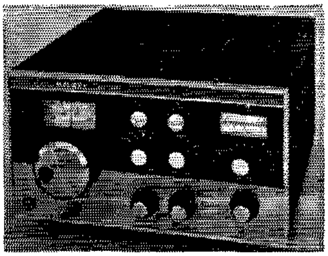
Recent Equipment

To acquaint you with the technical features of current amateur gear.

Galaxy GT-550 Transceiver



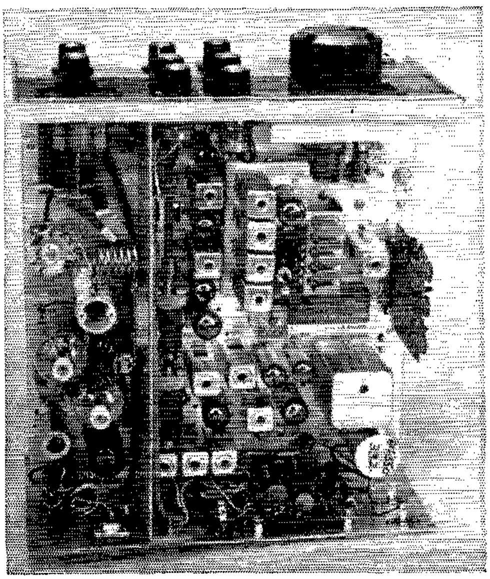
THE present trend in transceivers is toward versatile compact units that operate at higher power levels than their predecessors and use, wherever practical, semiconductors in place of vacuum tubes. The new Galaxy GT-550 transceiver is no exception. Rated at 550 watts p.e.p. input on s.s.b. and 360 watts input on c.w., the unit covers 3.5 to 4.0, 7.0 to 7.5, 14.0 to 14.5, 21.0 to 21.5 and 28.0 to 29.0 MHz. in six 500-kHz. segments. Semiconductors in the GT-550 outnumber tubes by more than two to one. There are eighteen transistors, nine diodes and thirteen tubes in the transceiver. The rig measures $6 \times 11\frac{1}{4} \times 12\frac{1}{2}$ inches and weighs only 17 pounds.

Because of the complexity of the transceiver, the circuit of the GT-550 has been broken down into two block diagrams to make it easy to follow an explanation of the operation of the unit. Fig. 1 shows the transmitter section and Fig. 2 shows the receiver. A star is located next to each tube and transistor that is used for both transmitting and receiving.

Transmitter Section

Referring to Fig. 1, when the rig is on s.s.b. audio from any high-impedance microphone is amplified in Q_9 and Q_{10} and fed to the 12AT7 balanced modulator, V_7. Also arriving at V_7 is the r.f. signal from the 6GX6 crystal-controlled carrier oscillator, V_5. Depending on the position of a front-panel switch, S_2, the output of V_5 is on either 9001.25 or 8998.75 kHz. To prevent V_7 from pulling V_5's frequency when the GT-550 goes from receive to transmit a transistor buffer, Q_{16}, is used between V_5 and the balanced modulator (when the rig is in the receive mode, pentode V_5 is used as a b.f.o., product detector and audio amplifier).

The double-sideband output from the balanced modulator is fed into a 9-MHz. crystal filter which suppresses the unwanted sideband. The s.s.b. signal leaving the filter is amplified in V_3, a 6EW6, and passed on to the 6EJ7 mixer, V_8. Here the s.s.b. signal is heterodyned to the desired amateur frequency. Depending on the band of operation, injection is furnished by either the v.f.o. alone or by the v.f.o. in combination with crystal oscillator Q_3 and mixer V_{6A}. The 2N3563 v.f.o., Q_{12}, tunes 5.0 to 5.5 MHz. in a Colpitts configuration and is followed by three



