TD-2 RADIO SYSTEM

CONTENTS

1. GENERAL

1.01 The TD-2 Radio System is a microwave radio relay system designed for handling television, multichannel telephony, telegraphy or other wide band communication signals. The transmission band width of each repeater at the radiated frequencies is 20 mc, with an effective channel band width of the order of 8 mc. The system is designed for a maximum of six channels in each of two directions with the possibility of spurs utilizing frequencies between the regular channel assignments. In the latter case, care must be taken in the location of the antennas to prevent interference. One transmitting antenna and one receiving antenna are required for each direction of transmission. The general relationship between the radio equipments is shown in Fig. 1.

1.02 The radio equipment operates in the common-carrier band 3700 to 4200 mc. At these frequencies, transmission is limited essentially to line-of-sight distances, that is, up to a maximum of 35-40 miles. Repeater spacings average 25 to 30 miles depending upon terrain, transmission considerations including fading and over-all system economies.

1.03 Stations are usually located at elevated sites. The basic repeater station building is a square-base concrete structure about 60 feet in height. The first three floors house the power equip-

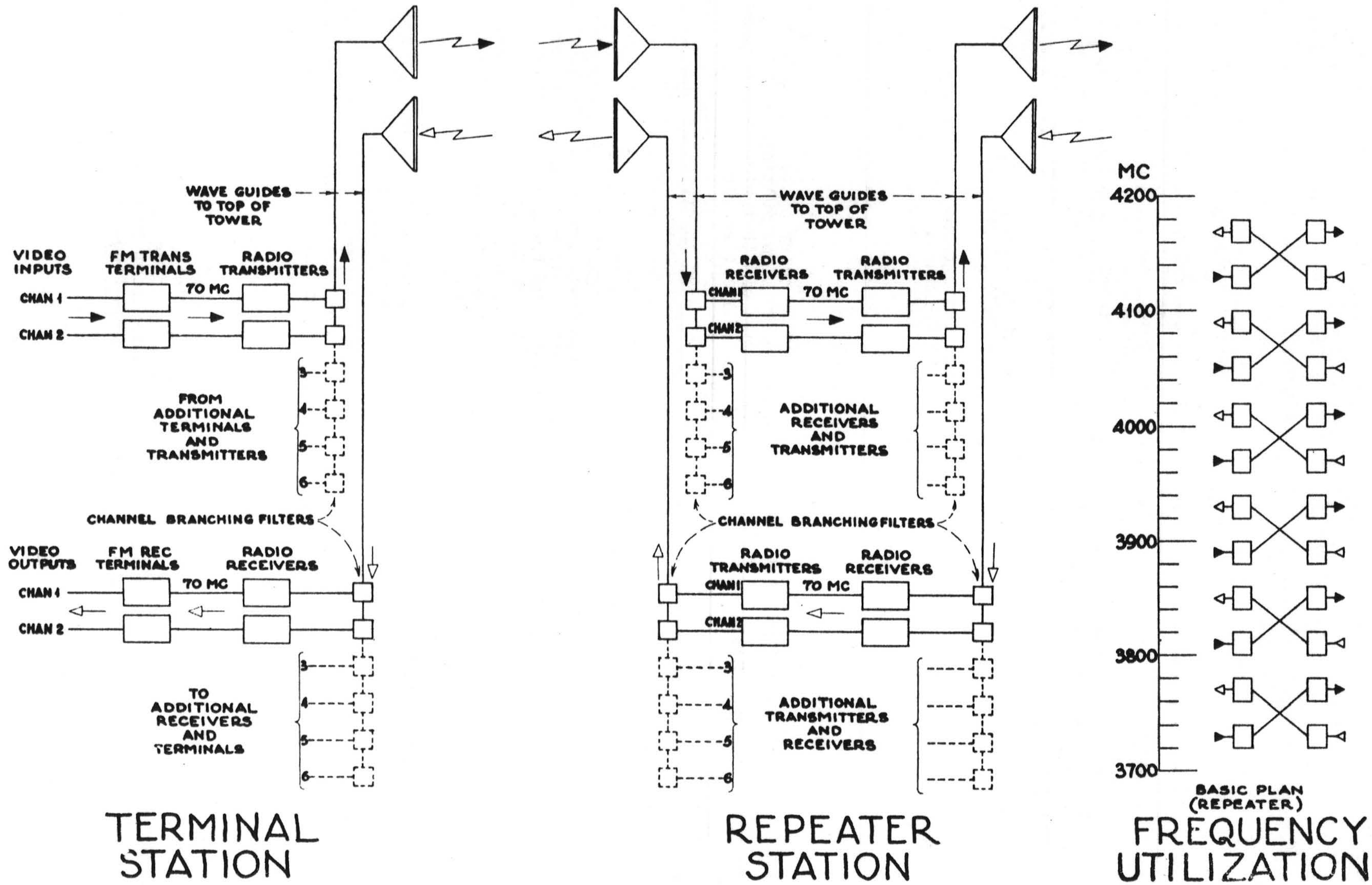


Fig. 1 - Block Diagram Showing Relationship Between Terminal and Repeater Radio Stations of TD-2 Radio System

ment. The radio equipment is installed on the fourth floor and the antennas on the roof.

Other building versions provide for heights up to 190 feet where the additional antenna height is required.

1.04 There are three general types of radio stations involved in a TD-2 system, viz: terminal stations, main repeater stations and auxiliary repeater stations. At a terminal station are found the FM terminal equipment, the radio equipment and the IF switching equipment. This type of station will be either fully or partially attended. At a main station, in addition to the radio equipment, IF switching equipment is provided to enable channels to be switched from regular to spare for maintenance purposes, for dropping or picking up programs, or for other traffic purposes. The spacing of main stations along the radio relay route will depend upon traffic, maintenance or other considerations but on an average will occur every fifth or sixth station. Initially, main repeater stations will be either fully or partially attended. Auxiliary repeater stations constitute the intermediate repeaters. These will normally be unattended.

