 18–Antenna Preamplifier, Version 1, Power Supply Schematic

voltage from the receiver through the same coax cable that carries the amplified signal. The mounting details and alignment data given for preamp version 1 apply to this version also.

## FM RECEIVER

The FM receiver is the most important part of the APT station. It must be relatively noise-free, and must be equipped with automatic frequency control (AFC), automatic gain control (AGC), and a meter to indicate signal strength for tracking purposes.

Whether the receiver is designed for telemetry or is a communication receiver/converter combination, it should:

- Have a 1-microvolt input for 27 db of quieting.
- Have a 50-kHz bandwidth minimum, 80-kHz maximum.
- Be crystal-controlled if possible.
- Be capable of receiving the following frequencies: 135.6 MHz Weather Facsimile (WEFAX); 136.95 MHz (NIMBUS); 137.5 MHz and 137.62 MHz (ESSA).*

The builder may procure his receiver in any of the following ways:

- (The most suitable). Use a regular telemetry receiver–readily available from most surplus equipment dealers. Some receivers may have to be converted to accommodate the necessary frequencies.

*ESSA has proposed that every other APT-equipped satellite use 137.62 MHz an avoid a conflict between two ESSA satellites in operation at the same time.

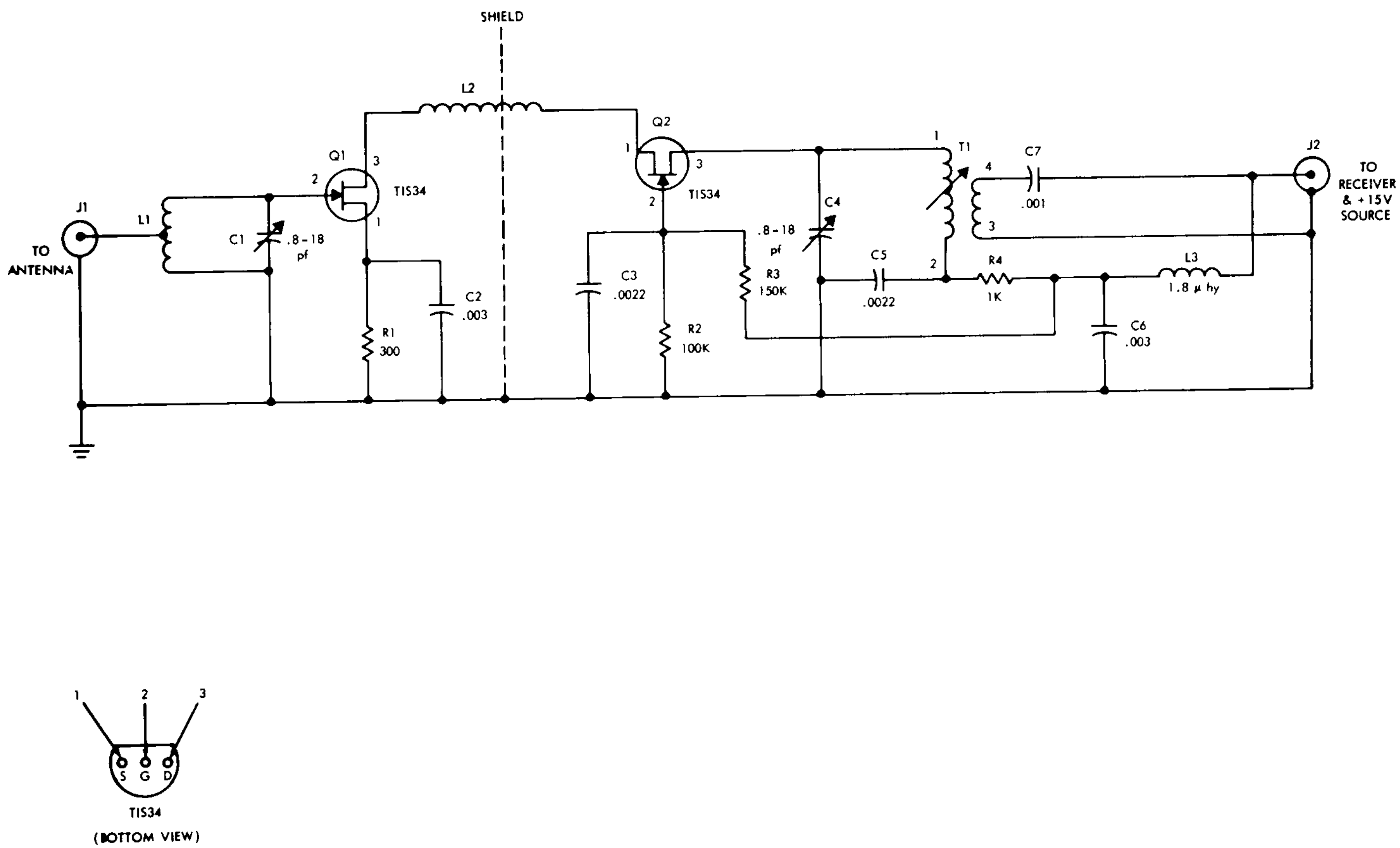
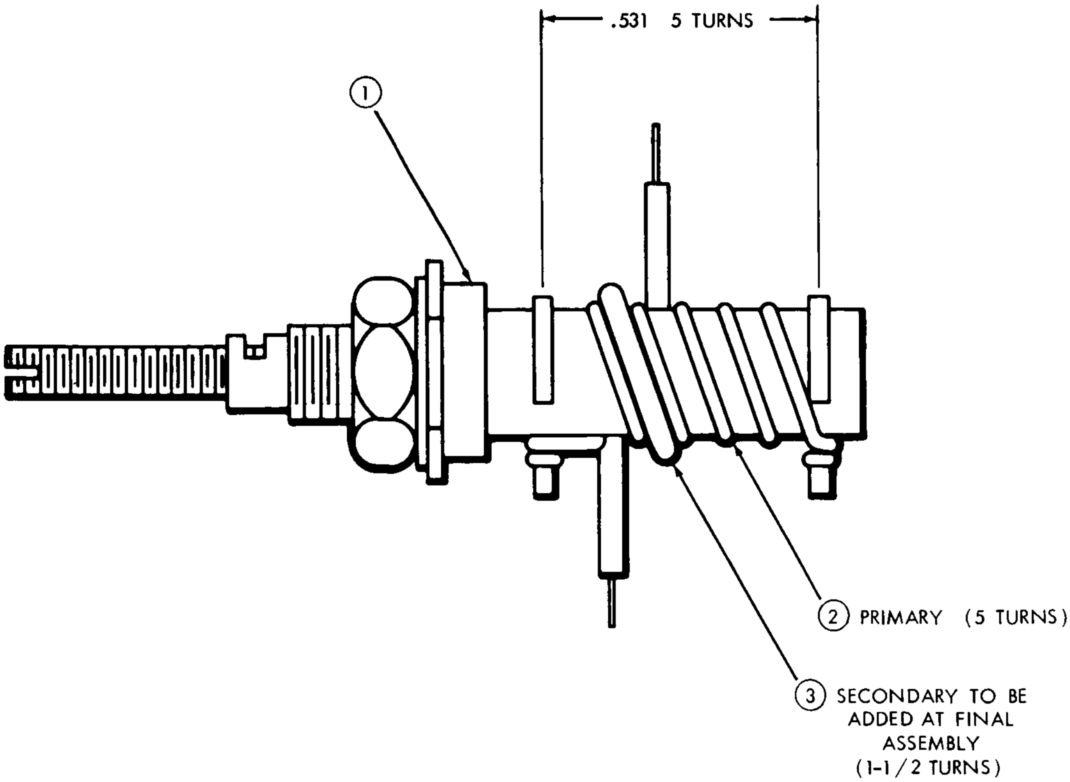
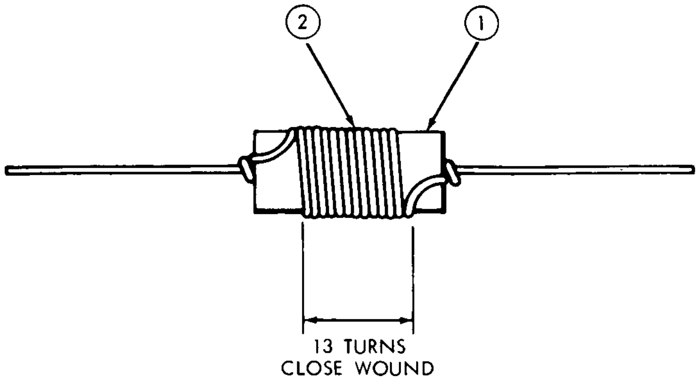



Figure 19–Antenna Preamplifier, Version 2, Schematic



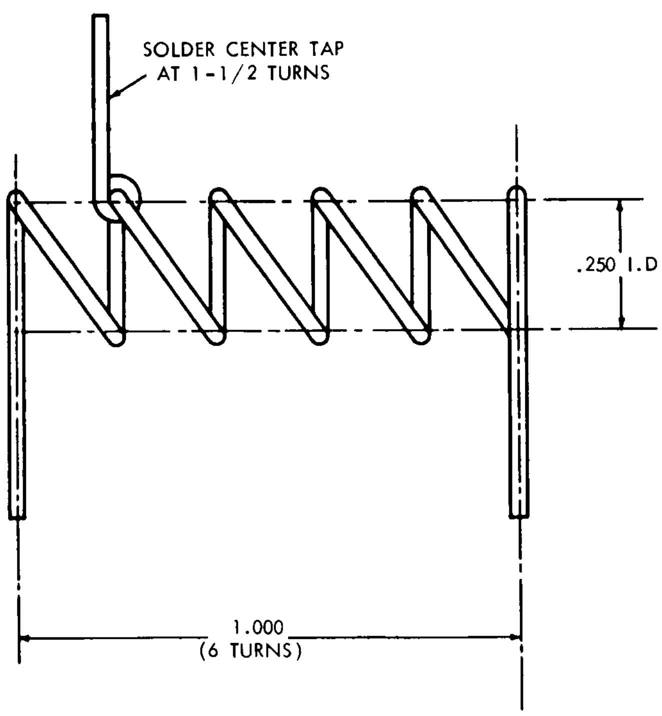

| | | | | |
|---|---|---|---|---|
| AR | | 4 | SOLDER, SN60/SN63 | |
| AR | 8530 | 3 | WIRE, SOLID, BELDEN #22, THERMO PLASTIC INSULATION | |
| AR | 8020 | 2 | BUS WIRE, BELDEN #20, TINNED COPPER | |
| 1 | 4500-2 | 1 | COIL FORM, J.W. MILLER | |
| REQD | PART NO. | ITEM | DESCRIPTION | SYM |

Figure 20–Output Transformer T1 for Antenna Preamplifier, Version 2



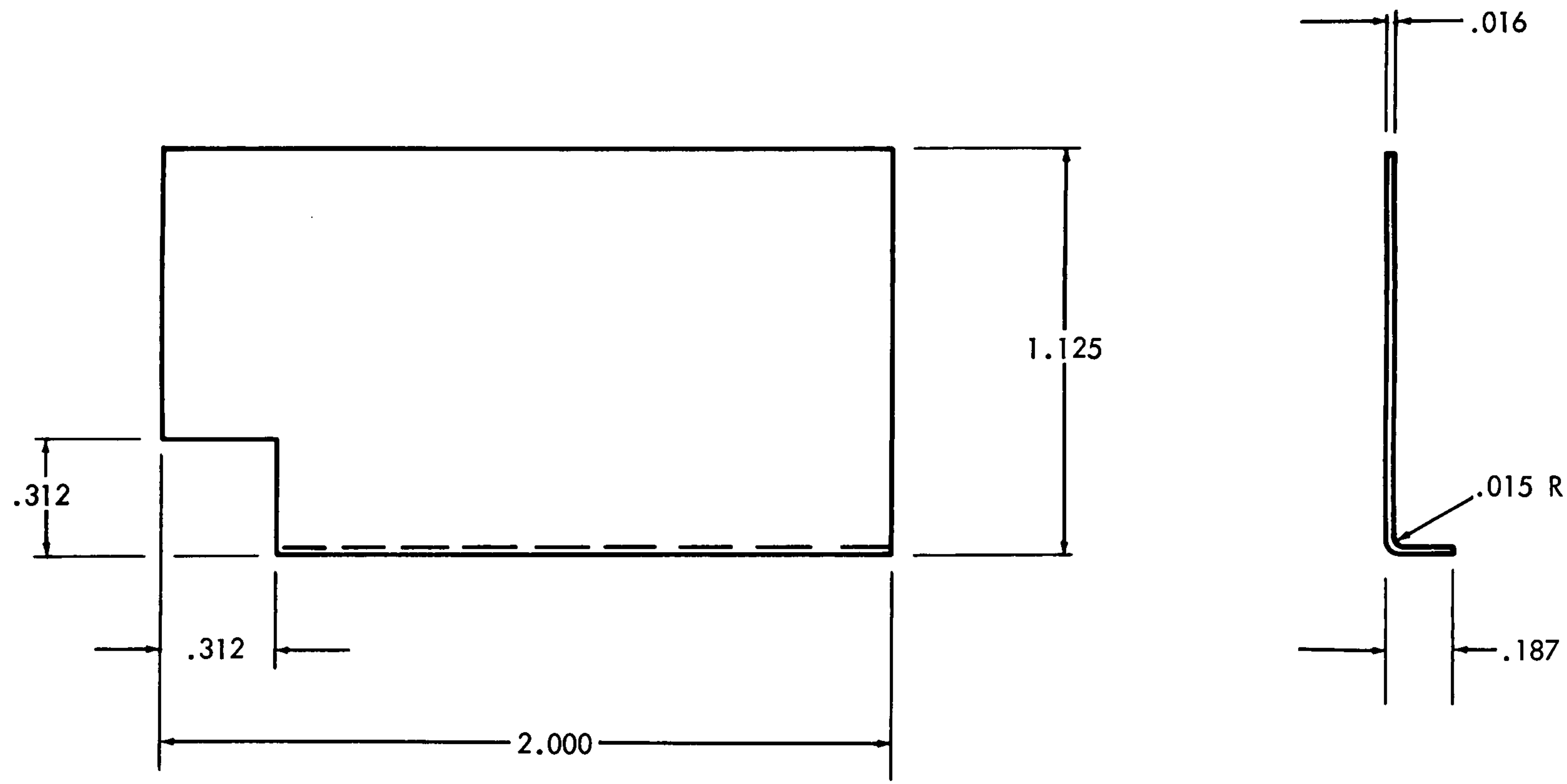

| | | | | |
|---|---|---|---|---|
| AR | | 3 | SOLDER, SN60/SN63 | |
| AR | 8065 | 2 | WIRE, SOLID, BELDEN #26 HNC NYCLAD | |
| 1 | RN20 | 1 | RESISTOR, FIXED COMP, 100K, 1/2W | |
| REQD | PART NO. | ITEM | DESCRIPTION | SYM |

Figure 21–Neutralizing Induction L2 for Antenna Preamplifier, Version 2.




| | | | | |
|---|---|---|---|---|
| AR | | 2 | SOLDER, SN60/SN63 | |
| AR | 8019 | 1 | BUS WIRES, BELDEN #18 TINNED COPPER | |
| REQD | PART NO. | ITEM | DESCRIPTION | SYM |

Figure 22–Input Inductor L1 for Antenna Preamplifier, Version 2




NOTE: BREAK SHARP EDGES AND REMOVE ALL BURRS.