Top view of the transceiver. At the left of a partition that runs the length of the chassis are the tubes used in the receiver r.f. amplifier, transmitter driver, and final amplifier. The two variables adjacent to the right side of this plate tune the receiver r.f. amplifier and the transmitter driver. At the far right is the plug-in circuit board of the optional VOX unit. Anti-VOX, delay, and VOX gain controls on the right side of this board can be adjusted by inserting a screwdriver through cutouts in the perforated cover shown in the title photo. The large rectangle can in the lower right corner houses the components of the optional plug-in crystal calibrator. The components of the transistor audio stages are mounted on the circuit board at the bottom of the photo. Not shown is a perforated cover (not the one in the title photo) used to shield the components on the left side of the previously-mentioned divider.

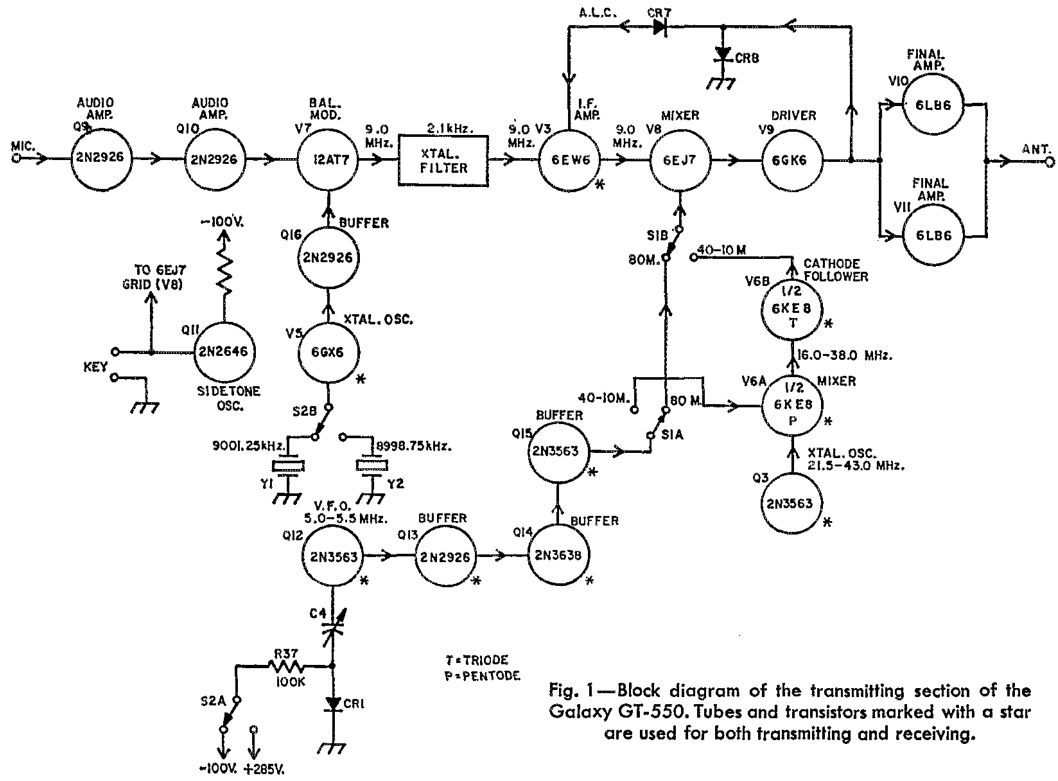


Fig. 1—Block diagram of the transmitting section of the Galaxy GT-550. Tubes and transistors marked with a star are used for both transmitting and receiving.

