TRANSMISSION SURVEILLANCE SYSTEM—RADIO (TSS-R) APPLICATION ENGINEERING

CONTENTS PAGE

1. GENERAL

1.01 The Transmission Surveillance System—Radio (TSS-R) is a computer-controlled measurement system designed initially for maintenance of AR 6A radio (a single-sideband microwave radio relay system operating in the 6-GHz common carrier band). The TSS-R system provides for fully automatic (unmanned) measurements at switching stations under the remote control of a central minicomputer. TSS-R measurements include in-service measurements of pilot level and intermastergroup noise at the combiner shelf of the mastergroup translator B (MGTB) and at the 500A protection switch or 501A hot standby equipment. In addition automatic out-of-service measurements on switch sections and on individual repeater hops can be made through access points in the 500A protection switch. Switch section tests include measurements of idle noise, spurious tones and modulation, amplitude response, linearity, and cochannel and adjacent channel leakage. Remote controllable stress test and pilot resupply equipment at each repeater station allows the TSS-R system to check individual repeater hops for fade margin, interference, transmitter linearity, and operation of the space diversity switch and antenna.

1.02 Whenever this section is reissued, the reason for reissue will be listed in this paragraph.

2. OVERALL SYSTEM DESCRIPTION

The Transmission Surveillance System—Radio

2.01 TSS-R is a fully automated system designed for making out-of-service and in-service selective level measurements in the frequency range from 50 kHz to 110 MHz at main (switching) and terminal stations of AR 6A. TSS-R (Fig. 1), consists of a computer controlled central, microprocessor controlled remotes, and an interface with operational SCOTS or TASC systems (Surveillance and control of Transmission Systems/Telecommunications Alarm Surveillance and Control System) Terminals at SCOTS/TASC centers or other OTC designated locations can be used as report output stations or to request measurements.

2.02 Communication links between the TSS-R central and TSS-R remote use the DDD network. The DDD network is also used to provide the communications link between the central and terminals and the central and SCOTS/TASC.

2.03 TSS-R can make in-service measurements at the MGTB combiner shelf, at the 500A protection switch on frequency diversity systems, and on the 501A switch on hot standby systems. Out-of-service measurements can also be made through the 500A protection switch.

In-Service Measurements

2.04 The TSS-R will perform in-service measurements on a scheduled routine basis at both the MGTB combiner shelves and the 500A (or 501A) switching equipment. These measurements allow the condition of the AR 6A system to be periodically monitored and serve as an aid in detecting trends in the degradation of system performance. In-service measurement capabilities provided by TSS-R are:

- Pilot levels and frequency at the MGTB
- Pilot and resupply pilot level as well as their frequency at the 500A
- Intermastergroup noise
- Weighted phase jitter on pilots at the 500A
- Normal (nonweighted) phase jitter on pilots at the MGTB receiving combiner
- Level measurements in a specified bandwidth at requested frequencies.

Out-of-Service Measurements

2.05 TSS-R will provide for out-of-service measurements at the 500A TSS-R monitor ports. Out-of-service measurements provide for characterization of radio transmission performance to a greater degree than the normal on-going in-service measurements. Out-of-service measurements are performed as a result of out-of-limit conditions detected by routine in-service measurements or as a result of trouble reports from other sources. The out-of-service measurement capabilities provided by TSS-R are:

- Pilot resupply frequency and level measurements
- Gain versus frequency (with or without dynamic equalizers)
- Idle channel characterization (noise and spurious tone content)
- Spurious tone scan
- Linearity measurements
- Incidental modulation
- Frequency level measurement
- Interference and cross-polarization discrimination (XPD) measurements
- Space diversity switch operation
- TWT gain
- Phase jitter.

Trouble Isolation

2.06 The out-of-service tests outlined above can be made in conjunction with the stress test units in the AR 6A to implement trouble isolation procedures. This capability provides a tool in localizing troubles to a specific hop. The stress test units can be controlled by TSS-R either directly (at the 500A) or indirectly via SCOTS/TASC (at repeater stations).