1.05 Alarms and order circuits are provided over wire facilities. As many as 42 alarm indications may be transmitted from each station to its associated alarm center and a maximum of ten orders may be transmitted to each repeater station. A local order circuit serves to connect a group of unattended auxiliary stations with their associated main or terminal station and with their associated alarm and maintenance centers. An express order circuit terminates at the terminal stations and has appearances at all main repeater stations and at all alarm and maintenance centers.

2. SERVICE REQUIREMENTS

(A) Transmission

2.01 Number of Channels - The maximum number of channels which can be operated over a given route is a function of the frequency space available and the selectivity requirements of the radio equipment. The particular band for which the TD-2 radio equipment is designed, extends from 3700 mc to 4200 mc. With channel separations of 40 mc, 12 channels are therefore available. With reference to Fig. 1, these are assigned in pairs of one transmitting and one receiving frequency 40 mc apart. The same frequencies are used at succeeding stations but the specific functions alternate. The maximum number of standard channels along a given route is therefore 12, as follows: 3730, 3770, 3810, 3850, 3890, 3930, 3970, 4010, 4050, 4090, 4130, and 4170 mc. However, with proper antenna orientation, limited use may be made of frequencies midway between the above for bridging spurs. The staggered frequencies are 3710, 3750, 3790, 3830, 3870, 3910, 3950, 3990, 4030, 4070, 4110 and 4150 mc. The application of the standard frequencies to alternate stations is shown in Fig. 2.

2.02 Radio Transmission:-

(a) Characteristics of radio transmission at frequencies of the order of 4,000 mc make it desirable to provide a free optical path. Free-space path loss for a 40 mile path is about 140 db, (isotropic antennas). Since signal field strength varies inversely with distance, the corresponding figure for 20 miles is 134 db. However, the encroachment of the earth's terrain may affect the resultant signal materially.