transistor buffer amplifier stages, Q_{13} through Q_{15}. On 80 meters the 5.0- to 5.5-MHz. output of Q_{15} is fed directly to V_8 where it beats with the incoming 9-MHz. s.s.b. signal to give an output of 4.0 to 3.5 MHz. On 40, 20, 15 and 10 meters the output of Q_{15} is passed on to V_{6A}. Fixed-frequency injection for V_{6A} on each band is provided by Q_3, which is on 21.5 MHz. for 40 meters, 28.5 MHz. for 20 meters, 35.5 MHz. for 15 meters, 42.5 MHz. for the bottom 500 kHz. of 10 meters, and 43.0 MHz. for the next 500 kHz. of 10 meters. As a result of the mixing process, the output of V_{6A} is in the range of 16.0 to 16.5 MHz. for 40 meters, 23.0 to 23.5 MHz. for 20 meters, 30.0 to 30.5 MHz. for 15 meters and 37.0 to 38.0 MHz. for 10 meters. (The top 700 kHz. of 10 meters can be covered by substituting optional crystals for those used in Q_3 to cover the bottom 1000 kHz. of the band.) The signal from V_{6A} goes to cathode follower V_{6B} and then to V_8 where it combines with the incoming 9-MHz. s.s.b. signal to produce output in the selected amateur band.

To keep the dial calibration accurate for both upper and lower sideband operation, a diode switching arrangement (C_4, CR_1, R_{37} and S_{2A}) is used in conjunction with the v.f.o. When V_5 is operating at 9001.25 kHz., CR_1 is reverse biased, allowing one end of C_4, which is connected to the v.f.o. tuned circuit, to float. However, when V_5 is operating at 8998.75 kHz., CR_1 is forward biased, effectively grounding the previously-free end of C_4. This decreases the v.f.o. frequency by an amount equal to the frequency difference between Y_1 and Y_2, thus keeping the v.f.o. dial calibration the same regardless of the sideband selected.

The amateur-band signal from mixer V_8 is amplified in the 6GK6 driver, V_9, and then fed to the final amplifier, a pair of parallel-connected 6LB6 TV horizontal-sweep tubes operated in Class AB_1. A pi network in the plate circuit is designed for non-reactive loads between 40 and 100 ohms. Two 1N462 diodes, CR_7 and CR_8, provide a.l.c. action. Whenever the final tubes draw grid current, audio is generated in the p.a. grid circuit. This audio is rectified by CR_7 and CR_8, and the resulting d.c. voltage is used to reduce the gain of the 6EW6 i.f. amplifier, V_3.

Three types of c.w. operation are possible with the GT-550: manual low power, manual high power and VOX break-in. The first type is accomplished by putting the FUNCTION switch in the TUNE position, and the last two are achieved by turning the FUNCTION switch to the CW position. In either position, a section of the FUNCTION switch reverse biases a diode switch which, in turn, unshorts a 100-pf. capacitor in series with the 8998.75-kHz. crystal in the carrier oscillator, V_5. This shifts the output of V_5 to 8999.45 kHz., a frequency within the 2.1-kHz. bandpass of the 9-MHz. crystal filter. Another