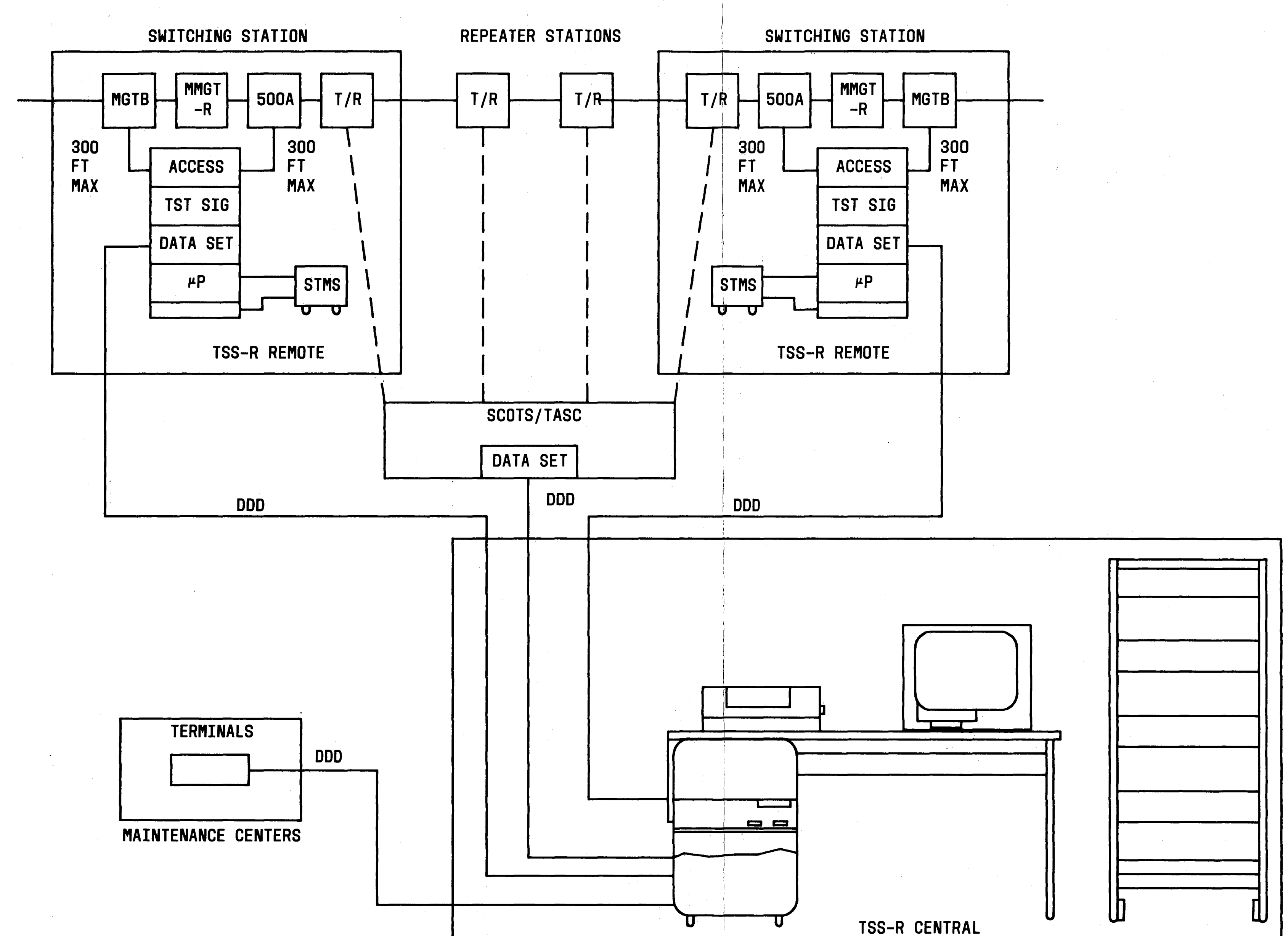

Fig. 1—TSS-R System

2.07 The stress test unit is interposed between the pilot resupply and linearity test oscillators and the resupply injection point. It has five states which control the level of signals passing through it. They are:

- Normal state (all pilots -10 dBm0)
- Pilots attenuated by 33 dB
- Pilot attenuated by 39 dB
- Two high-level linearity test tones (+17 dBm0) with four +10-dBm0 pilots
- Two high-level linearity test tones (+17 dBm0) with four 0-dBm0 pilots.

2.08 Since stress test units and pilot resupply units are present at all repeater stations as well as at the 500A transmit switch, they can be used to isolate a measurement result to a specific number of hops before the receive 500A switch. For instance, on an out-of-service channel, the resupply switch at a repeater station can be operated by TSS-R via SCOTS/TASC. Thus, the signals measured by the TSS-R at the next 500A will not reflect any transmission effects from system components preceding the operated resupply switch. Any transmission anomalies measured must then be attributed to the succeeding system components. By operating the repeater resupply switches successively along a switch section, trouble isolation to a specific repeater is possible.

2.09 Use of the stress test unit permits the effect of some undesired transmission characteristics to be enhanced. For example, the linearity test tones along with 10-dB hotter-than-normal pilots could be supplied via the resupply switch at a specific repeater site. The AGC action at the succeeding receiver would lower all signals by 10 dB (including the linearity test tones) thus, the nonlinear effects of the chosen transmitter would dominate the measurement.

3. EQUIPMENT CONFIGURATION

3.01 The TSS-R central (Fig. 2) is based on a Hewlett-Packard System 1000 Model 40 Computer System. The TSS-R central includes a HP21MX-E computer, two HP7906 20 Mbyte disc drives, HP2645 system console, HP2631 printer and a 40A2 data mounting for modems and automatic call units (ACUs). The disc drives and data mounting are mounted in a cabinet. The computer is mounted in a desk-type enclosure on which the system console and printer sit.

TSS-R CENTRAL

3.02 The HP21MX-E computer has 128K words of fault correcting/detecting memory. All the peripherals, including the modems and ACUs are interfaced to the computer with Hewlett-Packard printed circuit boards. Three 212A modems with associated ACUs, which are installed in the 40A2 data mounting, are used by the TSS-R central to connect to the TSS-R remotes or to the SCOTS/TASC computer via DDD. A fourth 212A and ACU (also in the 40A2) is used as a dial-in port for remote TTYs or as a dial-out port for transmitting exception reports on measurements to TTYs in maintenance centers. An optional fifth 212A data set and ACU can be provided for connecting to TSS-R remotes or SCOTS/TASC.

3.03 The TSS-R central is connected to TSS-R remotes through data sets and the DDD network, which is accessible at all switching stations where the AR 6A system is installed. The data sets are obtained locally. At least two 212A data sets with automatic dial units are required at the TSS-R central for communication with the remotes, because the remotes at both ends of a switch section must be simultaneously active to perform certain measurements.

3.04 The TSS-R system uses SCOTS/TASC only for simple commands and statuses to and from AR 6A T/R bays and stress test units in the support bay. No other data are transmitted via SCOTS/TASC to the TSS-R central and no requests for protection switching are passed from the TSS-R central to SCOTS/TASC. Communication with the SCOTS/TASC central requires a third data set at the TSS-R central and also one at the SCOTS/TASC central. No hardware or software modification of the SCOTS/TASC central other than provision of a partial access port is required.