(b) Take the case of an intervening ridge. Referring to the theoretical "knife-edge" curve of Fig. 3 in which reflection plays no part, it is seen that for a path which just grazes the top of the ridge, the signal field will be 6 db below the free-space field. Maximum field (1 db above free-space field) is not obtained until there is a clearance approximately equivalent to the first Fresnel zone. A difference in path length of 1/2 wavelength obtains between the direct transmission and transmission along the boundary of such a zone. This clearance can be computed by the equation:

$$c = 131.5 \sqrt{\lambda\, ab/(a+b)} \text{ feet}$$

where a and b are the distances from the ends of the path to the obstruction in miles and the wavelength is in meters. For 4,000 mc, this equation reduces to:

$$c = 36 \sqrt{ab/(a+b)} \quad \text{feet}$$

Little change in field strength results from greater than first zone clearances. However, one cannot rely on straight-line radio transmission. Due to refraction in the earth's atmosphere, the path is more than likely to curve convex upward in which case the clearance is increased. As noted above, this effect on the received signal is small. However, the path may also curve concave upward and unless the clearance is adequate, the signal will decrease.

(c) In the case of flat terrain, the "obstruction" is due to the bulge caused by the earth's curvature. In this case the reflected component may seriously affect the resultant signal. Again referring to Fig. 3, the signal field over a path which just grazes the