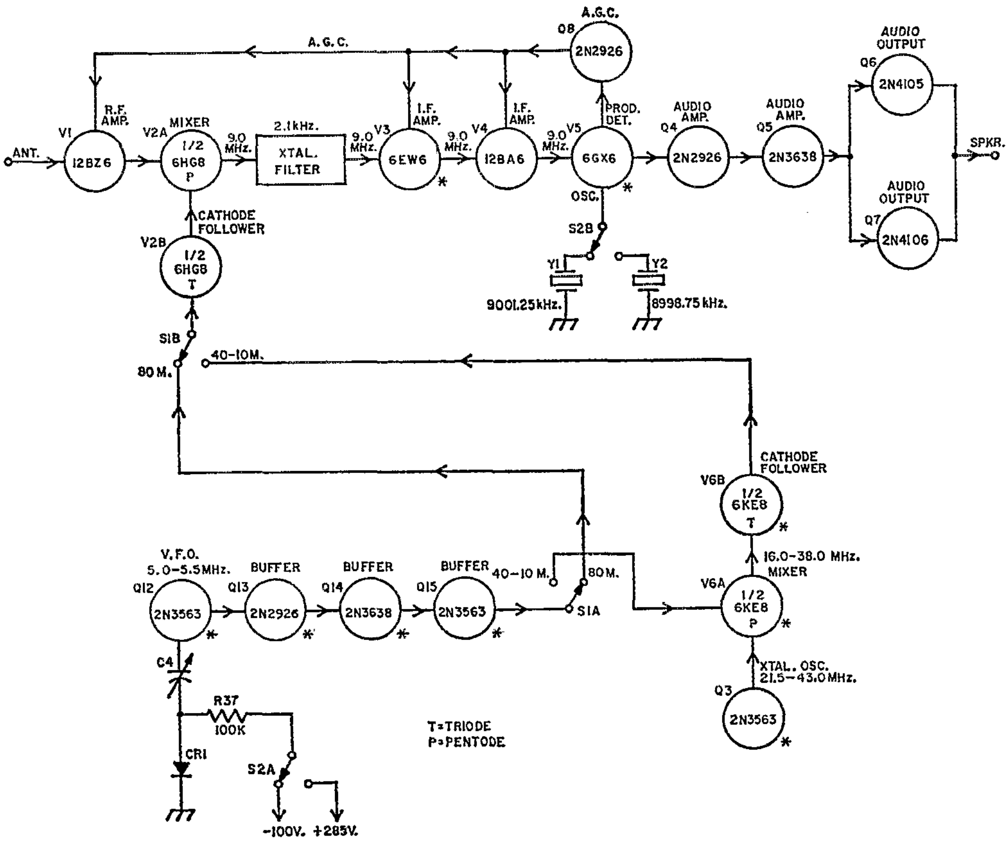


Fig. 2—Block diagram of the receiver section of the Galaxy GT-550. A star is shown alongside those tubes and transistors that are used for both transmitting and receiving.

section of the switch unbalances the balanced modulator so that the carrier can pass through. In the TUNE position of the FUNCTION switch, this section connects a variable negative bias to one of the triodes in the 12AT7 balanced modulator. (The potentiometer that controls this bias is ganged to the MIC gain control, permitting the c.w. input to be varied by adjustment of the aforesaid control.) In the CW position of the FUNCTION switch, this same switch section connects fixed bias, rather than variable bias, to one half of the balanced modulator, preventing adjustment by the MIC gain control of the amplifier input.

Still another section of the FUNCTION switch establishes the maximum input level for low and high power c.w. When the transmitter is on s.s.b., this switch section allows regulated 180 volts to be applied to the screens of the final amplifier tubes. It does so by shorting a 33,000-ohm resistor that is in series with the amplifier screens and the supply. For low power c.w. (TUNE position) this switch section removes the short, permitting the final amplifier to run at a maximum input of about 250 watts. For high power c.w. (CW position) this same switch section parallels the 33,000-ohm resistor with a 10,000-ohm resistor, allowing the final to operate at 360 watts input.

The rig is keyed in mixer V_8 by the blocked-grid method. A 2N2646 unijunction sidetone oscillator, Q_{11}, which operates at about 700 Hz., is keyed at the same time.

In the PTT position of the FUNCTION switch, push-to-talk switching operates the GT-550's send-receive relay. In the VOX position the changeover is accomplished by an accessory VOX unit, which plugs in a nine-contact socket inside the transceiver. In order to receive signals when operating low-power c.w. in the TUNE position it is necessary to return the FUNCTION switch to PTT or VOX, because the switch, not the key, operates the relay. When operating manual high-power c.w. in the CW position, before keying, the receive-transmit relay must be activated by closing the push-to-talk switch on the microphone. Of course, a foot switch can be used instead. It is not necessary to move the FUNCTION switch out of the CW position in order to receive signals; opening the p.t.t. circuit and the key is all that is required. For c.w. VOX break-in, the accessory VOX unit must be in-