TSS-R REMOTE

3.05 A TSS-R remote (Fig. 1) located at a switching station consists of a TSS-R distribution bay (Fig. 3) and a selective transmission measuring set (STMS) and coaxial and control wiring to the various

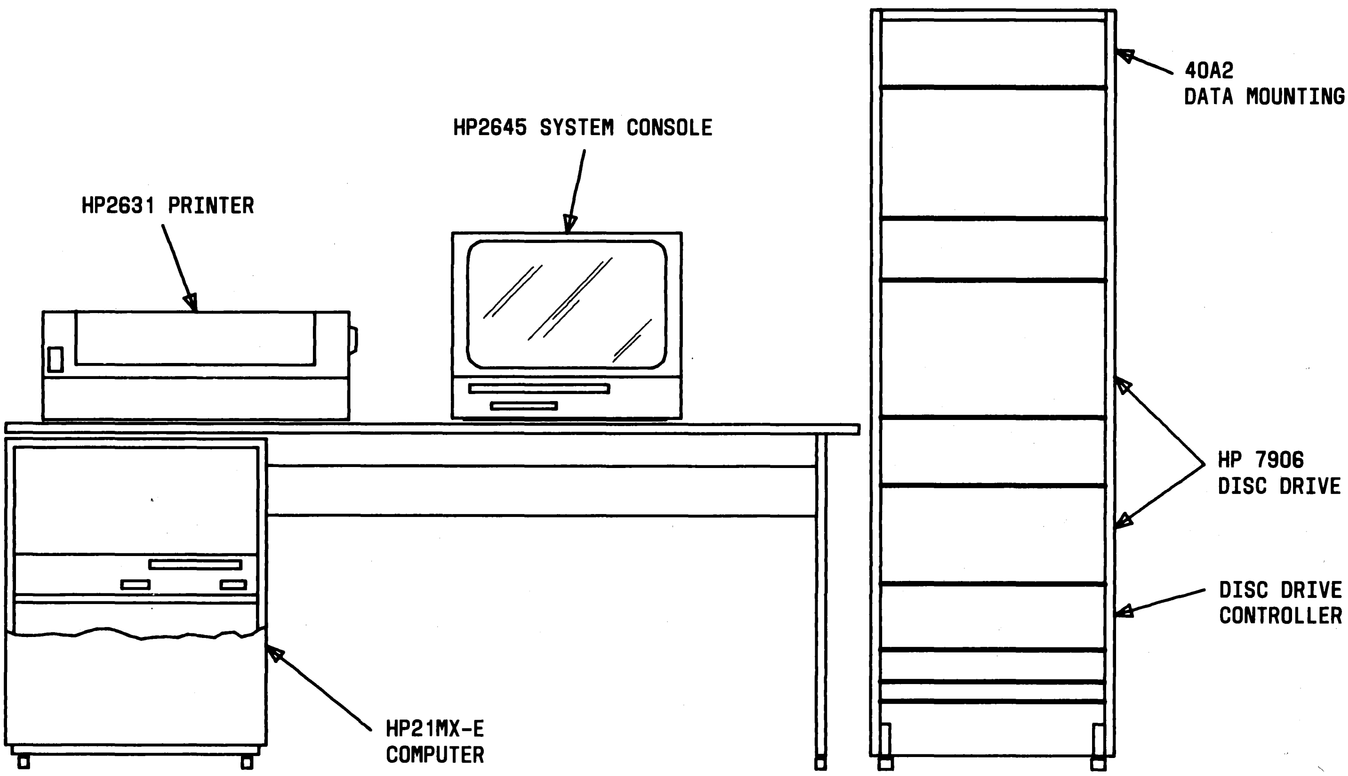

Fig. 2—TSS-R Central

AR 6A equipments which are to be monitored by the TSS-R System (Fig. 4).

A. Distribution Bay

3.06 The TSS-R distribution bay consists of an access switch network, a set of code cards to communicate via relay closures with the various MGTB (mastergroup translator B) and 500A bays, a test signal generator (TSG), and microprocessor circuitry to control the access switch network, the control cards, communication with the central, relays and switches and the STMS. Space is provided for a 212A data set that transfers data and commands between the TSS-R central and the microprocessor. A disconnect slide mount is provided in the bay for the STMS. One fully equipped TSS-R distribution bay can access and communicate with all the MGTB and 500A equipment for up to five AR 6A routes entering a switching station. The circuitry, access switch network, and bay are designed to allow possible future expansion for measurements on other systems.

B. STMS

3.07 The STMS (Fig. 4) is a W&G SPM 16AR selective level meter that is programmable by means of the IEEE 488-1975 interface bus. The STMS is also manually operable and can be