Figure 23–Shield for Antenna Preamplifier, Version 2

- Combine a good quality "ham" communications receiver, such as the BC603, and a commercially available frequency converter. Such a converter can be obtained from AMECO,* Tapetone and others for about $48.00, including the power supply.

  Be sure to specify the four input frequencies mentioned above when ordering the converter and crystals. The frequencies can be converted from the 136-MHz range down to the receiver range. Choose a frequency within the range of the receiver for the converter output. Hardwire the converter output directly to the receiver input.† Disconnect the receiver antenna if it is connected and match the impedances to the tracking antenna if they are unmatched. The receiver output must be one volt peak-to-peak for normal operation with the following suggested video electronics.††

- Build the receiver yourself. This is advantageous because you can integrate it into the oscilloscope housing along with the video electronics. Figures 24, 25, 26, 27, and 28 show the schematic and other details needed to build the receiver. Table 1 lists the required parts. The crystal specification given by figure 25 should be used when purchasing the receiver's crystal. The receiver components should be mounted on fiber PC boards, with appropriate holes drilled beneath tuning slugs that have bottom adjustments.

If the receiver is built into the oscilloscope plug-in, a plug-in extender must be made. The only mechanical detail of this extender necessary to the functioning of the receiver is that the extender match the oscilloscope's internal connector. The extender permits access to the internal circuits of the receiver. After the receiver is finished, the following alignment procedure should be observed:

1. Set the frequency of an FM-signal generator to 10.7 MHz to align the I.F. Check the frequency with a counter if one is available. If not, refer to suggested procedures in the AARL or VHF Handbook.

2. Place the plug-in on the extender and apply power with the POWER ON switch.

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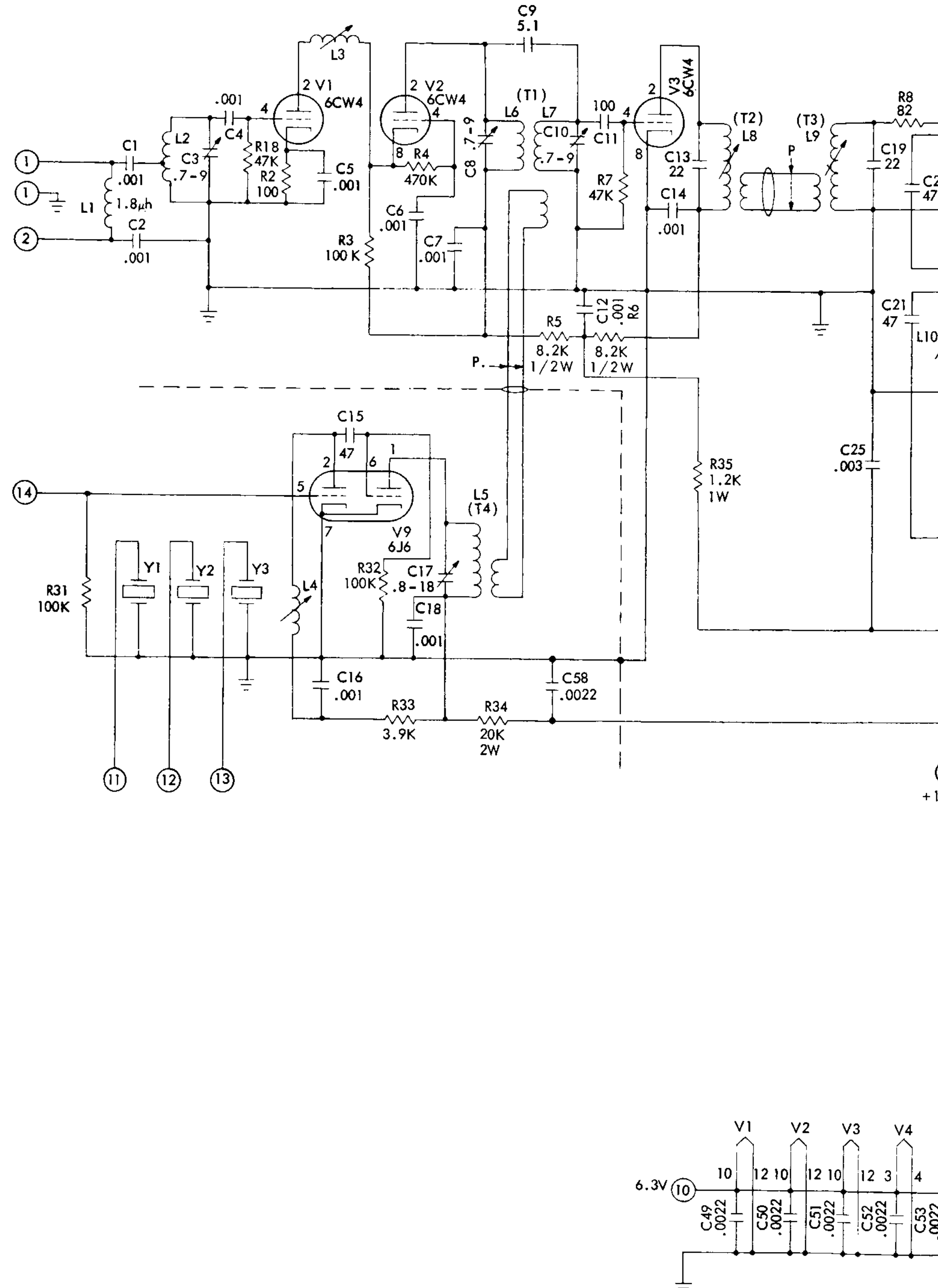
*Ameco Equipment Corporation, Raleigh, N. C. (Specify input and output frequencies.)

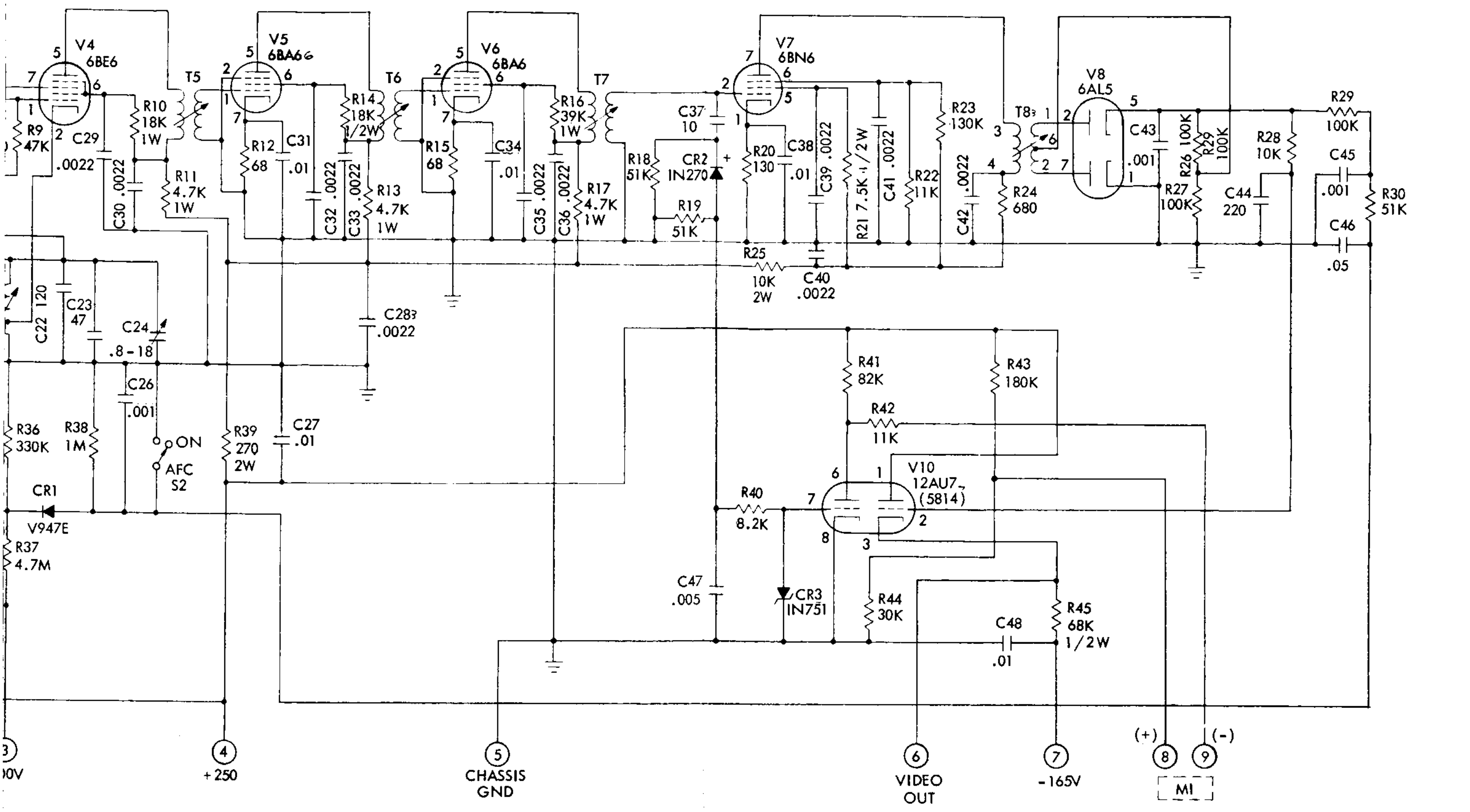
†The range of 21–25 MHz is satisfactory and is available in the BC603 receiver.

††See "The Facsimle."



C9
5.1
L3
V1
6CW4
V2
6CW4
V3
6CW4
(T1)
(T2)
(T3)
L6
L7
L8
L9
R8
82
C1
.001
L1
1.8μh
C2
.001
L2
C3
.7-9
C4
R18
47K
R2
100
C5
.001
R4
470K
C6
.001
C7
.001
C8
R3
100 K
C10
.7-9
100
C11
C13
22
C14
.001
R7
47K
C19
22
C21
47
L10
C12
.001
R5
8.2K
1/2W
R6
8.2K
1/2W
C15
47
V9
6J6
L5
(T4)
R32
100K
C17
.8-18
C18
.001
Y1
Y2
Y3
R31
100K
L4
C16
.001
R33
3.9K
R34
20K
2W
C58
.0022
R35
1.2K
1W
C25
.003
6.3V
V4
C49
.0022
C50
.0022
C51
.0022
C52
.0022
C53


~~28~~ 29-1



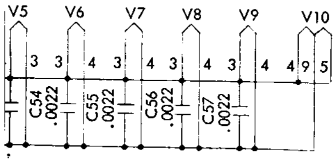




Figure 24—VHF Receiver Schematic

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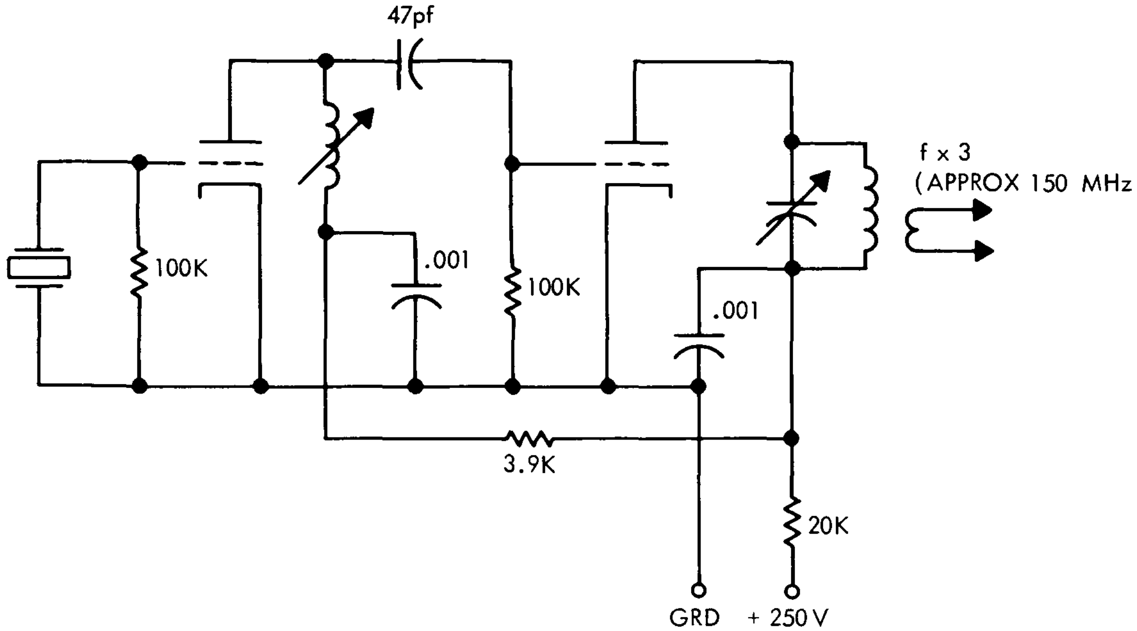



1. Crystal to oscillate on overtone
2. Frequency tolerance to be .005%
3. Housed in HC6 holder.
4. Crystal to operate in circuit as shown.
5. Tube type 6J6
6. Output of circuit to be f (crystal) X3. Approximately 150 MHz.