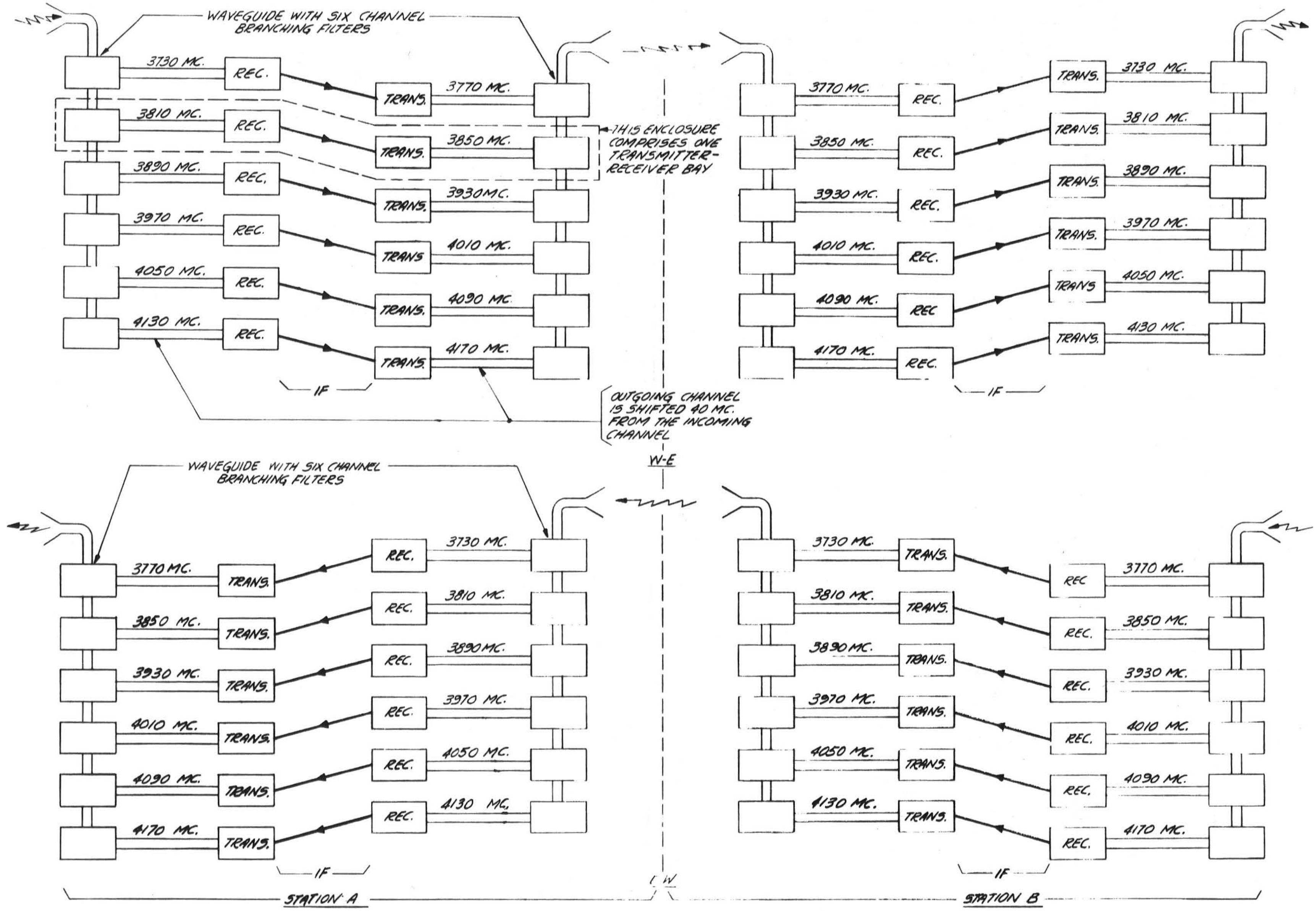


Fig. 2 - Frequency Allocations at Adjacent Repeater Stations

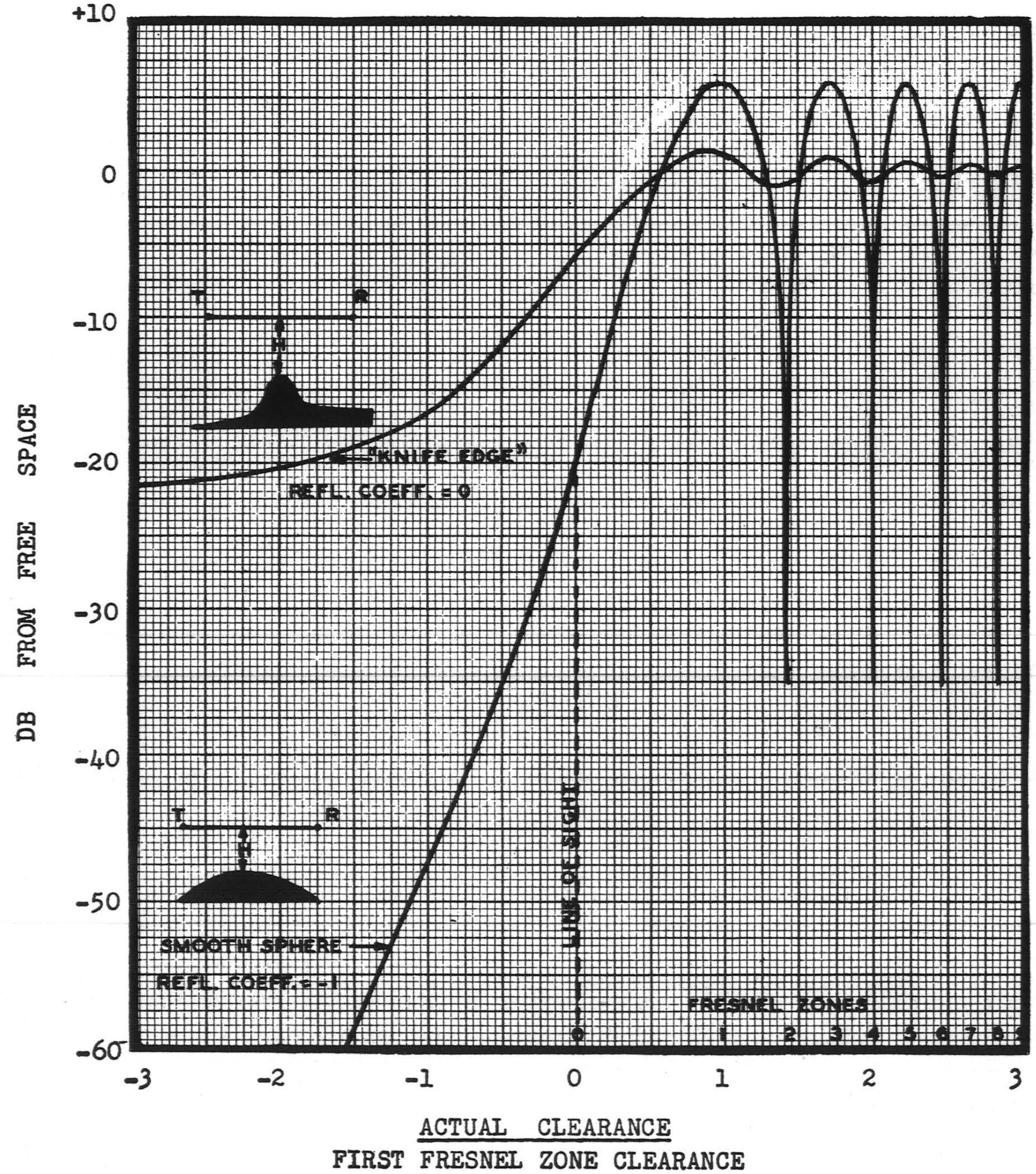


Fig. 3 - Effect of Clearance on Radio Transmission

earth's surface is 20 db below the free-space field. Clearance of the first Fresnel zone results in a signal field approximately 6 db higher than the free-space field. This is because the reflected wave undergoes a 180-degree phase shift on reflection and travels 1/2 wavelength farther so that it is in phase with the direct wave. With somewhat greater clearance, the path length of the reflected wave will increase and at some point the two waves will be in phase-opposition. Were transmission stable, it should be possible to select antenna heights so as to work always on the peak of the characteristic. But the effects of atmospheric refraction varies the effective clearance and results in fading. The higher the reflection coefficient, the more serious this is. The widest maximum is in the case of first-zone clearance.

Present indications are that statistically the effect of refraction is such that the earth radius should be treated as about 4/3 the actual radius. Greatest stability will, therefore, most likely be obtained by employing antenna heights which will just provide first-zone clearance on a 4/3 earth's radius basis.

(d) Fading is generally greater at night than during the day, greater under quiet conditions than during periods of wind, greater during summer than in winter, greater during rainy seasons than in dry, and greater over smooth terrain or water paths than over rough ground.

(e) The radio equipment will accommodate signal fields with a free-space path loss of 140 db and an additional allowance of 20 db for fading.

2.03 Noise - A substantial part of the noise power that will be present in the video output at the terminals of the TD-2 system will be of the fluctuation type. This noise originates in the receiving converters of the various repeaters in the over-all system since these are the points of lowest carrier level. The magnitude of video noise at a given level point at the terminal depends on: (1) the carrier power output at each repeater; (2) the net path loss between the transmitter output tube and receiving converter; (3) the inherent noise in the receiving converter; (4) the