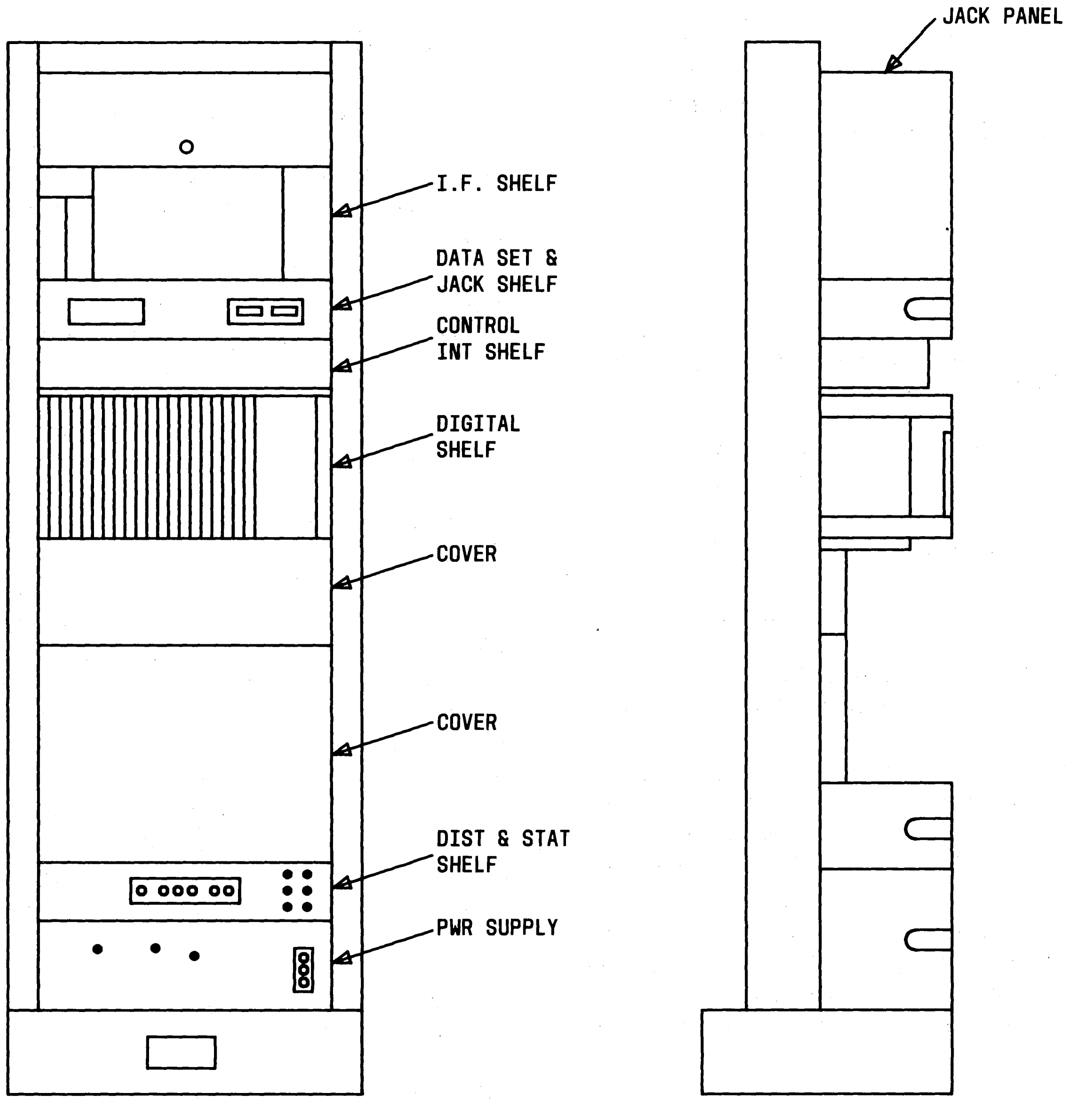

Fig. 3—TSS-R Distribution Bay

placed temporarily on a rolling cart if needed temporarily for other measurements in the same office. The STMS is designed to meet the technical specifications listed in Table A. Because the standard interface bus is specified, purchase of units satisfying the IEEE 488-1975 specification from other commerical vendors would require no hardware change in the TSS-R distribution bay. Changes in microprocessor firmware (read-only memory), however, would be required.

C. Access Switch Network

3.08 The high frequency access switch network is built up from programmable switch modules, each of which is one plug-in circuit pack on a printed wiring board (there are three types: 1×15, mode select, and preselect filter). These modules have the capability of providing excellent uniformity in insertion loss from one output to the next. High isolation is not needed in these switches because all signals to the TSS-R distribution bay pass through high isolation switches in the MGTB and 500A bays. Use of these new 1×15 switch modules result in considerable space and cost savings in the distribution bay.

D. Microprocessor Circuitry

3.09 The microprocessor circuitry controls the following:

- The communication between the TSS-R remote bay and the TSS-R central
- Access switching networks
- The STMS measurement programs
- The control interfaces between the TSS-R bay and the 500A and MGTB bays.

Communication between the central and remote is in the form of transceived data blocks embedded in TSS-R protocol messages. These data blocks are stored temporarily in the RAM section of the microprocessor circuits, and contain measurement or access switching parameters and measurement results. The protocol messages allow for the detection of transmission errors between the central and the remote and vice versa. No error correction is attempted.

3.10 The measurement, switching, control, and communication routines are stored in the ROM section of the microprocessor circuitry. Each of these routines will generate errors for many cases of hardware failure in the distribution bay. Some failure modes, such as a faulty access switch, are not detectable directly but may be detected implicitly by examination of the measurement results at the central.

Portable Terminal

3.11 A 300 or 1200 baud port is provided for access to the microprocessor using a local terminal for testing of the bay either at installation or as an aid in diagnosing bay failures. If the local terminal has a minitape cartridge facility, more elaborate test programs can be loaded directly into RAM.

4. TSS-R INTERFACES

A. MGTB High Frequency Interface

4.01 The switches provided in the MGTB combiner shelf (Fig. 5) are high frequency coaxed dry reed type relays. A sample of either the signal transmitted to an MMGT-R bay or the signal received from the MMGT-R can be connected to the cable returning to the TSS-R distribution bay. In addition, a calibration signal can be looped back to the bay. The maximum cable distance of the combiner shelf from the distribution bay is limited to 300 feet of 730A coaxial cable.