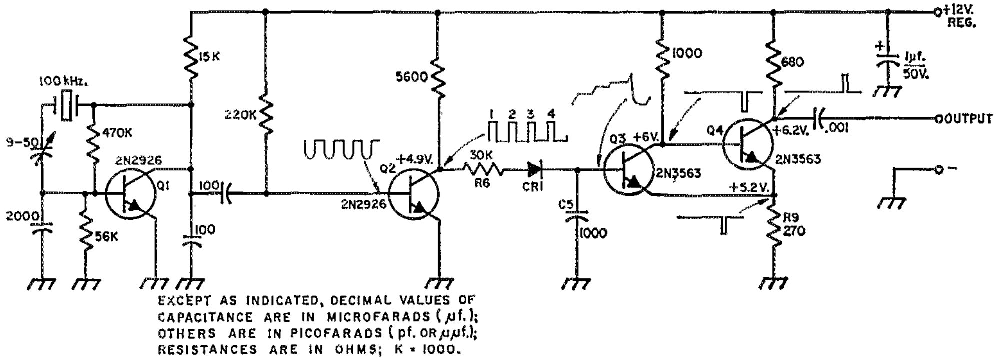


Fig. 3—Partial schematic diagram of the CAL-25 crystal calibrator. Voltages shown were measured with a v.t.v.m. between the points indicated and ground. Component labels are for text reference.

stalled and correctly adjusted. Then when the key is closed, the sidetone signal will key the VOX unit which, in turn, will switch the send-receive relay from receive to transmit. After the key is released, the relay will stay in the transmit condition for a length of time that depends on the setting of a DELAY control in the VOX unit. When this time is up, the set will automatically return to receive.

Transmitter adjustments are made by monitoring a meter in the cathode circuit of the final amplifier.

Receiver Section

Referring to Fig. 2, signals coming from the antenna are amplified in V_1 and fed to a 6HG8 mixer, V_{2A}. Local oscillator energy for V_{2A} is generated by the same stages used to provide injection for transmitter mixer V_8, and the injection frequencies are the same. A cathode follower, V_{2B}, is used to isolate V_{2A} from the local oscillator chain. The output of V_{2A} is fed through the 9-MHz. crystal filter, amplified in two i.f. stages, V_3 and V_4, and then passed on to V_5.

As mentioned earlier, on receive pentode V_5 functions as a product detector, b.f.o. and audio amplifier. The crystal-controlled b.f.o. employs the cathode, grid No. 1 and grid No. 2 of V_5 as a triode. Grid No. 2 serves as the oscillator plate, and S_{2B} selects the appropriate crystal for upper or lower sideband reception. During transmitting this oscillator supplies the carrier for the balanced modulator. The detector/audio amplifier uses the cathode, grid No. 3 and the plate of V_5.

Sideband selection, as well as v.f.o. shift for keeping the dial calibration the same regardless of the choice of sidebands, is accomplished in the same manner as described for transmitting. Audio from V_5 is amplified by Q_4 and Q_5 and then fed to the audio output stage, Q_6Q_7. Q_6 and Q_7 are used in complementary-symmetry push-pull, a circuit that eliminates the need for an output transformer. Output to an external 8-ohm speaker or headset is through two 100-µf. electrolytic capacitors.

The meter used to indicate transmitter adjustments is switched to the screen circuits of V_1 and V_4 during receiving periods. It shows signal strength by measuring the increase in screen voltage that results when a.g.c. voltage, caused by an incoming signal, reduces the gain of V_1 and V_4.

Accessories

There are at least ten accessories available from Galaxy for use with the GT-550. They include the AC-400 a.c. power supply, the SC-550 speaker console, the VOX-35C VOX unit, the RV-550 remote v.f.o., the F-3 audio filter, the CAL-25 crystal calibrator, the G-1000DC mobile supply, the RF-550 wattmeter, the LA-550 linear amplifier, and the PR-550 phone patch.