number of repeater sections in tandem, and (5) the peak frequency deviation of the FM carrier. The noise power per cycle of bandwidth in the converter is substantially flat over the useful band. Due to the use of frequency modulation, however, the resulting video noise power per cycle normally increases 6 db as the video frequency is doubled, resulting in what is called a triangular noise spectrum. Physically this means that the noise per cycle at some frequency, such as at 1 mc, is 6 db greater than the noise power per cycle at one-half this frequency or 500 kc. Of the various factors affecting noise, the net path loss is the only one subject to large changes with time. For a large portion of the time the path loss will not differ much from its free space value, but during fading conditions the loss in a repeater section may, on rare occasions, increase by 40 db or more for a matter of a few seconds. The video noise contribution from that section will increase correspondingly, db for db, up to the point where the ratio of carrier to noise at the FM terminal limiter becomes less than about 10 db, beyond which point the video noise increases rapidly in amplitude and the system is seriously degraded. In a 30-mile repeater section this point is reached with a 40 db fade, which should occur less than .01 per cent of the time. When the TD-2 system is used for 480-channel telephony, it is expected that the average noise power during fading should be substantially equal to the average noise on a high-grade toll circuit of the same length. When used for television transmission, the noise impairment during fading conditions should be slight.

2.04 Modulation:

(a) The TD-2 system utilizes frequency modulation for carrier transmission. It is the property of frequency modulation that it is sensitive to envelope delay distortion and relatively insensitive to compression in repeaters. The effect is cross-modulation between message channels when the TD-2 system is used to transmit multichannel telephony. Such delay distortion occurs in this system as in all others as a result of the cut-off characteristics of the various filters involved. The addition of phase equalizers is expected to reduce the cross-modulation from this source to a value normally expected on any toll circuit of the same length.

