X-Band Radar Development

M. A. Gregg and R. B. Kolbly
R. F. Systems Development Section

Development progress of the DSS 14 X-band radar transmitter is described. Specific subassemblies discussed are the exciter, combiner controller for the two 250-kW klystrons, and various high-power components associated with klystron output combining and monitoring.

I. Introduction

This portion of the X-band radar development effort involves the installation and integration of two 250-kW klystrons into the lower part of a Cassegrain cone which will be mounted onto the tricone assembly of the DSS 14 64-m antenna. The object of the effort is to obtain 400 kW (+86 dBm) output using a hybrid combiner, power splitters, directional couplers, waveguide switches, and an associated exciter-combiner control.

Because of the limited space in the Cassegrain cone, a special handling fixture and carriage were designed to install and remove the klystrons with the cone mounted on the antenna.

II. Exciter-Buffer Amplifier

Figure 1 is a block diagram of the buffer amplifier and combiner control subsystem. The high-power klystron amplifiers used in the X-band radar system require approximately 5 watts (+37 dBm) of drive, when operating at full power output in a saturated mode. To assure adequate drive at the klystron, two Varian model VTH-6079H1 traveling wave tube amplifiers are used as buffer amplifiers. The helix of this traveling wave tube (TWT) will change the relative phase shift through the TWT by approximately 1.6 deg for each volt change in the helix voltage. Therefore, the helices of the TWT amplifiers will be used as phase control elements to keep the output of the high-power klystron amplifiers in proper phase. The phase-error signal from the combiner control unit is converted to a push-pull signal and applied to the helices of both TWT amplifiers to minimize amplitude variations of the drive signal. A diode phase switch is incorporated in one of the drive lines to reverse the relative phase between the two outputs of the buffer amplifier. Such a phase reversal will cause the power output of the high-power combiner to be delivered to the "waster" load instead of the antenna. The diode phase switch, operating at a few milliwatts of power, is performing the function of a high-speed 500-kW RF switch.

III. RF Drive Control Circuitry

In order to provide remote control of the drive power supplied to each klystron, P-intrinsic-N (PIN) diode modulators are used to control the drive power to each TWT amplifier. A voltage-controlled constant current source supplies the required bias current to the PIN-diode modulators. Voltage for the current source is derived from a digital-to-analog (D/A) converter. A remotely controlled up/down counter is used to furnish the data for the (D/A) converter. This method allows the klystron drive to be controlled from many locations and effectively prevents any noise on the control lines from amplitude-modulating the klystron drive. In addition, it is necessary that the drive control circuitry allow rapid removal of drive from the klystron in the event of a waveguide arc. If an arc is detected in the waveguide, a signal is applied to one or more of the arc detector inputs, and the drive control logic drives the PIN-diode attenuators to maximum attenuation. For redundancy, a PIN-diode switch on the output of the ×16 multiplier is also opened. An arc detector signal at any one of the inputs will cause the drive to both klystrons to be removed.

IV. Combiner Control Circuitry

Samples of the outputs from the two high-power klystron amplifiers are compared in the phase detector section of the combiner control unit. This phase error signal then drives a high-gain amplifier with appropriate filtering to drive the helices of the TWT amplifiers in the buffer amplifier assembly. Since the sense of the phase detector is reversed when the phase switch in the buffer amplifier is in a position to deliver the output power to the "waster" load, it is necessary to incorporate an inversion in the combiner control amplifier when it is desired to deliver the power to the "waster" load. Provision is also made to open the control loop and operate with a variable voltage source for manual phase control.

V. Power Amplifier

To date, three 250-kW klystrons have been received and tested. All three have failed in test before reaching full output power. Two failed with shorted cathodes which resulted from arcing; the third would not hold the required high voltage. Additionally, one of the first two klystrons had a cracked output window. All have been returned to the manufacturer.

Three waterloads, one of the three repaired dual directional couplers, one of the 400-kW single directional couplers, one of the waveguide switches, two waveguide elbows, and the prototype arc detector head and package have been tested at 200 kW for a short time only because of failure of the klystrons.