The CAL-25 25-kHz. crystal calibrator, probably the most novel accessory of the group, is illustrated in Fig. 3. Waveforms are shown at various points in the circuit to indicate what is going on in the device during four cycles of the 100-kHz. signal developed by crystal oscillator Q_1. The 100-kHz. output from Q_1 is amplified by Q_2. Q_2 is set up to saturate easily, resulting in a squared waveform in its collector circuit. Such a waveform is desirable if reliable frequency division is to be achieved.

If Q_1 was not oscillating, Q_2 would be conducting heavily and its collector voltage would be only about 0.1 volt. Because the oscillator is operating, Q_2's collector voltage goes highly positive every time a negative pulse reaches the base of the transistor. This voltage is used to charge C_5 through diode CR_1. Q_3 receives its forward bias from the voltage developed across C_5. Until this voltage gets to be about 0.6 volt greater than the reverse bias developed across R_9, Q_3 does not conduct. Referring to Q_2's collector waveform, during the first positive pulse C_5 charges up to some positive voltage. The charge on C_5 goes higher during the second positive pulse and even higher during the third. This can be seen by examining the waveform at the base of Q_3. Because Q_3 is cut off and because of the polarity of CR_1, C_5 can't discharge during the first three pulses. The fourth positive pulse on the collector of Q_2 charges C_5 to a sufficiently high voltage to forward bias Q_3 into conduction. This gives C_5 a discharge path, and the capacitor quickly discharges through the base-to-emitter junction of Q_3. Then the whole cycle of events described above is repeated. As a result, one pulse (25 kHz.) is generated in the collector and emitter circuits of Q_3 for every four pulses (100 kHz.) from the oscillator.

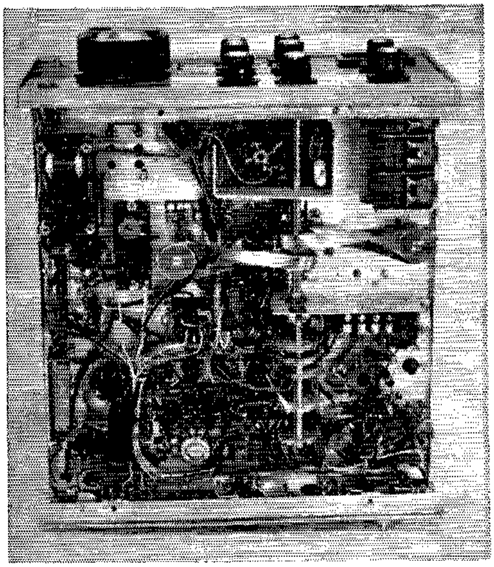
Note that the collector of Q_3 is tied to the base of Q_4 and that the emitters of the two transistors are connected together. Because of this wiring arrangement, an increase in current in one stage tends to cause a decrease in current in the other stage and vice versa. As a result, Q_4 not only amplifies the pulse from Q_3, but serves as a voltage regulator for R_9 as well. If R_9's voltage isn't held fairly constant, there is a chance of incorrect frequency division. That is, the output might be on 33.3 kHz. (divide by three) or 20 kHz. (divide by five).

Physical Details

The transceiver seems to be mechanically sound. Front and rear panels are of heavy-gauge aluminum, as is the chassis. Strips of aluminum angle stock and a heavy dial bezel give added strength to the front panel. The top and bottom covers are perforated to provide ventilation, as is a shield used to cover the final amplifier compartment. Sockets for the final amplifier tubes are mounted on spacers below chassis level, permitting the use of a low-silhouette cabinet and making it easy for air to circulate around the tubes. Circuit boards are used to mount most of the components of the various transistor stages.

A ball drive in conjunction with a gear train is used to tune the v.f.o. capacitor. The dial is calibrated from 0 to 500 in 5-kHz. steps. It takes 36 turns of the v.f.o. knob to tune 500 kHz. or, to put it another way, about one turn of the knob to tune 12 or 13 kHz. The large knob that is used should make the tuning process relatively easy, but in the set we tested there was some backlash in the mechanism. A finger hole in the knob lets one move around a band in short order, and a tab next to the dial window makes it possible to move the dial pointer about 10 kHz. for calibration purposes.