(b) The reflections due to the small impedance mismatches at the ends of each antenna waveguide run result effectively in envelope delay distortion which in turn produces cross-modulation. It is not practical to equalize this envelope delay distortion because of the large number of sources present in a long system. Although for any one waveguide run, the echoes are down about 55 db, nevertheless for long routes with many waveguide runs, considerable cross-modulation may result. The results are more serious the greater the echo delay. These are reduced to a permissible value by adequately reducing the impedance mismatches involved and by keeping the waveguide runs as short as possible.

(c) Although the mechanism of fading is not entirely understood it seems probable that most fading is due to cancellation between signals arriving at an antenna over different paths. This also produces cross-modulation but the duration of such intervals may be expected to be short.

2.05 Interference

(a) Interference between channels of the TD-2 microwave system results from unwanted coupling between antennas. Fig. 4 shows the various types of interferences of significant magnitude that occur. In order to avoid confusion. this illustration involves one 2-way backbone system and a converging or

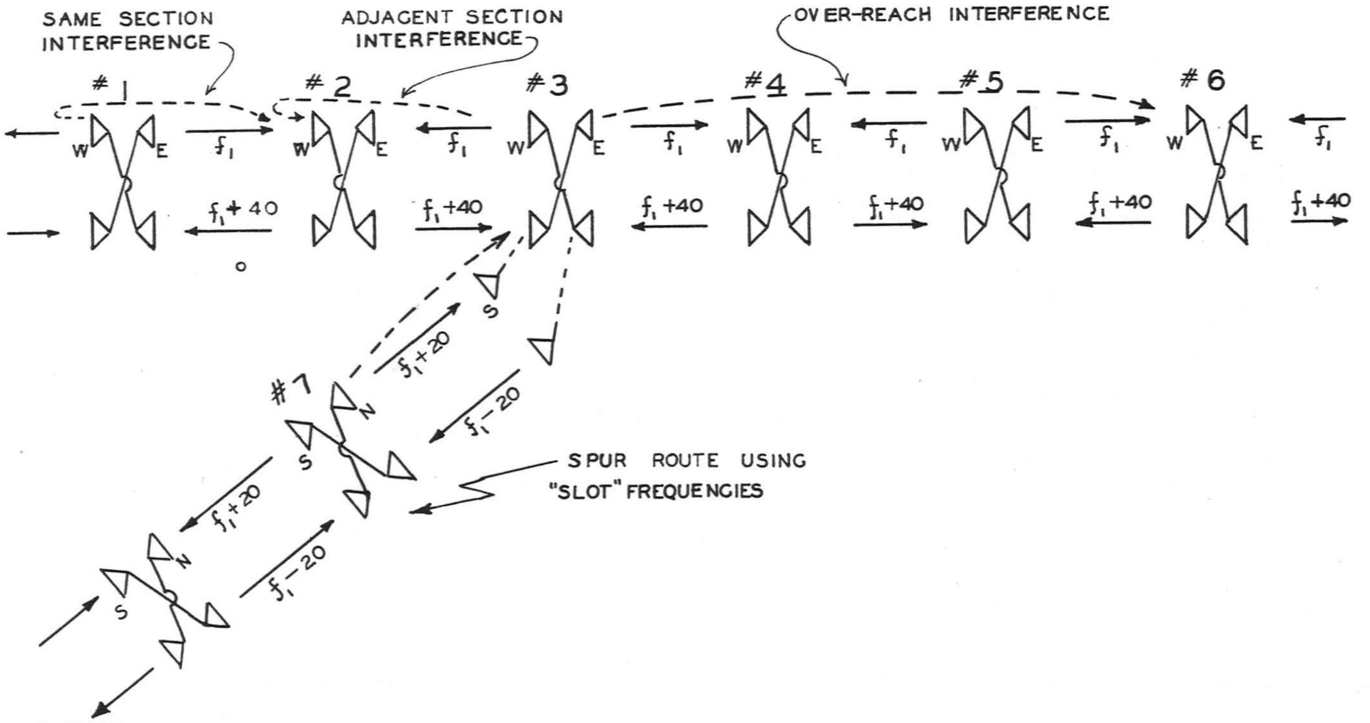


Fig. 4 - Interchannel Interference

spur route. The various crosstalk paths may be classified as follows for convenience in discussion:

(1) Over-reach Interference - As shown on Fig. 4, this involves like-frequency transmission between repeaters which are three, five, etc., sections apart. A typical case is repeater 3E (transmitting) cross-talking into repeater 6W, and it will be noted that the interference is intra-system. Another typical possibility, involving five section over-reach is repeater 1E crosstalking into repeater 6W.

(2) Adjacent-Section Interference - A typical case of this type is antenna 3W transmitting into antenna 2W, where the desired path is 1E into 2W.

(3) Same-section Interference - A typical example of this type involves energy from antenna 1W being received in antenna 2W together with the desired signal from 1E.

(4) Spur Interference - This involves interference from antenna 7N of the spur into various antennas of the backbone route of which the interference into antenna 3W is the most serious for the case shown on Fig. 4.

(b) The magnitude of these interferences depends on the directional pattern of the antenna which is made sufficiently great in the reverse direction as to insure that the interference is normally not excessive. The effect of these interferences on the recovered video signal depends on the ratio of the magnitude of the interfering carrier to that of the desired carrier in each case. Both of these signals are subject to independent fading. Therefore the video interference may reach a high value momentarily during a deep fade. This is expected to happen, however, only a very small percentage of the time. In considering the allocation of a total permissible rms noise from all sources of 29 dba at the -9 db transmission level, it has seemed reasonable to assign 13 dba per 1000 miles for crosstalk of which 8 dba will be as the contribution from the spurs to the backbone route total and 11 dba to the backbone route itself. On the basis of 40 repeaters per 1000 miles and spurs at 250 mile intervals, this amounts to -5 dba per repeater at the -9 db transmission level, and +2 dba at the -9 db transmission level for each spur.

(B) Switching

2.06 Two types of IF switching are necessary: for establishing or rearranging a television network and for replacing one channel or equipment unit with another for maintenance either routine or emergency. Switching without service reaction is the objective for maintenance switches made for releasing working channels from service. The requirements established for multichannel systems state that such a switch in its effect on the individual working channels, should limit phase changes to a maximum of 30 degrees and level changes to a maximum of ±3 db unless the reaction on service is less than 3 milliseconds duration, in which case the reaction on service may be considerably greater than 3 db. The requirement for emergency switches is less severe, the phase limits being 60 degrees and the level limits ±5 db in 10 milliseconds. It should be noted that the signals at IF switching points are frequency modulated and the limits outlined above are not directly applicable. FM performance may reduce the magnitude of the amplitude changes materially. Generally speaking, however, the switching interval will have to be extremely short to avoid loss of picture framing in television receivers.

2.07 Because of the hazards to service introduced by inserting IF switching equipment in the through circuit, bridging taps should be resorted to whenever possible. This is generally feasible at points where it is not necessary to pick up a program and where switching is not necessary for maintenance purposes. Switching of the bridging circuit from one program circuit to another will need to be done by remote control as this type of station will normally be unattended. At stations which require program pick-up from a connecting radio circuit or at which switching arrangements are required for routine or emergency switching sections in and out for maintenance, switching equipment should be provided in the main program circuit. Such stations are called "main repeater stations" and are normally attended. Similar facilities are also provided at "terminal stations" where, of course, video switching facilities are also provided.

2.08 The minimum limit of permissible crosstalk for 1000-mile circuits is 54 db. This imposes a rather severe requirement on the switching amplifiers. There is, however, an uncertainty regarding the interference effects between two FM signals having low deviation ratios.

(C) Requirements for Connecting Services

2.09 Television service requirements are as follows:

(a) Signal received from the television switching center

Signal Amplitude	0.25 volt peak-to-peak
Transmission Line Impedance	110 ohms - balanced

Note - FM transmitter impedance is 75 ohms unbalanced. Matching transformer is supplied in the monitoring bay.