B. MGTB Control Interface

4.02 Each MGTB control card is designed to control up to 14 MGTB combiner shelves. When a measurement is made, one of three function leads is grounded simultaneously in all the MGTB combiner shelves corresponding to one AR 6A route. Since there are two 5 mastergroup MGTB combiners for each 10 mastergroup AR 6A channel, up to 14 MGTB combiner shelves may be dedicated to one route. Only one of the 14 address control leads is energized with 24 volts, so that the coaxial switch relay corresponding to the desired function is activated in only one combiner shelf at a time.

C. High Frequency Interface With the 500A Protection Switch

4.03 Figure 6 shows the high frequency between the TSS-R bay and the 500A equipment.

4.04 The receive signal to the TSS-R bay always passes through an in-service director. The 2×1 combining switch in the 500A transmitting shelf determines whether the transmitting or the receiving in-service director is accessed. The TSS-R test signal is either a spectrum of equally spaced tones 145 kHz apart that covers the IF band from 59 to 89 MHz or a single tone of 83168 kHz. The spectrum serves two functions.

4.05 First, the TSS-R test spectrum can be looped back to the TSS-R distribution bay to serve as an aid in calibrating the 500A access cable.

4.06 Secondly, the TSS-R test signal spectrum is used in out-of-service measurements of the AR 6A channel amplitude response. The level of this signal at the transmitting out-of-service on

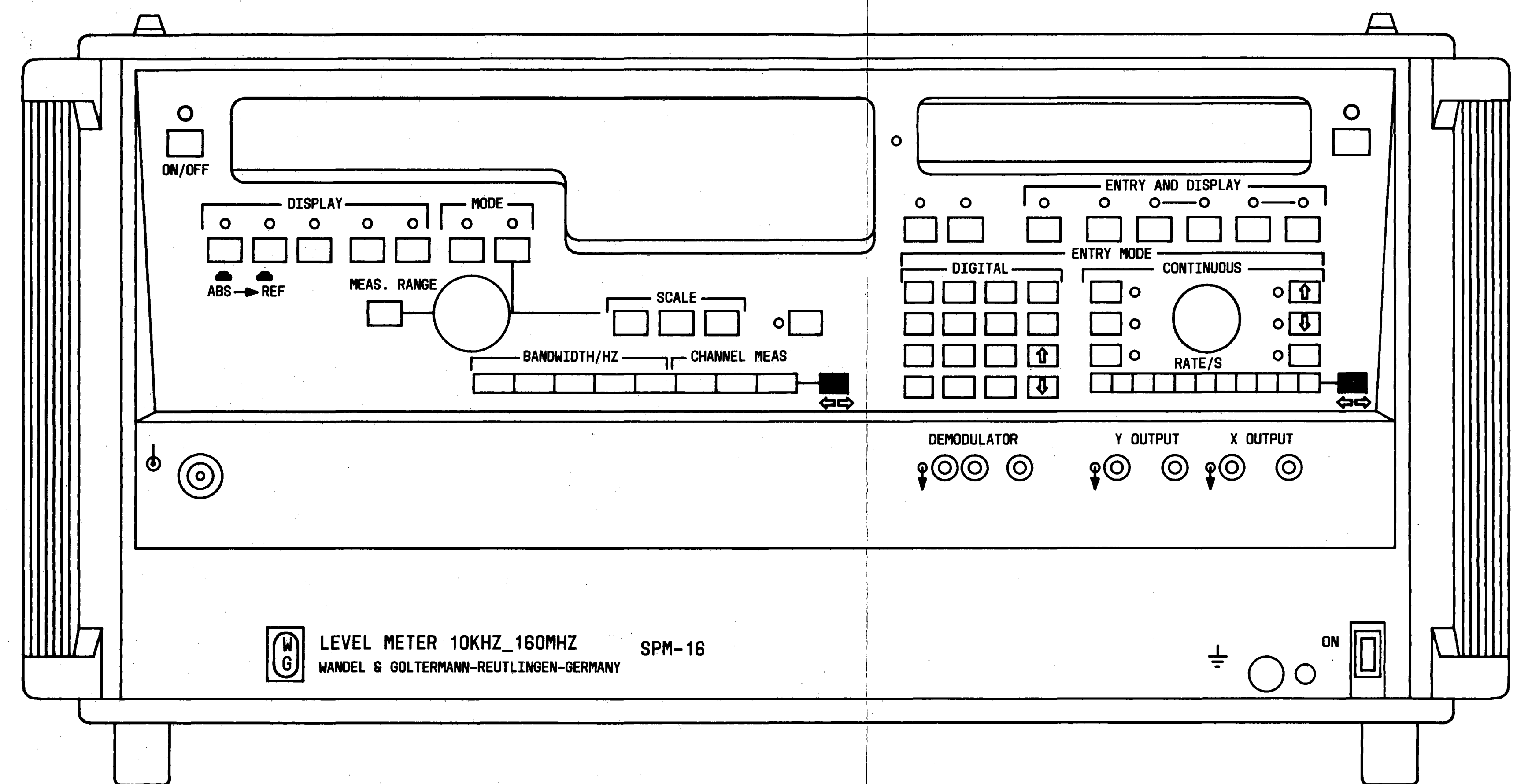

Fig. 4—Selective Transmission Measurement Set (STMS)