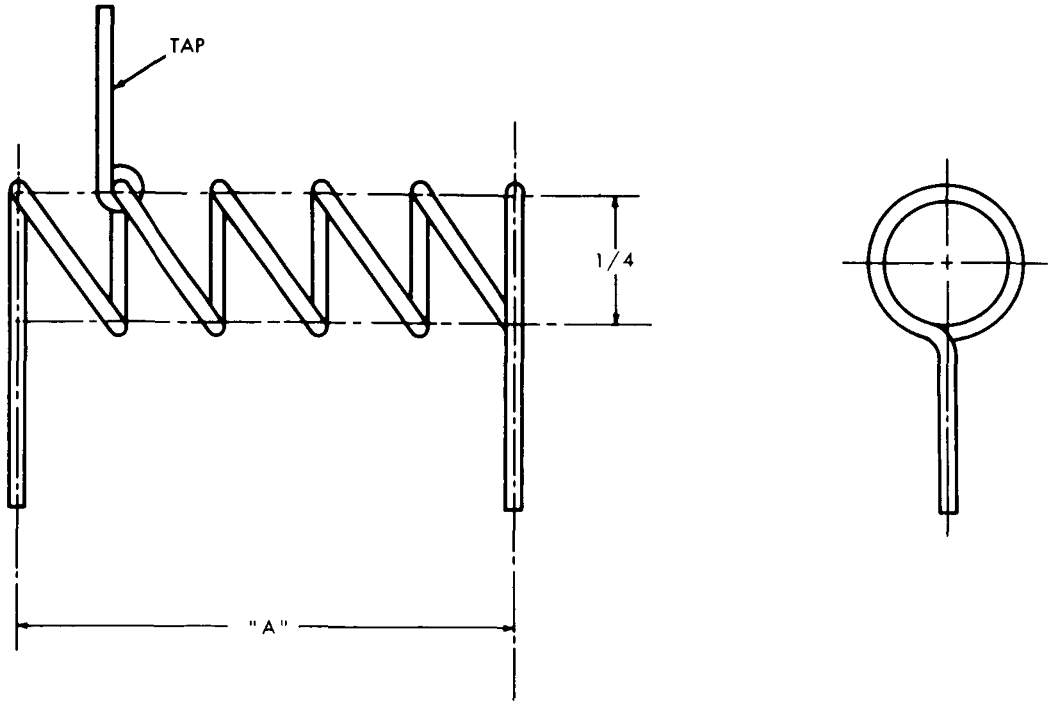
Figure 25–Receiver-Crystal Specification, Schematic

3. Turn the AFC switch to OFF. Connect the output of the FM-signal generator to pin 7 of tube V4.

4. Connect the oscilloscope to pin 2 of tube V8.

5. Increase the FM-signal generator-output level until a signal is observed on the oscilloscope.

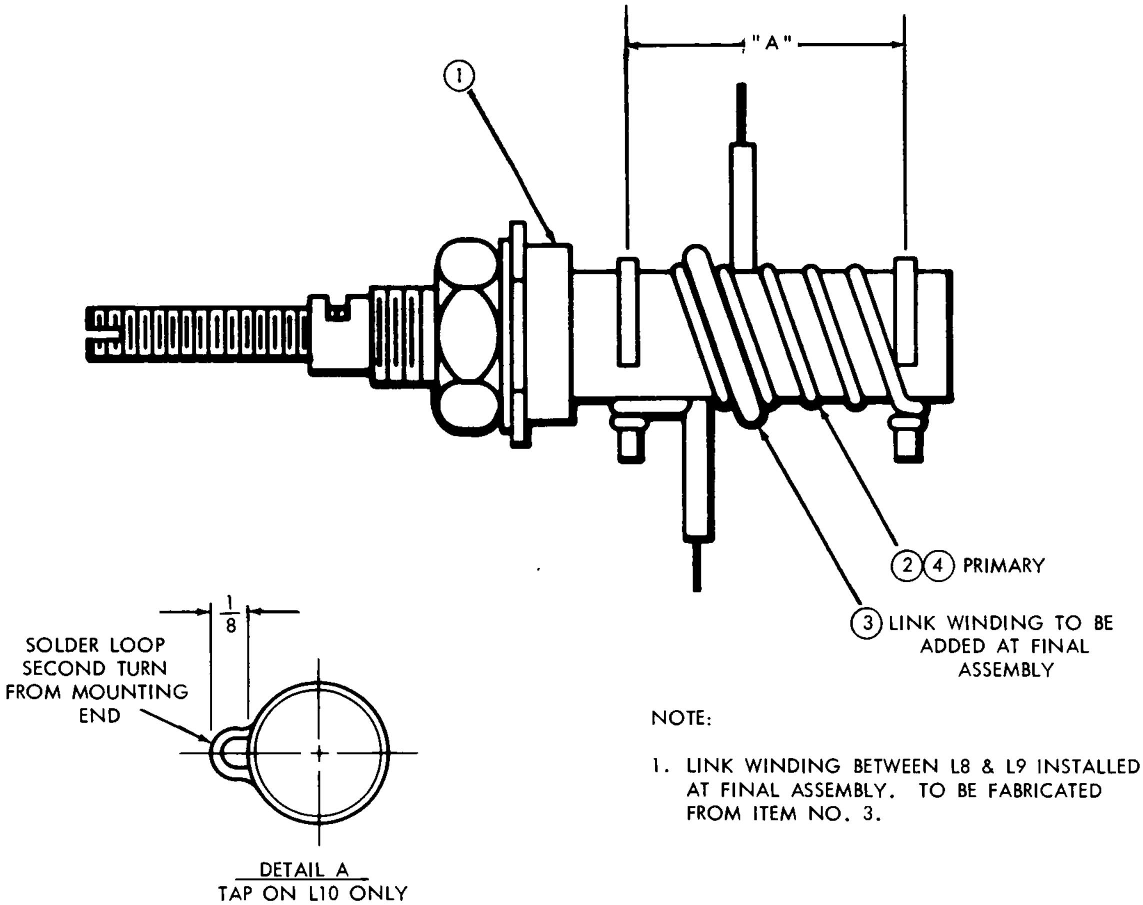
6. Using a fiberglass tuning tool, adjust the bottom tuning slug of transformer T8 (reached from the bottom of the plug-in through a hole in the PC board) for maximum amplitude as observed on the oscilloscope. Do not adjust the top tuning slug of T8.




| DASH NO. | SYMBOL | DIM. "A" | NO. OF TURNS | WIRE SIZE | TAP |
|---|---|---|---|---|---|
| -1 | L2 | 5/8" | 4 | #18 | 1 TURN |
| -2 | L5 | 3/4" | 6 | #18 | NONE |
| -3 | L6 | 3/4" | 6 | #18 | NONE |
| -4 | L7 | 3/4 | 5 | #18 | NONE |
| -5 | L1 | 3/4 | 6 | #18 | 1 3/4 TURN |

| | | | | |
|---|---|---|---|---|
| AR | | 2 | SOLDER, SN60/SN63 | |
| AR | 8019 | 1 | BUS WIRE, BELDEN #18 TINNED COPPER | |
| REQD | PART NO. | ITEM | DESCRIPTION | SYM |

Figure 26–Inductors L1, L2, L5, L6, and L7 for Receiver




NOTE:

1. LINK WINDING BETWEEN L8 & L9 INSTALLED AT FINAL ASSEMBLY. TO BE FABRICATED FROM ITEM NO. 3.

| DASH NO. | SYMBOL | DIM. "A" | NO. OF TURNS | WIRE SIZE | TAP | LINK WINDING |
|---|---|---|---|---|---|---|
| -1 | L4 | CLOSE WOULD | 9 | #26 | NONE | NONE |
| -2 | L8 | CLOSE WOUND | 25 | #26 | NONE | 2 TURNS |
| -3 | L9 | CLOSE WOUND | 25 | #26 | NONE | 2 TURNS |
| -4 | L10 | 1/2" | 6 | #18 | 2 TURNS | NONE |

| | | | | |
|---|---|---|---|---|
| AR | | 5 | SOLDER, SN60/SN63 | |
| AR | 8065 | 4 | WIRE, SOLID, BELDEN #26, HNC NYLCLAD | |
| AR | 8035 | 3 | WIRE, SOLID, BELDEN #22, THERMO PLASTIC INSULATION | |
| AR | 8019 | 2 | BUS WIRE, BELDEN #18, TINNED COPPER | |
| 1 | 4500-2 | 1 | COIL FORM, J. W. MILLER | |
| REQD | PART NO. | ITEM | DESCRIPTION | SYM |

Figure 27—Inductors L4, L8, L9, and L10 for Receiver

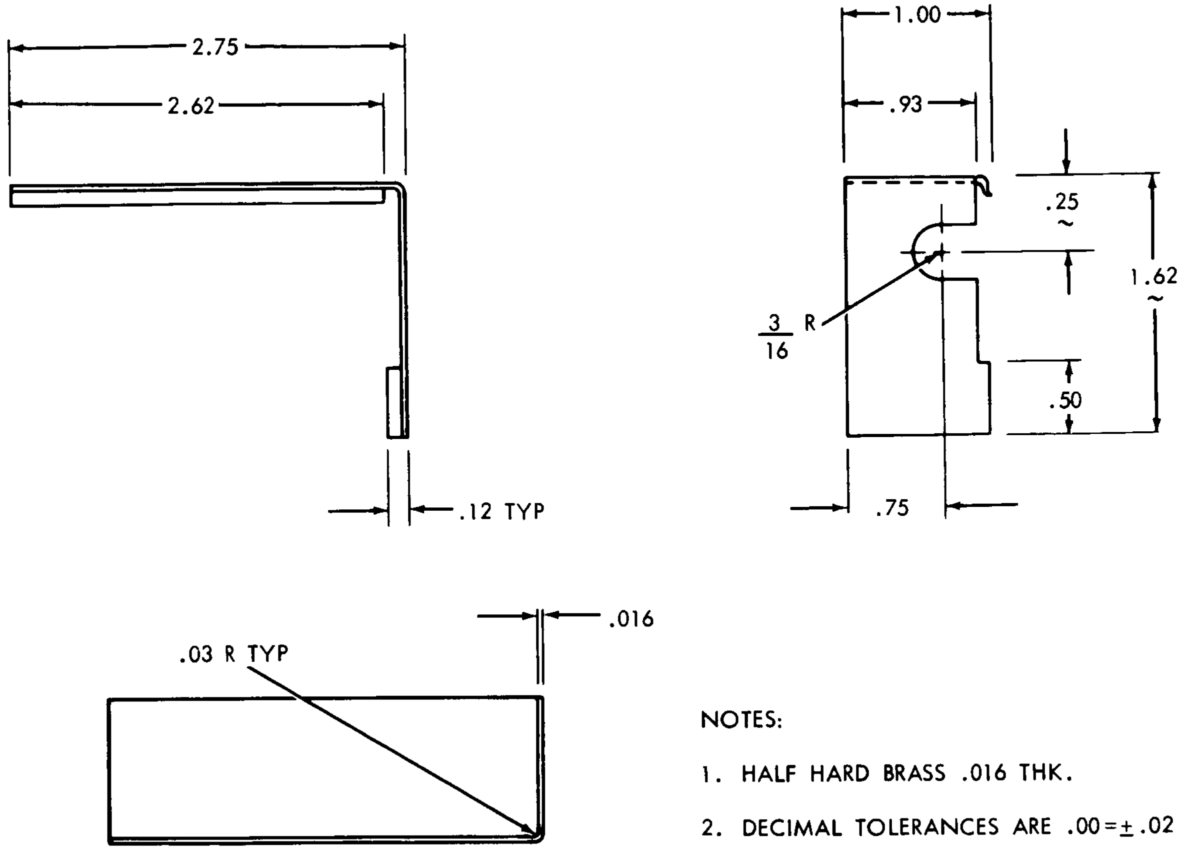



Figure 28–Shield for Receiver

7. Adjust IF transformer T7 for maximum output amplitude as observed on the oscilloscope. The bottom tuning slug (reached from the bottom side of the plug-in through a hole in the PC board) should be adjusted first, followed by the adjustment of the top tuning slug (through the hole at the top of the IF can).

8. Repeat step 7 for IF transformer T6

9. Repeat step 7 for IF transformer T5.

10. Because of some interaction between stages, repeat steps 6 through 9 if a large adjustment was required for any stage.

11. Connect the oscilloscope to pin 5 of tube V8.

12. Adjust the top tuning slug of discriminator transformer T8 to zero-volt level at pin 5 of tube V8.

Table 1
VHF Receiver Parts

| Quan. | Part No. | Description | Sym. |
|---|---|---|---|
| AR | | Solder, SN60/SN63 | |
| AR | 8022 | Bus wire, #22 tinned copper, Belden* | |
| 35 | 2010-B | Terminal, Useco* | |
| 4 | 4500-2 | Coil form, ceramic, 1/4 dia. J. W. Miller* | L4, L8 |
| | | Coil form, ceramic, 1/4 dia. J. W. Miller* | L9, L10 |
| 1 | 9S2 | Shield, tube, 9-pin min., 1-15/16 high, Cinch* | |
| 1 | 7S4 | Shield, tube, 7-pin min., 2-1/4 high, Cinch* | |
| 4 | 7S3 | Shield, tube, 7-pin min., 1-3/4 high, Cinch* | |
| 1 | 7S2 | Shield, tube, 7-pin min., 1-3/8 high, Cinch* | |
| 3 | 04-210-04 | Socket, crystal, HC-6 holder, Elco* | |
| 1 | 9PC-M2 | Socket, tube, 9-pin min, P.C., Cinch* | |
| 6 | 7PC-M2 | Socket, tube, 7-pin min. P.C., Cinch* | |
| 3 | 5NS-2 | Socket, tube, Nuvistor, P.C., Cinch* | |
| 3 | | Crystal units, quarts, as follows: Freq. to be determined by carrier $\frac{f(\text{crystal}) = f(\text{carrier}) + 17.55}{3}$ Chan. A = 51.05 MHz (135.6) Chan. B = 51.50 MHz (136.95) Chan. C = 51.683 MHz (137.50) | |
| 1 | | Resistor, fixed comp., 270 ohm, 2w 5% | R39 |
| 1 | | Resistor, fixed comp., 20k, 2w 5% | R34 |
| 1 | | Resistor, fixed comp., 10k, 2w 5% | R25 |
| 1 | | Resistor, fixed comp., 1.2k, 1w 5% | R35 |
| 1 | | Resistor, fixed comp., 39k, 1w 5% | R16 |
| 3 | | Resistor, fixed comp., 4.7k, 1w 5% | R11, R3 |
| | | Resistor, fixed comp., 4.7k, 1w 5% | R17 |
| 2 | | Resistor, fixed comp., 18k, 1w 5% | R10, R14 |
| 1 | | Resistor, fixed comp., 68k, 1/2w 5% | R45 |
| 2 | | Resistor, fixed comp., 8.2k, 1/2w 5% | R5, R6 |
| 1 | | Resistor, fixed comp., 30k, 1/4w 5% | R44 |
| 1 | | Resistor, fixed comp., 180k, 1/4w 5% | R43 |
| 1 | | Resistor, fixed comp., 82k, 1/4w 5% | R41 |
| 1 | | Resistor, fixed comp., 8.2k, 1/4w 5% | R40 |

*Other equivalent brands can be used.

Table 1
VHF Receiver Parts—(Continued)

| Quan. | Part No. | Description | Sym. |
|---|---|---|---|
| 1 | | Resistor, fixed comp., 1 Meg., 1/4w 5% | R38 |
| 1 | | Resistor, fixed comp., 4.7 Meg., 1/4w 5% | R37 |
| 1 | | Resistor, fixed comp., 330k, 1/4w 5% | R36 |
| 1 | | Resistor, fixed comp., 3.9k, 1/4w 5% | R33 |
| 1 | | Resistor, fixed comp., 10k, 1/4 5% | R28 |
| 1 | | Resistor, fixed comp., 680 ohm, 1/4w 5% | R24 |
| 1 | | Resistor, fixed comp., 130k, 1/4w 5% | R23 |
| 2 | | Resistor, fixed comp., 11k, 1/4w 5% | R22, R42 |
| 1 | | Resistor, fixed comp., 7.5k, 1/4w 5% | R21 |
| 1 | | Resistor, fixed comp., 130 ohm, 1/4 5% | R20 |
| 3 | | Resistor, fixed comp., 51k, 1/4w 5% | R18, R19 |
| | | Resistor, fixed comp., 51k, 1/4w 5% | R30 |
| 2 | | Resistor, fixed comp., 68 ohm, 1/4w 5% | R12, R15 |
| 1 | | Resistor, fixed comp., 150 ohm, 1/4w 5% | R8 |
| 1 | | Resistor, fixed comp., 470k, 1/4w 5% | R4 |
| 6 | | Resistor, fixed comp., 100k, 1/4w 5% | R3, R26 |
| | | Resistor, fixed comp., 100k, 1/4w 5% | R27, R29 |
| | | Resistor, fixed comp., 100k, 1/4w 5% | R31, R32 |
| 1 | | Resistor, fixed comp., 100 ohm, 1/4w 5% | R2 |
| 3 | | Resistor, fixed comp., 47k, 1/4w 5% | R1, R7 |
| | | Resistor, fixed comp., 47k 1/4w 5% | R9 |
| 1 | 12AU7 | Tube, electron, RCA* | V10 |
| 1 | 6J6 | Tube, electron, RCA* | V9 |
| 1 | 6AL5 | Tube, electron, RCA* | V8 |
| 1 | 6BN6 | Tube, electron, RCA* | V7 |
| 2 | 6BA6 | Tube, electron, RCA* | V5, V6 |
| 3 | 6CW4 | Tube, electron, RCA* | V1, V2 |
| | | Tube, electron, RCA* | V3 |
| 1 | 1464-PC | Transformer, disctr, 10.7 MHz, J.W. Miller* | T8 |
| 3 | 1463-PC | Transformer, I. F., 10.7 MHz, J. W. Miller* | T5, T6 |
| | | Transformer, I.F., 10.7 MHz, J. W. Miller* | T7 |
| 1 | MST-115D | Switch, miniature toggle, SPDT, Alco* | S2 |
| 1 | 12AU7 | Tube, electron, RCA* | V10 |

*Other equivalent brands can be used.