The cooling manifolds, associated mounting hardware, klystron assemblies, filament transformer mounting, body current probe brackets, high-voltage resistor and corona balls, flow and temperature panels, and associated housing have been designed, fabricated, and installed in the test fixture for fitting and harnessing in the cone. Refer to Figs. 2 and 3 for views of the test fixture.

Most of these units are now being passivated and assembled in the cone structure for expediency in testing a 400-kW system with delivery of the klystrons.

VI. Conclusion

Because of the failure of the klystrons, the testing of the components at 250 kW will have to be extended, and the 400-kW testing will be delayed considerably. All klystrons, associated hardware, and monitor (with the exception of the electronic package, exciter, and waveguide) should be installed in the cone by early March 1974.

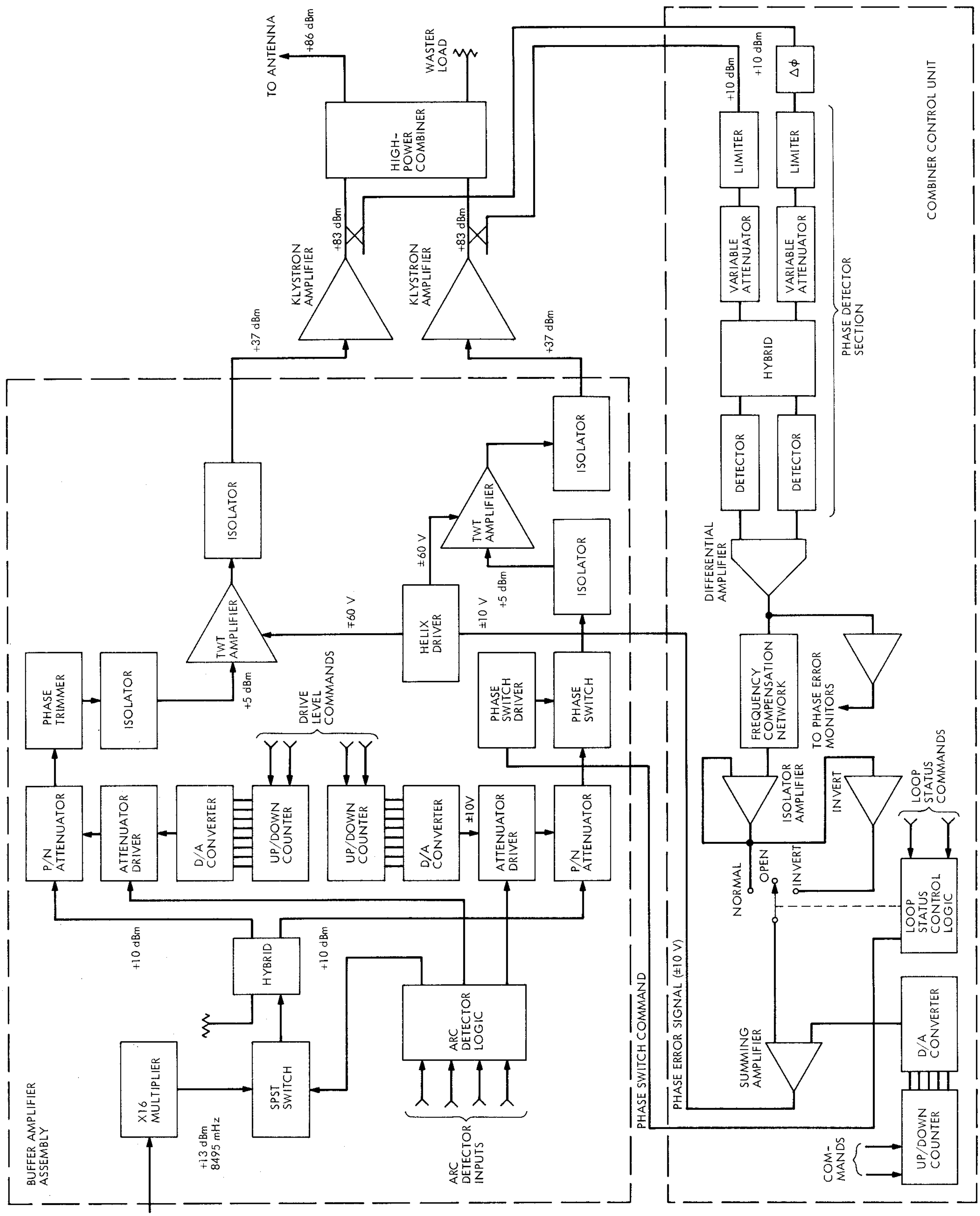

Fig. 1. Buffer amplifier and combiner control block diagram

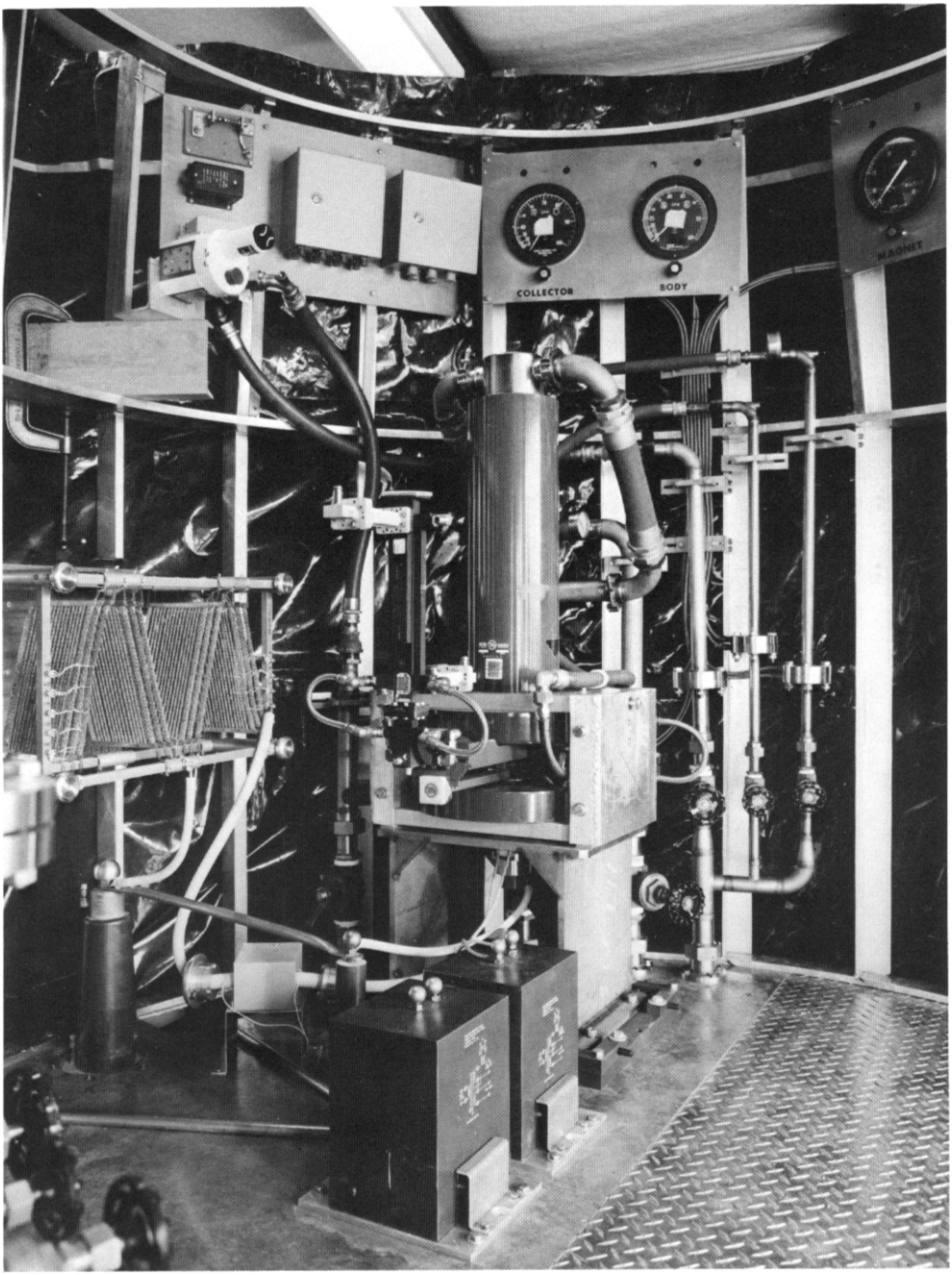

Fig. 2. Test fixture, front view

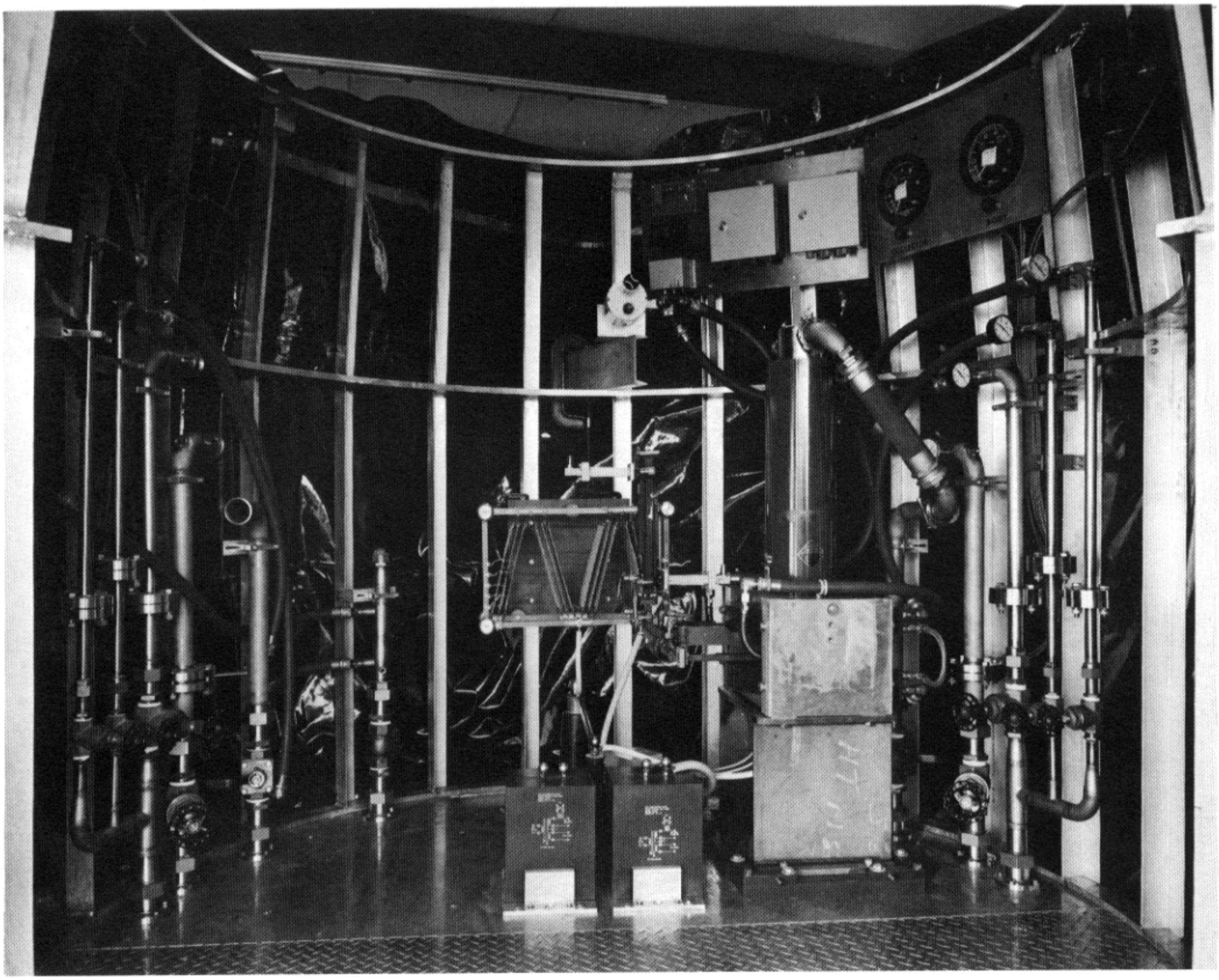

Fig. 3. Test fixture, side view