TABLE A

STMS TECHNICAL SPECIFICATIONS

FREQUENCY:	
Operating Range	50 kHz to 110 MHz
Settability	1 Hz
Error Limits	± 1×10^{-7}/Year
Adjustment Range	For 10 Years Aging
Auxillary Input/Output for Standard Frequency	10 MHz
SENSITIVITY:	
Measuring Range	—120 to +10 dBm
Autoranging	1 dB steps
Useful range at any Range Setting is at Least	±8 dB
Idle Noise of Receiver (1 Hz Bandwidth 0.3 to 110 MHz)	≤ —150 dBm
ACCURRACY OF DIGITAL READOUT:	**LEVEL *ERROR**
	0 To-60 dBm ±.2dB
	0 To-70 dBm ±.25dB
	0 To-100 dBm ±6dB
INPUT:	
Maximum Cont Input Power	+25 dBm
Return Loss	≥ 30 dB
Spurious Output	≤ —90 dBm
Input Coaxial	75 Ω
MEASUREMENT BANDWIDTH:	
Equivalent Noise Bandwidths	100, 1000, 1740, 3100 Hz
Sweep-Integration Mode	100 kHz

TABLE A (Contd)

STMS TECHNICAL SPECIFICATIONS

SHORT AVERAGING MEASUREMENT SPEED RESPONSE TIME:	
3100 OR 1740 Hz	20 ms
1000 Hz	20 ms
100 Hz	90 ms
100,000 Hz	350 ms
DISTORTION:	
NPR, Without Preselecton 30 MHz BW	≥ 45 dB
Signal Suppression/Selectivity for Sideband Measurements	≥ 65 dB
At Bandwidth 100 Hz	Minimum 600 Hz from signal
At Bandwidth 1000 Hz	Minimum 15 kHz from signal
At Bandwidth 1740 OR 3100 Hz	Minimum 50 kHz from signal
ENVIRONMENT:	
Ambient Temperature (with Stated Accuracy)	40 F to 100 F
Relative Humidity	≤ 75%
Maximum Operating Temp	120 F

*Added error when using short averaging is ±.4dB

one end of the switch section is monitored nearly simultaneously with the signal at the receiving in-service director on the other end of the switch section. The TSS-R central computes the difference in levels to obtain the amplitude response of the channel under test.

D. Control and Status Interface With the 500A Protection Switch

4.07 Table B shows the control and verification lines between the TSS-R and 500A bays. Communication between the TSS-R and 500A bays is via ground closures on leads terminating on relays in both bays.

E. Interface With Stress Test Units in the 500A Bay

4.08 Five leads from the TSS-R bay control the state of the stress test units used to simulate fades, and check linearity on out-of-service measurements. Ground closures on all other command leads from the TSS-R bay to the 500A must be maintained as long as the commanded state is desired. In contrast, the stress test control circuit has latching circuitry to accept momentary closures such as are provided through C_1 and E_2