Table 1
VHF Receiver Parts—(Continued)

| Quan. | Part No. | Description | Sym. |
|---|---|---|---|
| 1 | 6J6 | Tube, electron, RCA* | V9 |
| 1 | 6AL5 | Tube, electron, RCA* | V8 |
| 1 | 6BN6 | Tube, electron, RCA* | V7 |
| 2 | 6BA6 | Tube, electron, RCA* | V5 |
| | | Tube, electron, RCA* | V6 |
| 3 | 6CW4 | Tube, electron, RCA* | V1 |
| | | Tube, electron, RCA* | V2 |
| | | Tube, electron, RCA* | V3 |
| 1 | 1464-PC | Transformer, disctr, 10.7 MHz, J. W. Miller* | T8 |
| 3 | 1463-PC | Transformer, KF, 10.7 MHz, J. W. Miller* | T5 |
| | | Transformer, IF, 10.7 MHz, J. W. Miller* | T6 |
| | | Transformer, IF, 10.7 MHz, J. W. Miller* | T7 |
| 1 | MST-115D | Switch, miniature toggle, SPDT, Alco* | S2 |
| 1 | | Inductor, per Figure 26 | L10 |
| 1 | | Inductor, per Figure 26 | L9 |
| 1 | | Inductor, per Figure 26 | L8 |
| 1 | | Inductor, per Figure 25 | L7 |
| 1 | | Inductor, per Figure 25 | L6 |
| 1 | | Inductor, per Figure 25 | L5 |
| 1 | | Inductor, per Figure 26 | L4 |
| 1 | | Inductor, per Figure 25 | L2 |
| 1 | | Inductor, per Figure 25 | L1 |
| 1 | | Inductor, per Figure 26 | L10 |
| 1 | | Inductor, per Figure 26 | L9 |
| 1 | | Inductor, per Figure 26 | L8 |
| 1 | | Inductor, per Figure 26 | L4 |
| 1 | | Inductor, per Figure 25 | L7 |
| 1 | | Inductor, per Figure 25 | L6 |
| 1 | | Inductor, per Figure 25 | L5 |
| 1 | | Inductor, per Figure 25 | L2 |
| 1 | | Inductor, per Figure 25 | L1 |
| 1 | 20A337RB1 | Inductor, J. W. Miller* | L3 |
| 1 | IN751 | Diode, zener, 5. 1v Motorola* | CR3 |
| 1 | IN270 | Diode, germanium, Sylvania* | CR2 |
| 1 | V47E/947 | Diode, volt. var. cap., 4-7pf/14v, TRW* | CR1 |
| 1 | DD-502 | Capacitor, 0.005 $\mu$f/1000v (GMV), Centralab* | C47 |

*Other equivalent brands can be used.

Table 1
VHF Receiver Parts–(Continued)

| Quan. | Part No. | Description | Sym. |
|---|---|---|---|
| 1 | DA-503 | Capacitor, 0.05$\mu$ f/30v 100-20%, Centralab* | C46 |
| 1 | DD-221 | Capacitor, 220 pf/1000v 10%, Centralab* | C44 |
| 1 | DM-10-100J | Capacitor, 10 pf/500v 5%, Elemenco* | C37 |
| 21 | DD-222 | Capacitor, 0.0022$\mu$f/1000v (GMV), Centralab* | C28, C29 |
| | | Capacitor, 0.0022$\mu$f/1000v (GMV), Centralab* | C30, C32 |
| | | Capacitor, 0.0022$\mu$f/1000v (GMV), Centralab* | C33, C35 |
| | | Capacitor, 0.0022$\mu$f/1000v (GMV), Centralab* | C36 |
| | | Capacitor, 0.0022$\mu$f/1000v (GMV), Centralab* | C39, C42 |
| | | Capacitor, 0.0022$\mu$f/1000v (GMV), Centralab* | C49-C58 |
| 1 | 20A337RB1 | Inductor, J. W. Miller* | L3 |
| 1 | IN751 | Diode, zener, 5.1 v Motorola* | CR3 |
| 1 | IN270 | Diode, germanium, Sylvania* | CR2 |
| 1 | V47E/947 | Diode, volt. var. cap., 47pf, 14v, TRW* | CR1 |
| 1 | DD-502 | Capacitor, 0.005$\mu$ f/1000v (GMV), Centralab* | C47 |
| 1 | DA-503 | Capacitor, 0.05$\mu$ f/30v 100-20%, Centralab* | C46 |
| 1 | DD-221 | Capacitor, 220 pf/1000v 10%, Centralab* | C44 |
| 1 | DM-10-100J | Capacitor, 10 pf. 500v 5%, Elemenco* | C37 |
| 21 | DD-222 | Capacitor, 0.0022$\mu$ f/1000v (GMV), Centralab* | C28 |
| | | Capacitor, 0.0022$\mu$ f/1000v (GMV), Centralab* | C29 |
| | | Capacitor, 0.0022$\mu$ f/1000v (GMV), Centralab* | C30 |
| | | Capacitor, 0.0022$\mu$ f/1000v (GMV), Centralab* | C32 |
| | | Capacitor, 0.0022$\mu$ f/1000v (GMV), Centralab* | C33 |
| | | Capacitor, 0.0022$\mu$ f/1000v (GMV), Centralab* | C35 |
| | | Capacitor, 0.0022$\mu$ f/1000v (GMV), Centralab* | C36 |
| | | Capacitor, 0.0022$\mu$ f/1000v (GMV), Centralab* | C39-C42 |
| | | Capacitor, 0.0022$\mu$ f/1000v (GMV), Centralab* | C49-C58 |
| 5 | DD-6-103 | Capacitor, 0.01 $\mu$f/600v (GMV), Centralab* | C27 |
| | | Capacitor, 0.01$\mu$f/600v (GMV), Centralab* | C31 |
| | | Capacitor, 0.01 $\mu$f/600v (GMV), Centralab* | C34 |
| | | Capacitor, 0.01 $\mu$f/600v (GMV), Centralab* | C38 |
| | | Capacitor, 0.01 $\mu$f/600v (GMV), Centralab* | C48 |
| 1 | DD-302 | Capacitor, 0.003 $\mu$ f/1000v (GMV), Centralab* | C25 |
| 5 | DD-6-103 | Capacitor, 0.01$\mu$ f/600v (GMV), Centralab* | C27, C31 |
| | | Capacitor, 0.01$\mu$ f/600v (GMV), Centralab* | C34, C38 |
| | | Capacitor, 0.01$\mu$ f/600v (GMV), Centralab* | C48 |
| 1 | DD-302 | Capacitor, 0.003 $\mu$ f/1000v (GMV), Centralab* | C25 |

*Other equivalent brands can be used.

Table 1
VHF Receiver Parts—(Continued)

| Quan. | Part No. | Description | Sym. |
|---|---|---|---|
| 1 | DM-10-121G | Capacitor, 120 pf/500v 2%, Elemenco* | C22 |
| 1 | VC-4-G | Capacitor, Variable, .8-18.0 pf, J.F.D.* | C24 |
| 3 | DM-10-470J | Capacitor, 47 pf/500v 5%, Elemenco* | C15, C20 |
| | | Capacitor, 47 pf/500v 5%, Elemenco* | C21 |
| 2 | DC-220K | Capacitor, 22 pf/200v 10%, Nytronics* | C13, C19 |
| 1 | DM-10-101J | Capacitor, 100 pf/500v 5%, Elemenco* | C11 |
| 1 | DM-10-050K | Capacitor, 5 pf/500v 5%, Elemenco* | C9 |
| 4 | VC-1-G | Capacitor, Variable, 0.7-9.0 pf, J.F.D.* | C3, C8 |
| | | Capacitor, Variable, 0.7-9.0 pf, J.F.D.* | C10, C17 |
| 11 | DD-102 | Capacitor, 0.001$\mu$f/1000v 10%, Centralab* | C2, C5 |
| | | Capacitor, 0.001$\mu$f/1000v 10%, Centralab* | C6, C7 |
| | | Capacitor, 0.001$\mu$f/1000v 10%, Centralab* | C12, C14 |
| | | Capacitor, 0.001$\mu$f/1000v 10%, Centralab* | C16, C18 |
| | | Capacitor, 0.001$\mu$f/1000v 10%, Centralab* | C26, C43 |
| | | Capacitor, 0.001$\mu$f/1000v 10%, Nytronics* | C45 |
| 2 | | Capacitor, 0.001$\mu$f/100v 10%, Nytronics* | C1, C4 |
| 1 | DM10--- | Capacitor-valve, "TBD," Elemenco* | C23 |

*Other equivalent brands can be used.

13. Connect the FM-signal generator to pin 2 of V3.

14. Adjust the FM-signal generator frequency to 17.55 MHz. Check the frequency with a counter.

15. Observe the signal at pin 7 of tube V8.

16. Adjust inductor L10 for maximum output. Frequency across L10 should be 28.25 MHz.

17. Set the CHANNEL switch to B.

18. Adjust L4 for maximum dc level at the R33, R37 junction. The level should be from 120 to 160 volts dc. Frequency across L4, which can be checked with a grid-dip meter, should be 51.5 MHz.

19. Using a grid-dip meter, adjust C17 for maximum output at 154.5 MHz.

20. Set the FM-signal generator to 136.95 MHz and 10 kHz deviation. Check the frequency with a frequency counter.

21. Connect the output of the signal generator to the RF input at the front panel. NOTE: 15 V dc is supplied through the RF cable to the antenna preamp, therefore, use capacitor coupling between the signal generator and the RF input.

22. Connect the oscilloscope to pin 3 of tube V10.

23. Tune C10 for maximum output.

24. Tune C8 for maximum output.

25. Tune L3 for maximum output.

26. Tune C3 for maximum output.

27. Set the FM signal generator to 137.5 MHz and set the CHANNEL selector switch to C. Adjust L9 for maximum output.

28. Set the FM signal generator to 135.6 MHz and set the CHANNEL selector switch to A. Adjust L8 for maximum output.

29. Because of some interaction between stages, steps 21 through 28 should be repeated if a large adjustment was required for any stage.

30. If the SIGNAL strength meter does not read zero with no signal input, adjustment in voltage divider R43, R44 may be required.

31. Turn the AFC switch to ON.

32. Set the FM signal generator to 136.95 MHz and set the CHANNEL selector switch to B. Observe peak-to-peak amplitude on the CRT when the W. F. -PIC switch is in the W. F. mode. With 10-kHz input deviation applied to the receiver, the signal should be ±.3 centimeter peak-to-peak in amplitude. Adjustment can be made by changing resistor R95, which is located in the receiver board.

## THE FACSIMILE

The electrical portion of the facsimile consists of the video electronics and an oscilloscope display device. The video electronics may be built as a separate unit. If this is done, almost any model oscilloscope may be used. Both the video electronics and the receiver may be built into the same housing as the oscilloscope, however, if an Analab model M1100 or its equivalent is obtained. This model should be obtained without the plug-in unit and panel markings. Figure 29 shows the finished station when all the electronics are incorporated into the Analab oscilloscope. Any oscilloscope used must have the following features:

- Flat-face, low-persistency cathode-ray tube (such as P11 phospher) 5 inches in diameter, with less than .005" spot size for 800-line resolution. (Increased spot size creates slight degradation.)

- X and Y (horizontal and vertical) amplifiers.

- Z-axis input.

- Bezel to connect "scope" camera.

Figure 30 shows the location of all the controls on the plug-in. The front panel should be made of heavy-gauge aluminum for rigidity. Measure the internal space for the plug-in so that the connector already in the oscilloscope may be used.

The last steps are wiring the video electronics and properly connecting it to the oscilloscope, and mounting a scope camera on the CRT. (Video electronics, Figure 31.) Table 2 list the necessary parts for the video electronics. For the face of the CRT, a thin metal plate must be constructed and calibrated in centimeters. The video output from the tape recorder (in playback) or receiver (in real time) must be adjusted to 2 cm peak-to-peak; this corresponds to the 800-millivolt output of the amplifier and assures adequate signal to the Z axis.

All integrated circuits are of the Fairchild epoxy type.* Semi-conductors are Texas Instrument.* The operational amplifier used (A1 in Figure 31) is a George Philbrick solid-state P65AU.* The frequency standard is a 2400-cycle tuning fork. The connector shown in Figure 31 (J2) is the type used in the model 1100 Analab oscilloscope and must be changed if another oscilloscope is used.* Also, the receiver output must be matched to the 10k input impedance of this unit.

## TAPE RECORDER

Many articles have been written about APT; in some of these the author, seeking ways to reduce the price of APT, suggests that the tape recorder is not

*Other equivalent brands can be used.