In addition to the main tuning knob, there are nine controls on the front panel: A.F. GAIN (with an ON/OFF switch on the back) and R.F. GAIN (these two controls are on concentric shafts), FUNCTION switch (PTT, VOX, CAL, TUNE, CW), SIDEBAND selector, MIC gain, EXCITER tuning, BAND switch, PLATE tuning, and final LOADING. The only other items on the front of the transceiver are a MIC jack and the meter used to measure final amplifier cathode current and to indicate signal strength.



A look at the underside of the transceiver. Except for five capacitors and the tuning mechanism, the components of the v.f.o. and buffer stages are mounted on the circuit board in the upper left corner. The copper shield that normally covers this board is not shown. The shaft that turns the band switch runs through the middle of the photo from top to bottom. The two band-switch sections that aren't on the bottom of the chassis are ganged to this shaft via aluminum pulleys and figure-eight-shaped loops of brass.

Instruction Manuals

The instruction manuals for the GT-550 and its accessories give ample information on how to operate the equipment, and they have parts lists and schematics. In addition the GT-550 manual has a test and alignment section, a trouble-shooting chart, a resistance chart, a voltage chart, and a block diagram of the transceiver. However, none of the theory sections of these manuals contains sufficient information to explain thoroughly what is going on in any particular unit, and the schematics are woefully lacking in labels. The radio amateur who wants to repair his equipment or understand how the various stages function had better have a good background in the field of electronics if he wants to accomplish his objective in a reasonable length of time.

Performance

Manufacturer's specifications of particular interest are as follows:

Input: 550 watts p.e.p. s.s.b., 360 watts c.w.

Suppression: Carrier −45 db., unwanted sideband −55 db.

Frequency stability: Less than 100 Hz. drift in any 15 minute period after warmup.

Crystal filter: 2.1 kHz. with a 1.8:1 shape factor (db. points not specified)

Receiver sensitivity: 0.5 μv. for 10 db. $S + N/N$ ratio.

These specifications were met in the transceiver checked in the ARRL lab. The manufac-

Galaxy GT-550 Transceiver

Height: 6 inches.
Width: 11¼ inches.
Depth: 12½ inches.
Weight: 17 pounds.
Power Requirements: 900 volts d.c. at 600 ma., 350 volts d.c. at 300 ma., 16 volts d.c. at 1 ampere, −100 volts d.c. at 50 ma., and 12.6 volts a.c./d.c. at 5 amperes.
Price Class: $450 less power supply and speaker; AC-400 power supply: $90; SC-550 speaker console: $20.
Manufacturer: Galaxy Electronics, 10 South 34th Street, Council Bluffs, Iowa 51501.

turer gave no figures on distortion products; however, after proper adjustment of the rig, third- and fifth-order products were down more than 26 db. below p.e.p. On the four lower bands the output of the rig, as measured on a Bird model 43 wattmeter, was about 130 watts c.w. in the TUNE position of the FUNCTION switch, 200 watts c.w. in the CW position, and 260 watts p.e.p. s.s.b. in the PTT position. For the 28.5- to 29.0-MHz. band these figures dropped to, in the same order, 90 watts, 140 watts, and 160 watts p.e.p.