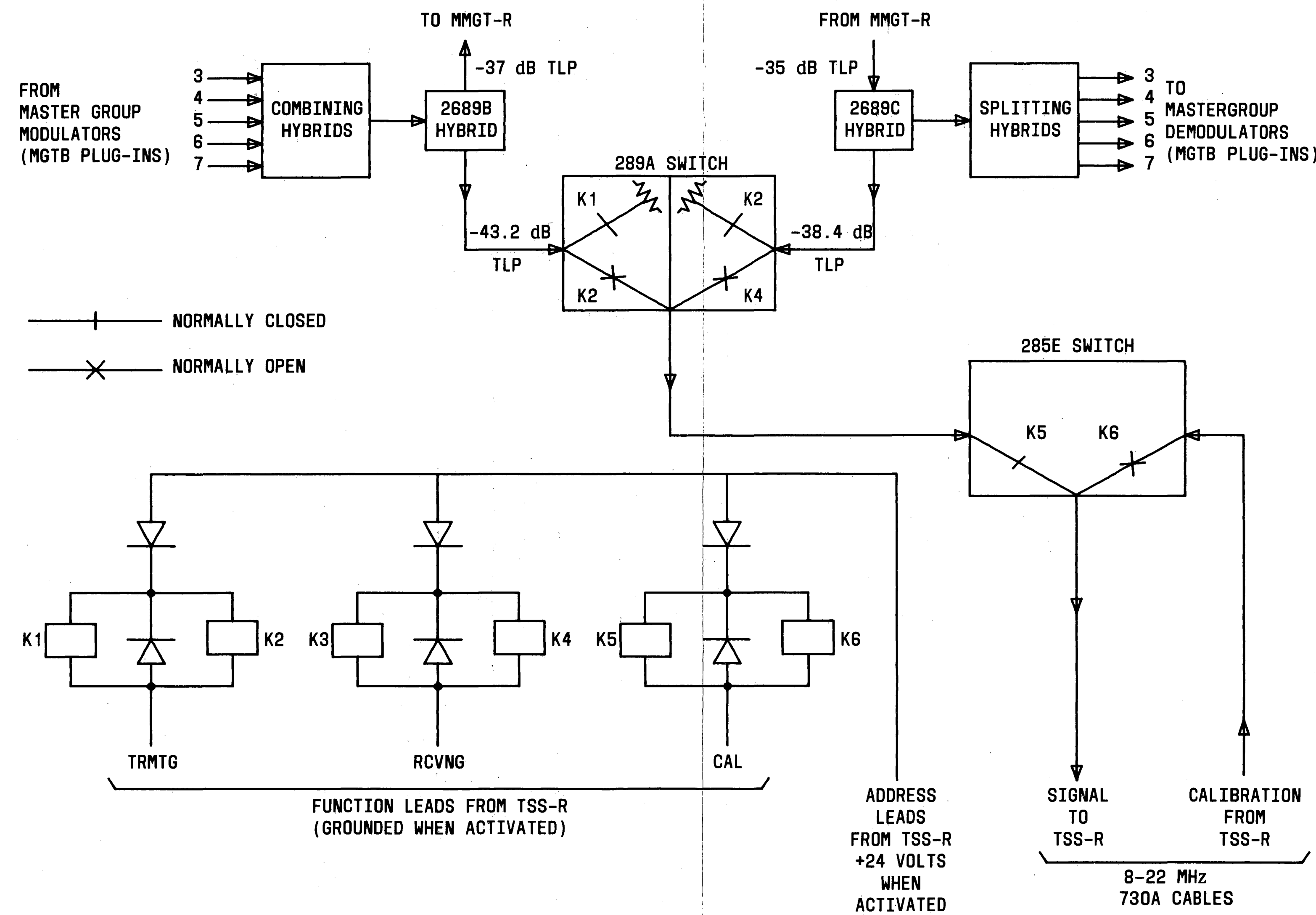

Fig. 5—Access Switch Circuitry in MGTB Combiner Shelf

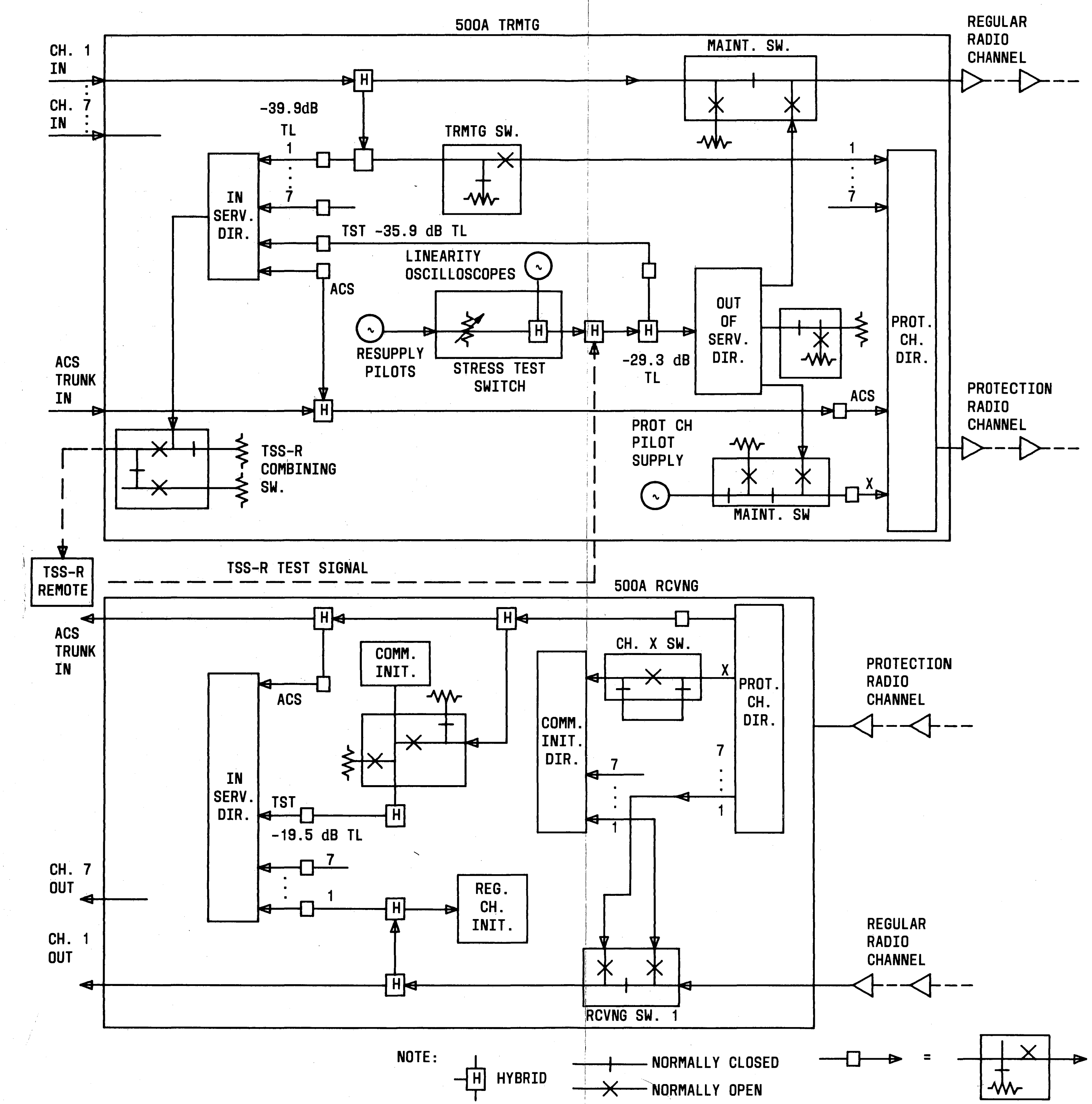

Fig. 6—Interface Between TSS-R Remote Bay and 500A Protection Switching Bay

TABLE B

CONTROL AND VERIFICATION LEADS BETWEEN TSS-R DISTRIBUTION BAY AND 500A PROTECTION SWITCHING BAY

	NO. OF CONTROL LEADS	NO. OF VERIFICATION LEADS
Transmitting 500A		
1. 433A Switches at In-Service Director: (a) 7 Working Channels and 1 Access Channel	8	1
(b) TSS-R TST Channel	1	1
2. 433C TSS-R Combining Switch	1	1
3. Stress Test Control Circuit	5	1
Receiving 500A		
1. 433A Switches at In-Service Director: (a) 7 Working Channels and 1 Access Channel	8	1
(b) TSS-R TST Channel	1	1
2. 500A Microprocessor: (a) Protection Channel Unavailable	—	1
(b) Maintenance Switch Request	1	1
(c) Binary Code of Desired Maintenance Switch (000= Protection, 001 to 111= Working Channels)	3	—
(d) Maintenance Switch Operated		1
(e) Binary Code of Channel Connected through Protection Channel Direction	—	4
TOTAL (Transmitting and Receiving)	28	13

telemetry at remote repeater stations. There are four leads which establish one of the four ***active*** states in the stress test control circuit. They are:

- Pilots attenuated by 33 dB
- Pilots attenuated by 39 dB
- Two high-level linearity test tones (+17 dBm0) with four -10 dBm0 pilots
- Two high-level linearity test tones (+17 dBm0) with four 0 -dBm0 pilots.