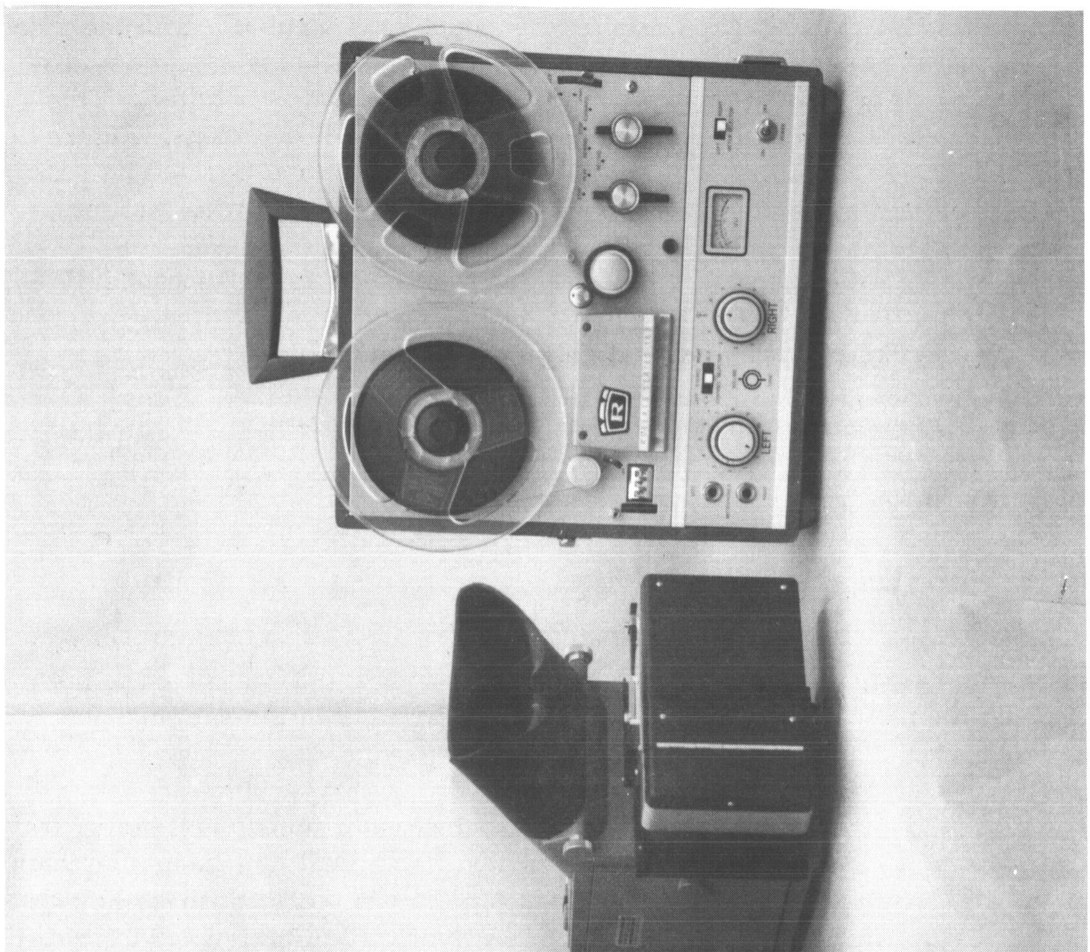



Figure 29–Assembled APT Station

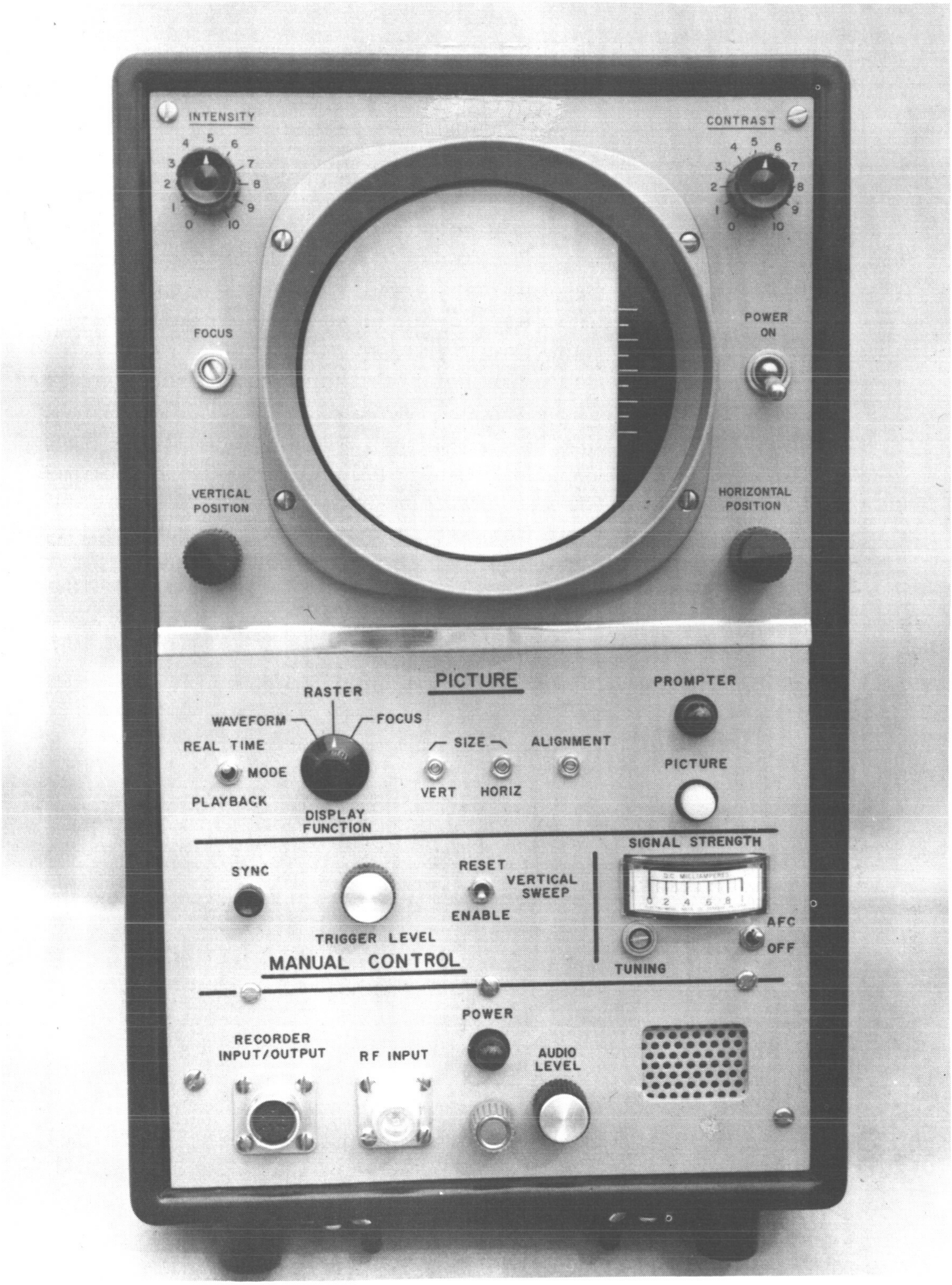



Figure 30–Closeup of APT Station Controls

Table 2
Video Electronics Parts

| Quan. | Part No. | Description |
|---|---|---|
| 1 | WMF1D22 | Capacitor, mylar, 0.0022$\mu$ f/100v 10%, CDE* |
| 3 | WMF1D47 | Capacitor, mylar, 0.0047$\mu$f/100v 10%, CDE* |
| 6 | WMF151 | Capacitor, mylar, 0.0.01$\mu$ f/100v 10%, CDE* |
| 1 | WMF1S47 | Capacitor, mylar, 0.047$\mu$f/100v 10%, CDE* |
| 4 | MFP1P1 | Capacitor, mylar, 0.1$\mu$f/100v 10%, CDE* |
| 1 | MFP1P22 | Capacitor, mylar, 0.22$\mu$ f/100v 10%, CDE* |
| 2 | MFP2P47 | Capacitor, mylar, .47$\mu$ f/100v 10% |
| 3 | 150D105X0035A2 | Capacitor, solid tantalum, 1$\mu$f/50v 20%, Sprague* |
| 2 | Y146XR-15 | Capacitor, solid tantalum, 2$\mu$ f/50v 20%, Aerovox* |
| 1 | 150D685X0035B2 | Capacitor, solid tantalum, 6.8$\mu$ f/50v 20%, Sprague* |
| 1 | 150D156X0020B2 | Capacitor, solid tantalum, 15$\mu$ f/50v 20%, Sprague* |
| 2 | MTP226M015P1A | Capacitor, wet tantalum, 22$\mu$ f/15v 20%, Mallory* |
| 1 | MTP157M020P1C | Capacitor, wet tantalum, 150$\mu$f/20v 20%, Mallory* |
| 1 | 39D508G010HP4 | Capacitor, al. electrolytic, 5000$\mu$ f/10v 20%, Sprague* |
| 1 | | Resistor, carbon comp., 8.2 ohm, 1/4w 5% |
| 2 | | Resistor, carbon comp., 10 ohm, 1/4w 5% |
| 1 | | Resistor, carbon comp., 15 ohm, 1/4w 5% |
| 1 | | Resistor, carbon comp., 220 ohm, 1/4w 5% |
| 2 | | Resistor, carbon comp., 560 ohm, 1/4w 5% |
| 3 | | Resistor, carbon comp., 1k, 1/4w 5% |
| 2 | | Resistor, carbon comp., 1.2k, 1/4w 5% |
| 2 | | Resistor, carbon comp., 1.3k, 1/4w 5% |
| 4 | | Resistor, carbon comp., 1.5k, 1/4w 5% |
| 1 | | Resistor, carbon comp., 2.2k, 1/4w 5% |
| 1 | | Resistor, carbon comp., 3k, 1/4w 5% |
| 1 | | Resistor, carbon comp., 4.7k, 1/4w 5% |
| 3 | | Resistor, carbon comp., 6.8k, 1/4w 5% |
| 1 | | Resistor, carbon comp., 7.5k, 1/4w 5% |
| 2 | | Resistor, carbon comp., 8.2k 1/4w 5% |
| 1 | | Resistor, carbon comp., 9.1k, 1/4w 5% |
| 8 | | Resistor, carbon comp., 10k, 1/4w 5% |
| 1 | | Resistor, carbon comp., 12k, 1/4w 5% |
| 2 | | Resistor, carbon comp., 13k, 1/4w 5% |
| 3 | | Resistor, carbon comp., 15k, 1/4w 5% |
| 3 | | Resistor, carbon comp., 16k, 1/4w 5% |
| 1 | | Resistor, carbon comp., 18k, 1/4w 5% |

*Other equivalent brands can be used.

Table 2
Video Electronics Parts–(Continued)

| Quan. | Part No. | Description |
|---|---|---|
| 1 | | Resistor, carbon comp., 20k, 1/4w 5% |
| 1 | | Resistor, carbon comp., 22k, 1/4w 5% |
| 7 | | Resistor, carbon comp., 27k, 1/4w 5% |
| 2 | | Resistor, carbon comp., 47k, 1/4w 5% |
| 1 | | Resistor, carbon comp., 51k, 1/4w 5% |
| 2 | | Resistor, carbon comp., 56k, 1/4w 5% |
| 1 | | Resistor, carbon comp., 62k, 1/4w 5% |
| 1 | | Resistor, carbon comp., 68k, 1/4w 5% |
| 2 | | Resistor, carbon comp., 82k, 1/4w 5% |
| 4 | | Resistor, carbon comp., 100k, 1/4w 5% |
| 1 | | Resistor, carbon comp., 150k, 1/4w 5% |
| 2 | | Resistor, carbon comp., 180k, 1/4w 5% |
| 2 | | Resistor, carbon comp., 220k, 1/4w 5% |
| 1 | | Resistor, carbon comp., 330k, 1/4w 5% |
| 1 | | Resistor, carbon comp., 470k, 1/4w 5% |
| 1 | | Resistor, carbon comp., 1.5 meg, 1/4w 5% |
| 2 | | Resistor, carbon comp., 10 meg, 1/4w 5% |
| 1 | | Resistor, carbon comp., 4.7 ohm, 1w 5% |
| 1 | | Resistor, carbon comp., 110 ohm, 2w 5% |
| 1 | V-4 | Potentiometer, 1 turn, 1k, 1w 20%, Mallory* |
| 2 | 273-1-502M | Potentiometer, 25 turn, 5k, 1/4w 10%, Bourn* |
| 1 | 273-1-103M | Potentiometer, 25 turn, 10k, 1/4w 10%, Bourn* |
| 1 | U-35 | Potentiometer, 50k, 1w 20%, Mallory* |
| 1 | F1-100K-R1-100K | Potentiometer, 1 turn-dual, 100k, 1/2w 20%, Centralab* |
| 10 | 2N3702 | Transistor, Texas Instrument* |
| 8 | 2N3704 | Transistor, Texas Instrument* |
| 8 | 2N3707 | Transistor, Texas Instrument* |
| 5 | IN4446 | Diode, General Electric* |
| 2 | IN538 | Diode, Texas Instrument or General Electric* |
| 1 | IN270 | Diode, Sylvania* |
| 3 | mL91428 | Integrated ckt, dual gate, Fairchild* |
| 10 | mL92328 | Integrated ckt, J-K flip-flop, Fairchild* |
| 1 | VIC-10 | Inductor, variable, 0.54H |
| 1 | FS-32 (Special) | Frequency standard, 2400 Hz, American Time Products* |
| 1 | PG 5AU | Amplifier, operational, Philbrick* |

*Other equivalent brands can be used.

Table 2
Video Electronics Parts—(Continued)

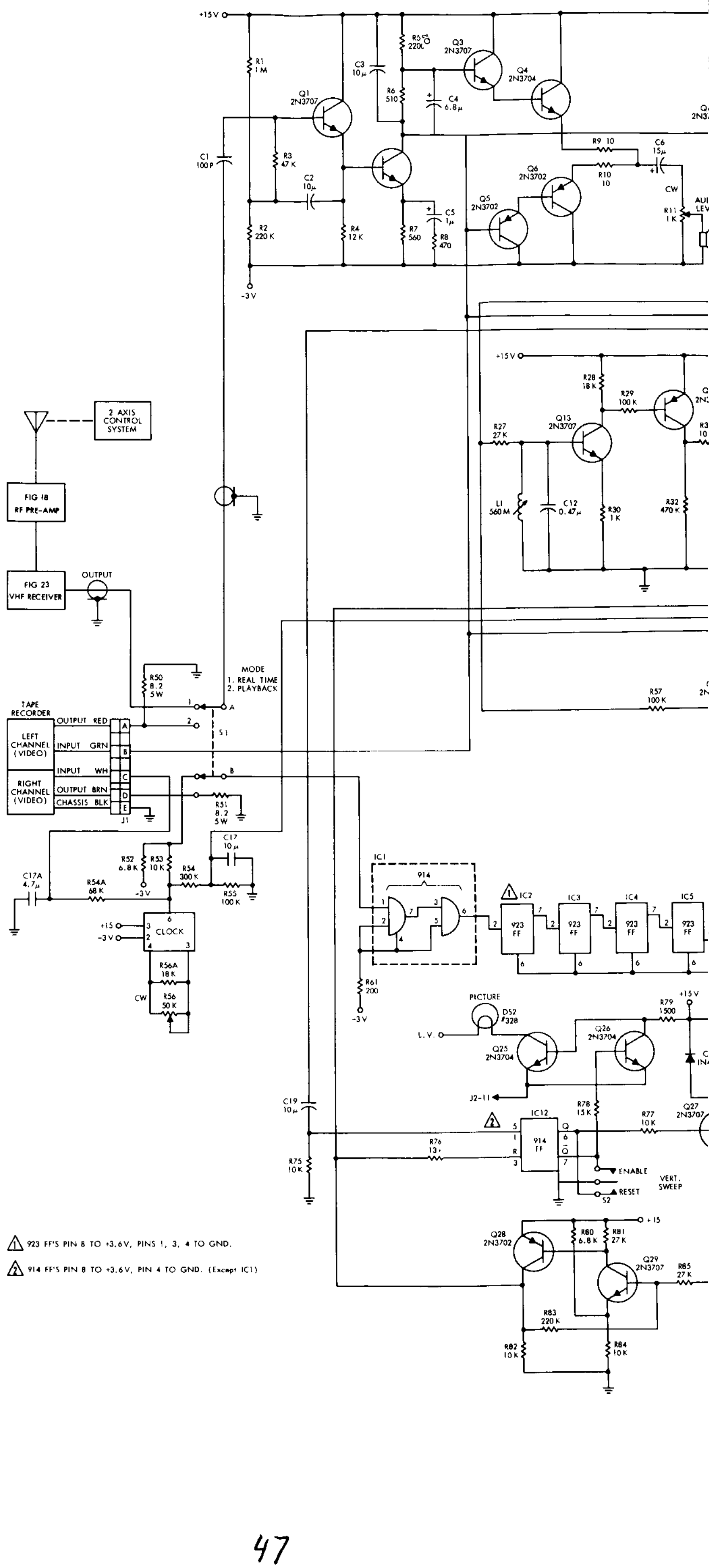
| Quan. | Part No. | Description |
|---|---|---|
| 2 | #328 | Lamp, mid. flanged T-1-3/4, General Electric* |
| 1 | #330 | Lamp, mid. flanged T-1-3/4, General Electric* |
| 1 | 162-843-933-502 | Lamp holder, yellow, Dialco* |
| 1 | 162-843-975-502 | Lamp holder, white, Dialco* |
| 1 | 162-843-931-502 | Lamp holder, red, Dialco* |
| 1 | Model 13.0-1 Ma. | Meter, Emico* |
| 1 | MFG. Type 250 | Phone plug, black, Switchcraft* |
| 2 | 3502 | Phone plug, Switchcraft* |
| 1 | 26-159-32 | Connector, Amphenol* |
| 3 | 50-6007-3314 | Connector, insert polarization, Elco* |
| 1 | 22A062100 | Speaker, 2 1/2", 100 ohm, Quam* |
| 8 | K-700G | Knob, aluminum instrument knobs |
| 1 | K-500G | Knob, aluminum instrument knobs |
| 1 | 50-2-1G | Knob, Raytheon* |
| 2 | 115-253 | Flexible shaft, E. F. Johnson* |
| 1 | Allied 47D4096 | Bearing, H. H. Smith |
| 5 ft | 8445 | Tape recorder cable, Belden* |