The amount of signal that it took to get a specific S-meter reading varied a little bit from band to band, but on the average the receiver required a 2-μv. signal for an S1 reading, a 20-μv. signal for an S9 reading, an 80-μv. signal for a 20 db. over S9 reading, and a 2000-μv. signal for a 60 db. over S9 reading. Internally-generated spurious signals were found on all but the 3.5- to 4.0-MHz. band. Of the 18 unwanted signals found, only two — 14.14 MHz. and 21.2 MHz. — were strong enough to be bothersome. They also were the only ones that resulted in S-meter readings, the former being S4 and the latter, which is the fourth harmonic of the v.f.o., being 30 db. over S9. On the 3.5- to 4.0-MHz. band the set picked up a couple of broadcast stations, even when the antenna connector was shorted out and no antenna was attached. Prior to turning on the transmitter section of the transceiver, the receiver section tended to be slightly regenerative except on 40 meters. Once the transmitter section heated the rest of the set, this condition disappeared.

While the unit was being put through a fairly rugged test, the final amplifier tubes went sour and had to be replaced. Although this was most likely the fault of the tester and not the manufacturer, it points out that it's best not to leave the key down for any length of time if one wants the final amplifier in a sweep-tube rig to last for a reasonable period. In the case of the GT-550 it's a good idea to let a fan blow air across the 6LB6s, because the tubes run very hot even in normal operation. — *W1YDS*

Satellite Weather Pictures

(*Continued from page 21*)

justments of the timing control probably will be needed for optimum operation.

In the vertical deflection circuit, the Miller rundown is initiated by opening the sweep/reset switch, with the test/use switch closed. Adjust the timing control for a 200-second ramp.

Opening the test/use switch removes the 24-μf. timing capacitor from the circuit and allows the operator to adjust the vertical gain (Fig. 3) for proper deflection.

The bucking controls of both horizontal and vertical sections are adjusted to produce a signal that swings from positive through zero to negative polarity, with equal-amplitude maximum voltages of both polarities. The voltage excursions can be measured with a d.c.-coupled scope connected at the high ends of the gain controls.

The astigmatism control, Fig. 4, should be adjusted in conjunction with the focus control to give a sharp trace.

Adjust the signal input amplitude and the brightness control for a suitable picture; this probably will require some experimentation. The first line of the picture is at the top of the c.r.t. face, with the horizontal sweep starting at the left.

Adjustment of the synchronizing and deflection circuits, if carried out as described above, can be done without applying high voltage to the c.r. tube. Extreme care should be used when the high voltage is on, and a metal enclosure grounded to the chassis should be used in regular operation.

Photography

The camera presently used here is a 35-mm. Praktica with a Zeiss *f*/2 58-mm. lens. A 10-mm. extension was used to allow the distance to the c.r.t. face to be 10.5 inches

The lens iris is set at *f*/8, and at the beginning of a picture sweep the shutter is opened by a cable release and locked. The monitor speaker is a great help at this time. At the end of the 200-second vertical sweep interval the shutter is closed. The pictures are taken in a darkened room, using tape recordings of the satellite passes as the signal source.

There is no reason why a Polaroid camera could not be used — perhaps with the use of a close-up lens kit.[3]

I would like to thank Mel Linse for his valuable aid and advice with the photographic work.

[3] Coy, "Build a $20 Scope Camera," *Radio Electronics*, April, 1969.

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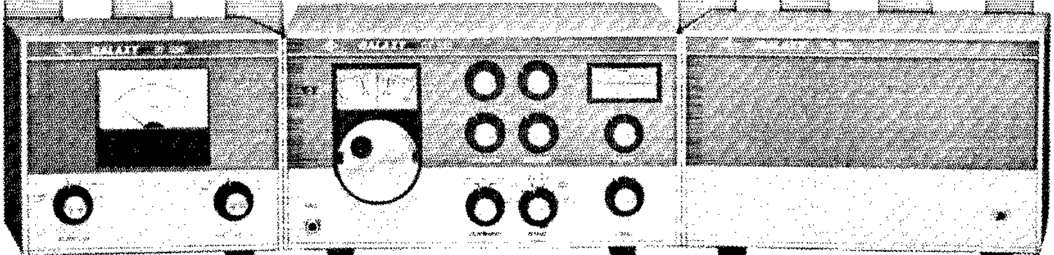

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