The fifth lead returns the stress test control circuit to its ***inactive*** state. That is:

- Normal state (all pilots -10 dBm0)

F. Interface With the SCOTS Central

4.09 Table C lists the required command and status communication between the TSS-R System and AR 6A radio bays that is accomplished via SCOTS/TASC, Section A of Table C shows that portion of the SCOTS/TASC interface at repeater stations that the TSS-R is able to control from the central. Section B of Table C shows that portion of the SCOTS interface at switching stations that TSS-R is able to control from the central. Note that the stress test control functions are not included in section B since the TSS-R distribution bay can control the stress test unit directly at a switching station via its 500A interface (Table B).

G. Interface with Hot Standby Equipment

4.10 On lightly loaded AR 6A routes a hot standby rather than a frequency diversity arrangement may be used. For hot standby routes, 501A hot standby protection switching equipment is installed where the 500A Protection Switching System would normally be placed.

4.11 TSS-R will monitor the condition of the hot standby AR 6A system by making in-service measurements on the IF spectrum. The TSS-R distribution bay is located at stations having the 501A hot standby protection switching equipment. The TSS-R distribution bays are installed initially with 500A control and status cards which serve as the interface between TSS-R and the 501A. Future conversion to 500A frequency diversity will require no hardware changes in the TSS-R distribution bay. The high frequency interface and the control and status interface between TSS-R and the 501A is shown in Fig. 7.

5. PHYSICAL FEATURES

A. TSS-R Central

5.01 The TSS-R central computer (Fig. 1) includes a desk, cabinet, and an equipment rack. The computer is 94 inches wide by 31-1/2 inches deep. A minimum of 21 inches is required in front and back of the computer for serviceability. Additional room should be allocated for the storage of backup discs and computer output. The central computer requires a 30-amp 110-volt ac essential electrical service with isolated ground that is stable and noise-free. It can operate in an environment ranging from 10 degrees centigrade to 40 degrees centigrade and relative humidity of 20 to 80 percent provided there is no condensation. The power requirements and heat loads are given in Tables D and E, respectively. While the computer can operate over a rather wide temperature range, it is recommended for the best system reliability that the ambient temperature of the computer area be maintained at 18 to 26 degrees centigrade. The TSS-R central dissipates heat at the rate of 2600 watts. This heat load must be considered when choosing the computer location.

B. Distribution Bay

5.02 The distribution bay uses a 7-foot, 9-foot 10-foot 6-inch, or 11-foot 6-inch unequal flange duct-type bay framework. The bays are 25-15/16 inches wide by 15 inches deep. Rear access is required to the bay for installation.

5.03 The distribution bay is shown in Fig. 3. The top shelf contains IF switches and jack panel. The jack panel is at the top of the bay and is mounted horizontally so the coaxial measurement cables plug into the bay vertically. The jack panel has capacity for 75 transmit and 75 receive coaxial measurement cables.

5.04 The recommended location for the distribution bay is in the 500A protection switch bay lineup.

5.05 The second shelf is the data set shelf and the shelf immediately below that is the control/status lead interface shelf. The digital shelf

TABLE C

CONTROL AND VERIFICATION BETWEEN TSS-R SYSTEM AND AR 6A RADIO BAYS

	CONTROL	VERIFICATION
A: In Remote Repeater Stations (per route)		
1. Stress Test Control Circuit (west)	5	1
2. Stress Test Control Circuit (east)	5	1
3. Operate Resupply Switch (RS)	1	1
4. Space Diversity Switch (SDS) Operated	—	1
5. TWT Gain Normal	—	1
6. Set AGC to Nominal Gain	1	1
7. Set Shape Equalizer to Flat*	1	1
8. TR Bay Addresses	16	—
9. Bay Address Reset	1	—
TOTAL	30	7
B: In Switching Stations (per direction)		
1. Space Diversity Switch Operated	—	1
2. Test TWT Gain	1	—
3. TWT Gain Normal	—	1
4. Set AGC to Nominal Gain	1	1
5. Set Shape Equalizer to Flat	1	1
6. TR Bay Addresses	8	—
7. Bay Address Reset	1	—
TOTAL	12	4

* Only rarely will the shape equalizer be located at remote repeater stations.

houses the microprocessor and interface cards for the 500A and MGTB combiner shelves.

5.06 Power requirements and heat load for the distribution bay are given in Tables D and E. The distribution bay is designed to operate in the normal environment of a radio protection switching station.

6. REFERENCES

6.01 Additional information is provided by the following reference material.

Bell System Practices

SECTION	TITLE
422-100-100	TSS-R System Description
422-100-101	TSS-R Administrative Practices
422-100-102	Users Guide
422-100-103	Operation/Maintenance Guide for Measurement System
422-100-104	Operation/Maintenance Guide for Operations Program
422-100-105	Distribution Bay Operations/ Maintenance
804-911-165	TSS-R Equipment Design Requirements

Other

NUMBER	TITLE
CD-5G183-01	Transmission Surveillance Systems—Radio
SD-5G183-01	Transmission Surveillance Systems—Radio