*Other equivalent brands can be used.

essential. However, if any malfunction occurs in the facsimile or the film, the picture will be lost if it is not recorded on tape. A good quality stereo recorder, with one channel for video and the other for recording the sync signal, is needed. The facsimile must be triggered by the sync signal in playback because of wow and flutter in the recorder. The tape-recorder requirements are:

- Must record and play back at 7-1/2 ips.
- Record and playback levels must have amplitude stability. Any change in output will affect the picture.
- Must be capable of recording 2400 cycles (the video carrier).
- Must be stereo for 2-channel recording.

A tape footage counter is helpful for picture-start reference.




923 FF'S PIN 8 TO +3.6V, PINS 1, 3, 4 TO GND.

914 FF'S PIN 8 TO +3.6V, PIN 4 TO GND. (Except IC1)

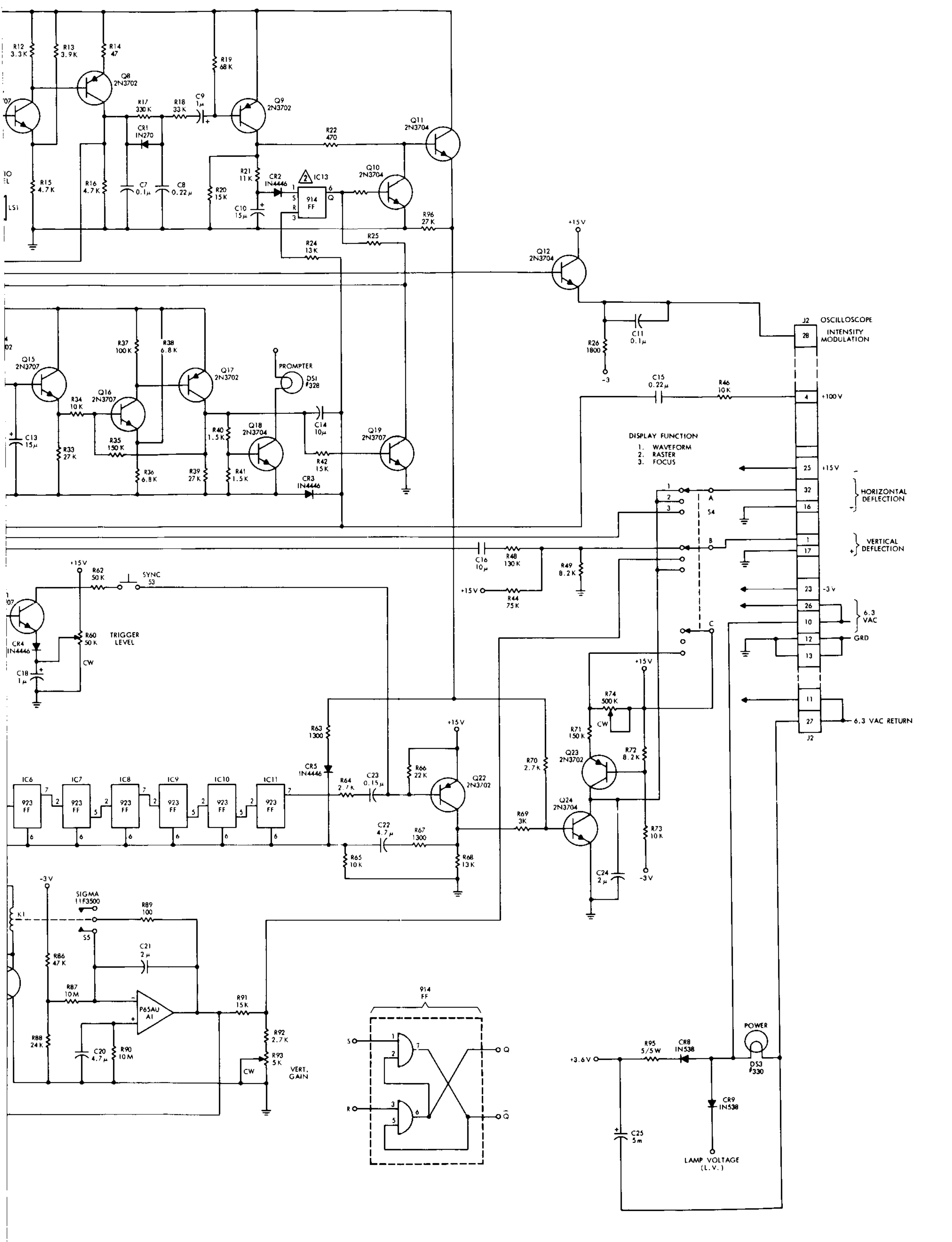


Figure 31–Video Electronics, Schematic

## CAMERA

The scope camera should have a $4 \times 5$ Polaroid back. Type 52 film can be used for normal prints, type 55 for negatives. Be sure to focus the electron beam and the camera to their optimum. The picture size on the film should be adjusted to 3.5 by 3.5 inches.

The video electronics (Figure 31) should be fabricated on a vector-type breadboard and "rigged" up to the scope for troubleshooting. Once operation is established, the breadboard can be incorporated on the plug-in. The video-detecting circuit (Figure 32) can be built into the oscilloscope mainframe.

## THEORY OF OPERATION

## SYSTEM LEVEL

Figure 33 is a block diagram of the APT station. All system-level discussion is relative to this diagram.

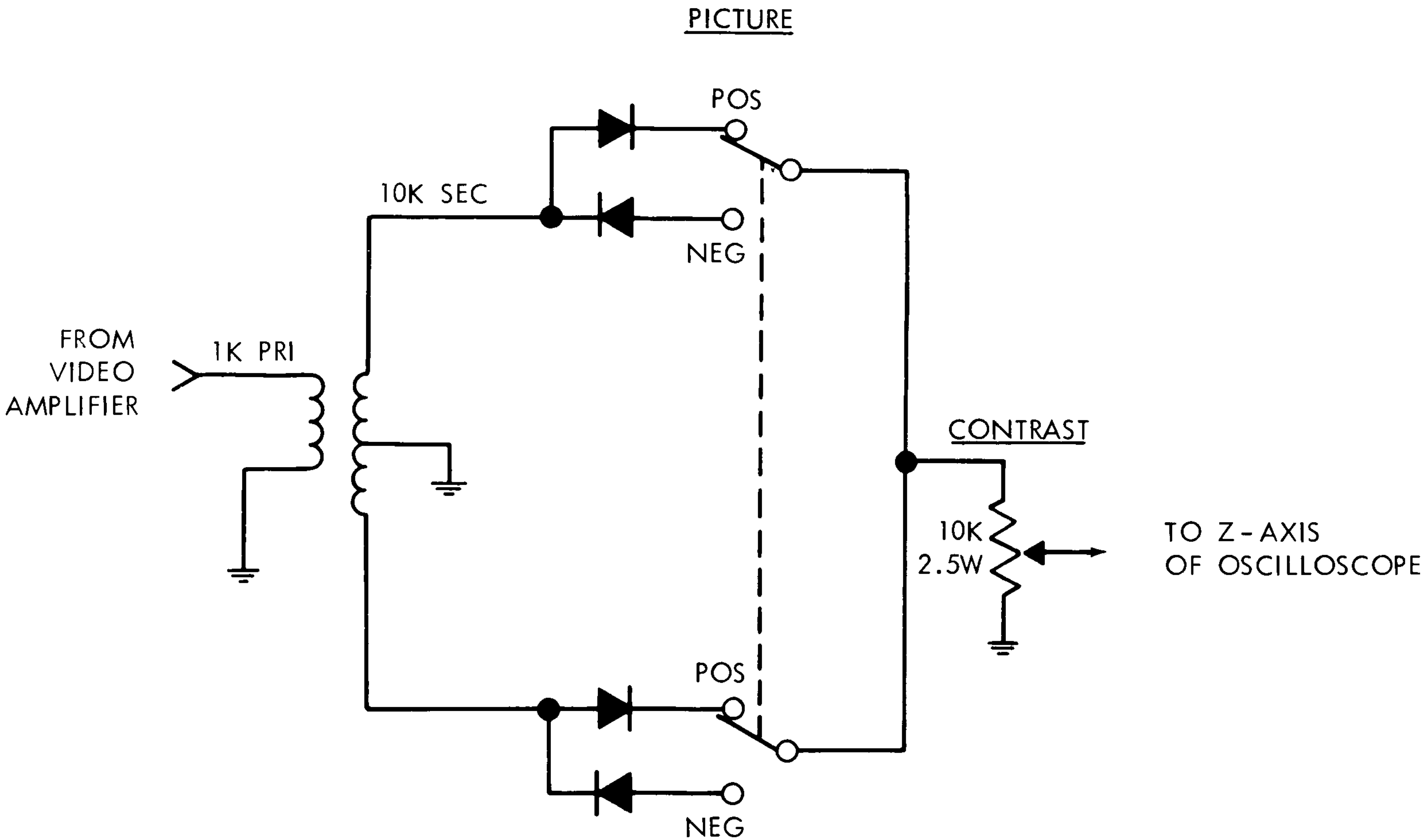
### System Operation

The picture displays a line at a time on the cathode-ray tube (similar to conventional television but corresponding to the sweep rates in the satellite camera). The resulting raster is photographed on polaroid film, which provides a processed photograph about 15 seconds after the end of each picture transmission or about 3.5 minutes after actual exposure by the satellite camera.

Vertical and horizontal sweep generators create the raster, the vertical generator providing a 200-second sweep and the horizontal generator providing a repetitive 250-millisecond sweep. The internal clock and binary dividers control the rate of the horizontal sweep. After the automatic circuitry performs initial synchronization, the horizontal sweep is controlled by the clock (either the actual frequency standard during real-time operation, or the recorded frequency standard signal during playback).

Vertical sweep, produced by an operational integrator containing an operational amplifier, is initiated by the combined control of the 300-Hz detector and the automatic synchronization circuit.

Automatic synchronization occurs during the 5-second period of the video signal just before picture transmission. The synchronization pulse generator is enabled by the 300-Hz detector, then self-disabled after synchronization pulse




CAUTION: HIGH VOLTAGE

Figure 32–Video Detecting and Matching Circuit, Schematic

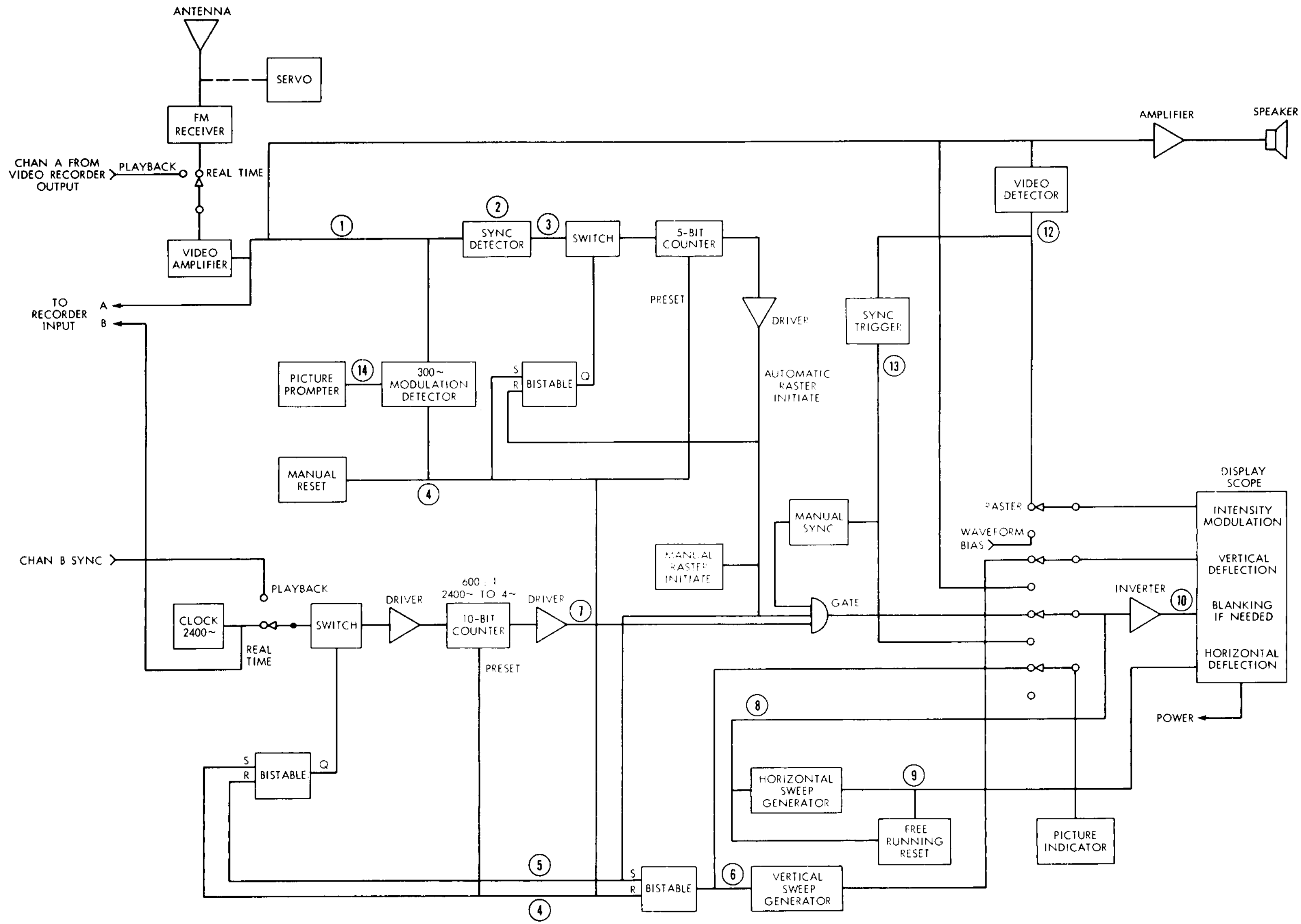



Figure 33–APT Station Electronics, Block Diagram

generation to prevent disruption of the synchronization timing during picture transmission.

The receiver-display unit is capable of either real-time or playback modes of operation. In the unit, the modulated raster is presented for picture photography, the video waveform is presented for calibration and observation, and a focusing waveform may be displayed to facilitate optimum line focusing.

During real-time and playback operation, the adjustment of the output level of the tape recorder or receiver to calibrate the amplitude of the video signal is made by observing the video waveform on the WAVEFORM display function.

The tape-recorder used in this system is a good quality, home-type stero recorder. One channel contains the video signal and the other contains the clock signal for accurate picture synchronization. The unit includes a digital display to facilitate location of individual picture information. Operation is simple, as described in the recorder's manual. The unit interconnects with the receiver/display unit by the tape-recorder interconnect cable.

The oscilloscope camera shown is a Fairchild Model 453-A-2.* It rapidly converts from 3.25- by 4.25-inch pack-back to 4- by 5-inch single-sheet operation. The unit's swing-away mount allows easy access to the CRT face and calibration plate. The binocular viewing port permits observation of the CRT display, even during film exposure.

Accessories for the system include photographic film, magnetic tape, and signal and control cables.

## Control Panel Features

- Control Unit (Plug-in).
- MODE switch: selects the video and synchronization signal sources. In the real-time mode, the video signal is received from the FM receiver during actual satellite transmission and synchronization is maintained by the internal frequency standard. In the playback mode, the video signal is received from the tape-recorder video channel, and synchronization is maintained by the recorded clock signal.
- DISPLAY FUNCTION switch: selects the display presented on the CRT phosphor as follows:

  WAVEFORM: displays the video waveform of successive picture lines, enabling observation of the video signal and amplitude calibration during playback operation

RASTER: displays the modulated raster for picture photography.

FOCUS: displays the 2400-Hz clock signal swept vertically at four expanded sweeps per second to enable optimum focusing.

SIZE CONTROLS

VERT: provides adjustment of vertical raster size.

HORIZ: provides adjustment of horizontal raster size.

Alignment Control: permits adjustment of the frequency of the internal frequency standard, thus controlling any skewing of the picture during scan.

TRIGGER LEVEL control: sets the level at which the manual synchronization circuit triggers off of the video waveform.

SYNC pushbutton: enables the manual sync trigger circuit.

VERTICAL SWEEP switch: provides manual reset or initiation of the vertical sweep (automatic during normal operation).

Tuning control: if the internal receiver was built, this provides optimum tuning of the FM receiver to the satellite RF-transmission frequency.

AFC Switch: provides enabling or defeat of the automatic frequency control, greatly reducing the effects of internal-receiver local-oscillator drift.

AUDIO LEVEL control: permits adjustment of the video signal's level of audio readout.

PROMPTER indicator: lights upon the receipt of 300-Hz modulation of the video carrier, indicating the end of the previous picture and prompting the operator for the subsequent picture.

PICTURE indicator: lights about one second before commencement of picture information, indicating the time for the camera shutter to be opened.

SIGNAL STRENGTH meter: indicates the relative level of the RF signal received by the antenna (internal receiver).

POWER light: lights when the power switch is ON and power is applied to the receiver/display unit.

RECORDER INPUT/OUTPUT connector: provides input and output video and clock signals to and from the tape recorder.

RF INPUT connector: accepts the RF signal from the RF interconnect cable attached to the RF preamplifier (internal receiver).

### Display Unit Features

INTENSITY control: permits adjustment of the picture-intensity level.

CONTRAST control: permits adjustment of the picture contrast.

FOCUS control: permits adjustment of the focus of the CRT's electron beam.

POWER switch: applies the input power to the unit.

VERTICAL POSITION control: permits adjustment of the vertical position of the CRT spot.

HORIZONTAL POSITION control: permits adjustment of the horizontal position of the CRT spot.

The black calibration plate provides amplitude increments for calibration in the "playback" mode.

## CIRCUIT LEVEL

### VHF Receiver

The operation of the VHF receiver is described stage-by-stage in relation to the receiver schematic, Figure 24. The received RF signal is amplified by a cascode amplifier, V1 and V2, tuned to the 135.6- to 137.5-MHz bandwidth. The amplified RF signal is mixed in transformer T1 with a signal from the first oscillator to produce a 17.55-MHz signal.

The frequency of the first oscillator V9 is determined by one of three crystals selected from the front panel. The choice of crystal depends upon the frequency of the incoming signal, which in turn is dependent on the satellite. The output tank circuit is tuned to the third harmonic of the crystal. This third harmonic is mixed with the incoming RF signal in T1.

The 17.55-MHz signal from T1 is amplified by V3. The amplified signal is then mixed in amplifier V4 with a 28.25-MHz signal from the second oscillator to produce a 10.7-MHz second-IF frequency.

The second oscillator consists of a tuned network whose frequency is determined primarily by a voltage-variable capacitor, CR1. The 10.7-MHz signal is kept frequency-stabilized by feedback from the discriminator output. This automatic frequency control (AFC) action thus keeps the second-IF frequency at the center of the discriminator's bandwidth.

The second IF signal is amplified by V5, V6, and V7 to produce a 10.7-MHz signal sufficient to drive discriminator V8. The discriminator produces a video output which is applied to cathode Follower V10. The video signal both drives the signal level meter and the video electronics.

Video Electronics

The video electronics consists of the video amplifier, synchronization circuits, a clock, and vertical and horizontal sweep generators. These circuits are all shown schematically on Figure 31 and are described in relation to that figure.

Video Amplifier—The video amplifier, consisting of Q1, Q2, Q3, Q4, Q5, and Q6, receives the video signal from the receiver during real-time mode and from the tape recorder during playback mode. The video signal is voltage-amplified by Q1 and Q2. The resulting signal then drives the speaker through Q3, Q4, Q5, and Q6 and drives the intensity-modulation transformer located in the main frame (figure 32) through emitter-follower Q12.

Synchronization Circuits—The synchronization circuits produce horizontal and vertical reset pulses that precisely align the picture scanned on the cathode-ray tube with the picture transmitted by the spacecraft. The alignment is accomplished during the eight-second inter-picture phasing interval. Vertical sync is achieved during an initial three seconds of 300-Hz modulation of the carrier; horizontal sync is achieved during the following five-second transmission of phasing pulses.

Vertical Synchronization—The 300-Hz modulation envelope is detected by a tuned circuit, L1 and C12, resonated at 300-Hz. The detected 300-Hz signal is amplified by Q13 and rectified by Q14. The rectified signal charges C13 positively. Eventually, the positive charge on C13 reaches the threshold voltage of a Schmidt trigger, Q16 and Q17. (Q15 is merely an emitter - following isolating C13 from the input impedance of Q16.) When the threshold voltage is reached, Q15 produces a transition to +15 volts. This transition causes the following functions to occur:

1. Turn-on of the PROMPTER lamp through Q18 to alert the operator that the inter-picture phasing period has begun.

2. Resetting of the horizontal sweep, phasing lockout flip-flop, IC13, through C14.

3. Turn-off of the PICTURE light by turning off Q25.

4. Resetting of the vertical sweep generator by resetting flip-flop IC12. (This reset returns the sweep on the cathode-ray tube to the top of the picture.)

Conditions 1, 3, and 4 above are held throughout the five-second phasing-pulse period to the beginning of the next picture. It is during this phasing-pulse period that the horizontal sweep is synchronized.

Horizontal Synchronization—During the five-second phasing pulse interval, the 250-millisecond blanks are in phase with the 12.5-millisecond tone burst (which begins each horizontal sweep line transmitted during the 200-second picture interval). A reset pulse is developed from each 12.5-millisecond blank. This aligns the tone burst at the left edge of the sweep.

Transistor Q8 amplifies and half-wave rectifies the video signal received from the video amplifier. Capacitor C9 filters the 2400-Hz AM carrier from the video. The network consisting of R19, R20, R21, C10, and CR2 has a characteristic fast pulse-rise time and slow pulse-fall time. Therefore, to turn Q9 on quickly, the 2400-Hz signal rapidly charges C10.

Capacitor C10 remains charged during the first 237.5-millisecond pulse interval. The 12.5-millisecond blank period that follows allows C10 to discharge to the point where Q9 is turned off.

Since the network's rise time response is fast, the negative-going edge of the pulse at the collector of Q9 occurs simultaneously with the beginning of the next 237.5-millisecond pulse. This negative edge is differentiated and applied to Q11 to produce a 7-millisecond reset pulse. This reset pulse performs the following functions:

- Applies a pulse through CR5 to the reset input of the clock countdown flip-flops.
- Sets the IC13 horizontal-sweep phasing-lockout flip-flop. The horizontal-sweep phasing-lockout flip-flop IC13 prevents pulses, that would be produced by this horizontal synchronization circuit during the picture interval, from resetting the clock-countdown flip-flops. This is done by holding the collector of Q9 low with Q11. Q11 is held on with the high-Q output of flip-flop IC13. Another clock-countdown reset-pulse can occur only after the 300-Hz interpicture interval is received and detected, causing flip-flop IC13 to be reset again.

Clock—The clock generates the four-pulse-per-second reset pulses used by the horizontal-sweep generator. The frequency source of the clock is a 2400-Hz tuning fork. An internal alignment potentiometer permits adjusting the frequency precisely to 2400-Hz. The tuning-fork output is squared by passing the signal through two gates (IC1). The ten-stage binary counter then divides the 2400-Hz gate output by 600 to obtain the required four pulses per second.

The four PPS square wave drives a one-shot circuit to produce a 2-millisecond reset pulse on each negative transition of the binary-countdown output square wave.

The pulses produced by the divided clock are coincident with the front edge of the tone burst beginning on each horizontal sweep line. Coincidence is thus created by the countdown-reset pulse of the synchronization circuit. This pulse is approximately 7 milliseconds long and occurs at the end of the 12.5-millisecond blank which, when using the 250-millisecond horizontal time reference, is in phase with the tone burst. In order that the tone burst begin at the left edge of the cathode ray trace, the binary countdown must be preset by 20 counts (approximately 20 milliseconds).

Vertical Sweep Generator—Amplifier A1 produces a 200-second sawtooth waveform, which is applied to the vertical-sweep amplifier. When the 300-Hz inter-picture tone is detected by the synchronization circuits, Q27 turns on to close relay K1. Relay K1 discharges the voltage across C21 to zero, driving the output of the operational amplifier to zero. When the phasing interval is completed, K1 opens and the operational amplifier is again permitted to integrate.

Horizontal Sweep Generator—A constant-current source, a capacitor, and a parallel switch are used to generate the 250-millisecond horizontal sawtooth sweep. The constant-current source charges capacitor C24 at a constant rate, producing a linear voltage ramp. The charging current is controlled by the voltage at the base of Q22 and by the value of the emitter-to-collector resistance.

The four-pulse per second waveform, generated by the clock, is applied to switch Q24, which is placed parallel to C24. Therefore, four times per second the output of C24 is discharged to ground through switch Q24. The 250-millisecond sawtooth waveform is applied to the horizontal-deflection amplifier located within the oscilloscope main frame.

## PRELIMINARY OPERATION PROCEDURES

Before operation, electrical power must be applied to the receiver/display unit, each antenna-positioning control box, and the tape recorder. Inter-connecting cables are required as follows:

- Stacking harness from the antenna to the preamplifier input
- RF cable from the preamplifier output to the receiver/display unit
- Interconnect cable between the receiver/display unit and the tape recorder
- Control cables from the antenna positioning system to the control units

## ANTENNA POSITIONING

The antenna and antenna-positioning system can be operated by moving the lever switches of the units which control the azimuth and elevation of the antenna. Read the meter scales carefully for proper indication. These units supply power to the drive motors and brake solenoids of the antenna-positioning system.

## RECEIVER DISPLAY UNIT

1. Apply power to the unit with the POWER switch on the display unit front panel. The POWER light should go on. Allow about 15 minutes for warmup.

2. Set INTENSITY and CONTRAST to 0.

3. Set the MODE switch to REAL TIME.

4. Set the DISPLAY FUNCTION switch to RASTER.

5. Reset the vertical sweep.

6. Increase the INTENSITY until the horizontal scan line is visible.

7. Adjust the horizontal and vertical positioning controls so that the line intersects the top corner formed by the circular phosphor edge and the left edge of the calibration graticule. (Figure 34.)

8. Now adjust the HORIZONTAL POSITION control counterclockwise until the left end of the scan line touches the edge of the phosphor on the left side.

9. Next adjust the HORIZONTAL SIZE control so that the right end of the scan line is positioned in the upper corner where the phosphor edge meets the calibration graticule. Adjustment of raster size and horizontal size are now complete.

10. Enable the verticle sweep, and note the time.

11. After an elapsed time of 200 seconds from the enabling of vertical sweep, adjust the VERTICAL SIZE control so that the right end of the scan line is positioned at the bottom corner formed by the phosphor edge, and at the left edge of the calibration graticule.

12. Set the DISPLAY FUNCTION switch to FOCUS.

13. Adjust the intensity for optimum display of the focus signal.

14. Adjust FOCUS and astigmatism (inside) controls for maximum resolution of the focus signal.

Preliminary picture adjustments are now complete. The position of the scan line, as initially set, should be checked before each period of operation. Focus and vertical raster size can be checked weekly, or less frequently if no adjustment appears necessary.

## CAMERA

The camera-clamp ring must be attached to the display unit bezel according to instructions in the camera instruction manual. Next, affix the camera body to the clamp-ring swingaway mount but do not lock it in place.

Two adjustments must now be performed: setting the image size and focusing the image. The display-unit scan line may be used to set the image size.

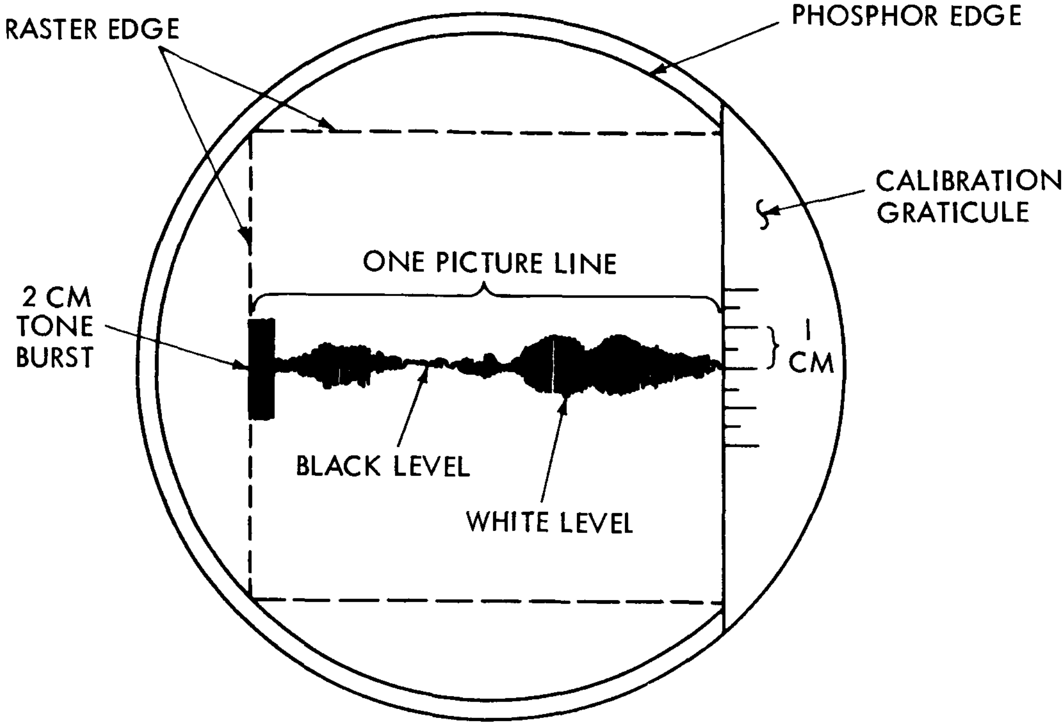



Figure 34–CRT Face in Waveform Mode

1. Set the MODE switch to REAL TIME.

2. Set the DISPLAY FUNCTION switch to RASTER.

3. Set INTENSITY at 10 and CONTRAST at 0.

4. Set the VERTICAL SWEEP to RESET. The scan line should be visible at the top of the normal raster area; reposition it if necessary.

5. Lock the camera into position against the clamp ring.

6. Set the aperture at f:2.8 and open the shutter.

7. Open the rear of the Polaroid pack-back, if used, and remove any film pack. Install the focusing adapter.

8. Referring to the camera manual for the method of adjustment, set up the image size by observing the scan-line image on the focusing plate.

Adjust the camera adjustments so that the scan line is placed about 1/8 inch above the bottom edge of the focusing plate.

9. Open the left side-access door on the camera and, while observing the actual scan line, adjust the vertical position of the scan line, positioning it at the bottom of the normal raster area.

10. Close the access door and observe the image of the scan line on the focusing plate. It should be visible at the top of the plate. If it is not, adjusting the camera-lens position to place the image of the scan line about 1/8 inch down from the top of the focusing plate.

11. Adjust the vertical position to put the scan line at the top of the normal raster area.

12. Now switch the DISPLAY FUNCTION switch to FOCUS. Observe the focus waveform on the focusing plate. This may require a magnifying glass and darkened room.

13. Adjust the position of the camera back to obtain the best focus. The adjustment of the lens position or the camera back may necessitate a readjustment of both to remove observable interaction.

14. Upon optimum adjustment, lock the camera adjustments. Close the aperture to f:4 and close the shutter. Remove the focusing adapter, install the film pack, and close the camera back.

If a 4- by 5-inch back is used as the camera back, preliminary adjustments are similar to those made using the 3.25- by 4.25-inch pack-back. Focusing and image size adjustment are accomplished when the 4- by 5-inch back is installed and the 4- by 5-inch Polaroid adapter has not been installed. After adjustments are complete, the Polaroid adapter may be installed.

## TAPE RECORDER

The tape recorder may be used according to its instruction manual, except for the following items:

1. Attach the interconnect cable according to wiring notations on the "Video Electronics" schematic found in this manual.

2. Approximate normal AUDIO LEVEL and tone settings should be marked on the control panel for both recording and playback.

3. Good-quality magnetic tape (instrumentation grade) should be used for this unit. Lower grade tapes will allow "dropouts" in which several cycles of clock signal may be lost, causing a horizontal shift in the picture.

4. The tape recorder should be modified so that each channel operates on half a track. The tape may be played in only one direction.

5. To achieve the disabling of the recorder speaker and to achieve low noise use the external speaker jacks instead of the preamp output in playback. The video electronics is wired for low impedance at the recorder input.

## OPERATING PROCEDURES

## REAL-TIME OPERATION

Before satellite ascent:

1. Complete all prěliminary operations.

2. Position the antenna toward ascent "look angle" (Refer to APT User's Guide for orbital information).

3. Set the MODE switch to REAL TIME.

4. Set the AUDIO LEVEL control high enough to pick up receiver noise.

5. Upon receipt of the satellite signal, adjust TUNING for maximum signal.

6. Enable the tape recorder in the record mode.

## MANUAL SYNCHRONIZATION

(Necessary only if the initial picture is required)

1. Set the DISPLAY FUNCTION switch to WAVEFORM.

2. Set CONTRAST to 0.

3. Set INTENSITY to 10.

4. Observe the video waveform on the CRT phosphor, either by viewing it through the binocular-viewing port or by swinging the camera housing aside. Observe, in the waveform, the full carrier tone bursts. (See Figure 34.)

5. Adjust the manual sync TRIGGER LEVEL fully CCW.

6. Depress the SYNC pushbutton and slowly adjust the TRIGGER LEVEL control clockwise until the horizontal sweep is reset by the pulses of the tone bursts. Release the SYNC pushbutton. The tone bursts should now appear at the far left of the sweep opposite the calibration plate. Correct sync is obtained only when manual sync occurs on a full-width tone burst; sync on a half burst may shift one-half of the data-code stripe to the opposite side of the picture. This will be corrected upon receipt of picture-sync information at the beginning of the next picture.

7. Close the binocular viewing port or close and lock the camera housing.

8. Set the INTENSITY and CONTRAST controls to the desired levels. These levels, which vary with the type of film used, should have been determined through prior use.

9. Set the DISPLAY FUNCTION switch to RASTER.

10. Reset and enable the vertical sweep.

11. Open the camera shutter. The picture is now being photographed.

## AUTOMATIC SYNCHRONIZATION

Upon completing the transmission of the first picture:

1. Set the DISPLAY FUNCTION switch to RASTER.

2. Set INTENSITY AND CONTRAST as desired. The first complete picture will be indicated by the presence of sync information (a 3-second period of 300-Hz modulation and a 5-second period of partly blanked video carrier). The PROMPTER indicator will light for about 7 seconds and go off, and the PICTURE indicator will then light. Raster scanning should have begun.

3. When the PICTURE indicator lights, open the camera shutter to expose the film. During reception, it is occasionally necessary to reposition

the antenna in order to track the satellite and receive adequate signal level. The antenna position should be updated about every minute, using Nimbus and ESSA look-angle data for the reception locality.

4. Close the shutter at the end of picture transmission (200 seconds, indicated audibly by the 300-Hz modulation, or visually by the PICTURE light going out.

5. Remove the exposed film.

6. When the PICTURE indicator relights, open the shutter to photograph the next picture.

7. After the recommended development time, separate the Polaroid print from the negative.

8. Immediately coat the print with the print coater supplied with the film. As the satellite begins to approach the horizon, the signal strength will diminish to a level below the limiting level of the receiver and noise will become audible. The signal-to-noise ratio and the picture quality diminish proportionately. At this point, the satellite pass may be considered complete.

9. Close the camera shutter, if it is open, and process the picture.

10. Stop the tape recorder.

If the satellite transmission has been recorded, the pictures may be rephotographed by playing back the recording for possible improvement of picture quality by variation of intensity and contrast. Copies may also be produced in this manner.

## PLAYBACK OPERATION

Preliminary operations:

1. Complete all preliminary operations.

2. Set the MODE switch to PLAYBACK.

3. Set the DISPLAY FUNCTION switch to WAVEFORM.

4. Set CONTRAST to 0.

5. Set INTENSITY to 10.

6. Install tape to correct the location of recorded data.

7. Adjust the channel VOLUME AUDIO LEVEL control to provide a 2/cm peak-to-peak signal amplitude for full video carrier which occurs during ESSA tone bursts, NIMBUS data code stripe, 300-Hz modulation, or sync waveform. You can adjust the amplitude by comparing it with the calibration plate on which the major divisions are 1-cm increments.

Operation from this point is identical with real-time operation, except for antenna positioning and RF receiver adjustments.

## ALTERNATE FACSIMILE

It may be possible to buy, from a surplus outlet, a standard facsimile such as those used in news agencies or police bureaus. The standard facsimile is a mechanical device using gears and clutches in place of electronic sweep cathode-ray tubes.

The video waveform is a standard facsimile format, described earlier, and is adaptable to any 240 RPM mechanical recorder. The described antenna-receiver combination will provide the necessary video signal to operate a 240 RPM recorder without modification. Some facsimilies, however, use a 120 RPM drum speed and would have to be converted before being used.

Generally, in the following standard facsimile recorders the start and phase procedure is similar but the method of display varies.

- Electrolytic paper: The video is converted from an analog voltage into a "marking current" and applied from a metal bar through the moving paper to a rotating drum. The chemical content of the paper allows a current flow proportional to the incoming video.

  The action of current passing from the metal bar through the paper causes the depositing of iron ions (many: black , a few: white) on the paper, thus reproducing the picture as seen by the spacecraft.

- Photo-sensitive paper: The video is used to vary a light source, which is usually a gas-filled tube energized to some ionizing potential. The video varies the ionizing potential, causing a proportional change in the intensity of the light tube. The light is optically focused on the photo-sensitive paper and traverses in a lateral direction to form the 200-second vertical sweep. The paper, in this instance, is formed on a rotating drum which revolves at a 240-RPM rate or four revolutions per second. This constitutes the horizontal frequency of four pulses per second.

After exposure, the paper is removed from the drum and subjected to a two-chemical developing process. Final prints are available within seconds.

- Negative film: As in the photo-sensitive paper facsimile, the video, once detected, is applied to a light source. The resultant light beam is focused through a minute aperture and focused once more on an oscillating mirror. The mirror oscillates at four sweeps per second (240 RPM). The image from the mirror is once again focused on a high quality, 70 millimeter, fine grain film. The film slowly traverses in front of the scanning. A video light beam forms the vertical sweep while an oscillating mirror forms the horizontal sweep.

The preceding types of facsimile recorders are all suited for APT. They may be purchased from a price range of $4,000 to $35,000. Included in the cost of a second-hand unit should be the price of making it operational.

## DIRECT READOUT INFRARED (DRIR)

In the near future, weather satellites will have an operational system designed to take nighttime infrared pictures of the earth. This system is similar to and will use the same frequencies as the APT; however, the format has been changed to accomodate the 48-RPM radiometer scan rate. This has necessitated a modification of the APT station design to enable reception. The modification manual should be available by December 1967 from the APT coordinator at GSFC.

Figure 35 is a preliminary block diagram of the DRIR electronics shown in relationship to the present APT electronics. The DRIR electronics will be packaged inside the oscilloscope plug-in. Added to the front panel will be two switches and an indicator light (one switch will select the APT or DRIR mode of operation). The DRIR system takes one continuous unframed picture during nighttime operation, and the unit will provide an indication signal to the operator when the sweeping trace has reached the bottom of the cathode ray tube. After advancing the camera film, the operator initiates the next picture with the vertical reset switch.

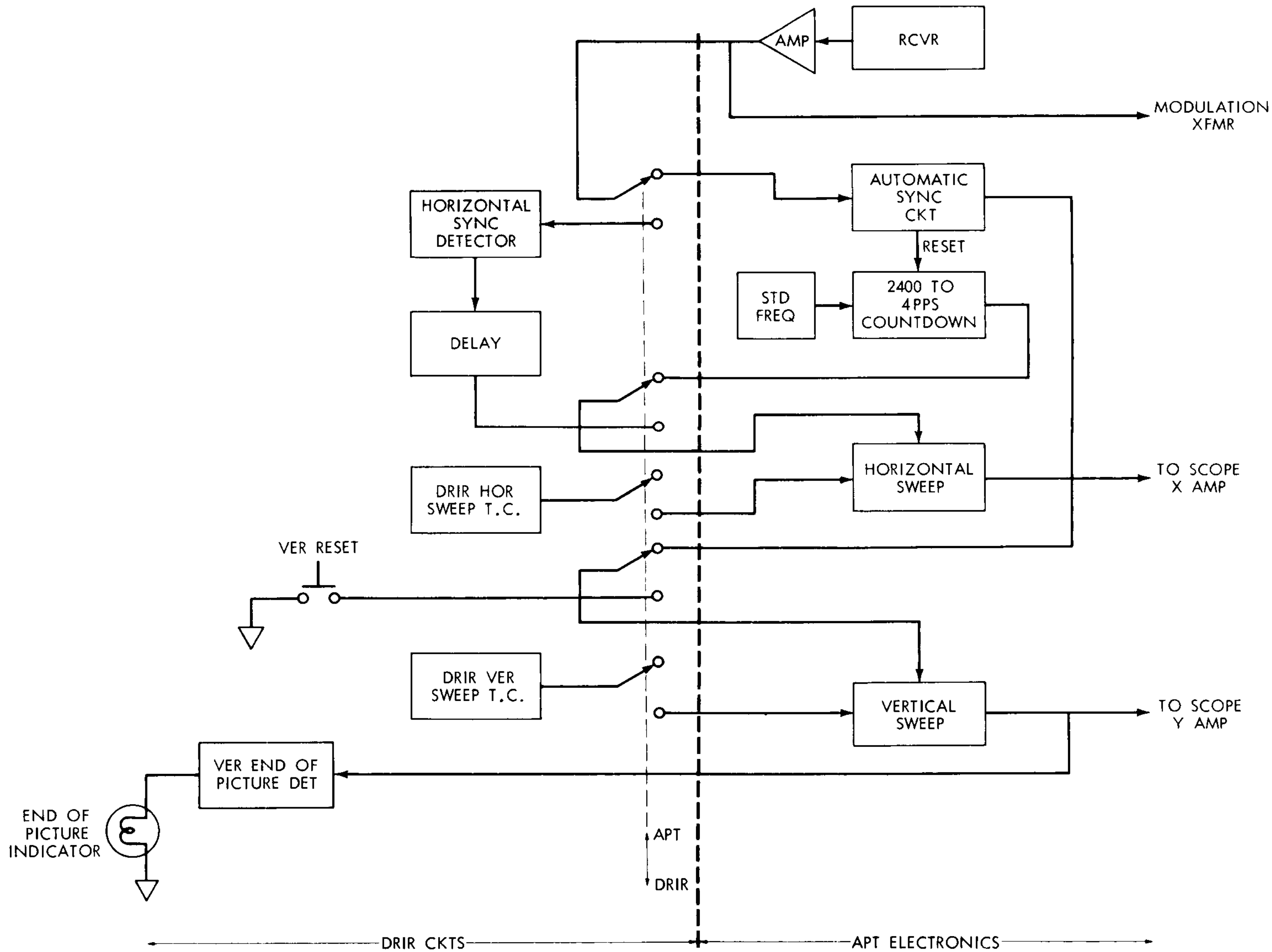



Figure 35–Proposed DRIR Modification, Block Diagram

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