Sync. Pulse	Negative

(b) Signal delivered to the television switching center

Signal Amplitude	2 volts peak-to-peak
Impedance	110 ohms balanced

2.10 L-Carrier telephone requirements are as follows:

(a) Signal received from telephone equipment

Signal Transmission Level	-34.5 db

Note - This is 15.5 db higher than the transmission level at the output of the L terminal. Additional amplification is therefore required in the telephone equipment. The level at the FM transmitter output was chosen so as to require no adjustment of the FM transmitter in changing from television to telephony.

Impedance - Transmission Line	110 ohms balanced
(FM Transmitter	75 ohms unbalanced)

(b) Signal delivered to the telephone equipment

Signal Transmission Level	-26 db

Note 16 db gain is required to feed the L-Carrier equipment. The low level is necessary to meet the multiplex telephone modulation requirements with output tubes facing low impedances.

Impedance	110 ohms balanced

3. ROUTES AND SITES

(A) General

3.01 Four general factors must be considered in selecting sites, namely:

(1) Transmission over the path.

(2) "Overreach" interference with other sections of the route.

(3) Site accessibility.

(4) Possible hazard to aviation.

A discussion of these factors is given in Bell System Practice R100.010, Siting of Fixed Radio Stations. Included in this Practice are directions for plotting path profiles. The map on page 115 shows the route as selected for the New York-Chicago system.

(B) Transmission Over The Path

3.02 The prime requirement of a prospective site is that a free path exist between it and the other stations with which it must work. By a free path is meant one with adequate first Fresnel zone clearance. For flat terrain it is recommended that clearance be determined using an effective 4/3 earth radius and that the heights be so selected that there is little or no excess clearance. In cases where the obstruction is of the "knife edge" type such as a ridge, the effect of excess clearance is not significant and it is recommended that the clearance be determined using the true earth's radius. Paths with reduced clearance may provide satisfactory transmission under normal conditions but during certain atmospheric conditions, fading will be more severe. In general, the terrain will limit path lengths to 25-30 miles. It is recommended that path lengths do not exceed 35 miles except in special cases. Path loss measurements should be made on all questionable paths.

(C) Overreach Interferences

3.03 Since alternate repeater sections utilize the same carrier frequency for a given direction of transmission, the possibility arises of occasional interference due to direct transmission between antennas spaced 3, 5, 7, etc., sections apart. The amount of interference will be determined mainly by the characteristics of the transmission path and the directivity of the antennas. With antenna discrimination 25 db down at the 5-degree points, it will generally not be difficult to obtain a combined discrimination of 50 db in the two antennas in question.

(D) Site Accessibility

3.04 It is desirable that the site be accessible to roads, telephone and power circuits. The site itself should be suitable for the building and parking space with a minimum area of about 1 acre for the lower buildings. A condition which requires considerable grading, including the possibility of blasting, to obtain a level area should be avoided if possible. Also to be avoided are subsoil conditions with poor bearing values which may involve costly foundations. Good access close to a highway of all-weather road is desirable not only for service and maintenance reasons, but also from the standpoint of reducing costs involved in long entrance road construction and maintenance. Entrance roads or driveways are required to permit the building contractor to bring his heavy equipment and material trucks to the site during construction and for normal installation, service and maintenance work. At locations where the existing soil conditions are not suitable, a foundation of about 6 inches of gravel should be sufficient. It may be necessary in the course of the work to fill in ruts or soft spots with gravel, crushed stone or cinders. A road width of about 10 feet is believed to be adequate during construction period. After the contractor's work has been completed, it will probably be found desirable to regrade the base, provide a top dressing of graded gravel and roll the surface. Surfacing by means of oil, black top dressings or the use of concrete is not considered necessary except in special cases. Good drainage involving crowning, side ditches and properly located culverts should, however, be provided. The finished road should in general be confined to a width of 8 feet. A drive 12 feet wide at the engine room side of the building and a combined drive and parking area 20 feet wide at the stairway side should be provided. Fig. 5 shows a suggested arrangement.

(E) Hazard to Aviation

3.05 In general, the problem of having a repeater station building constitute a hazard to aviation will not be

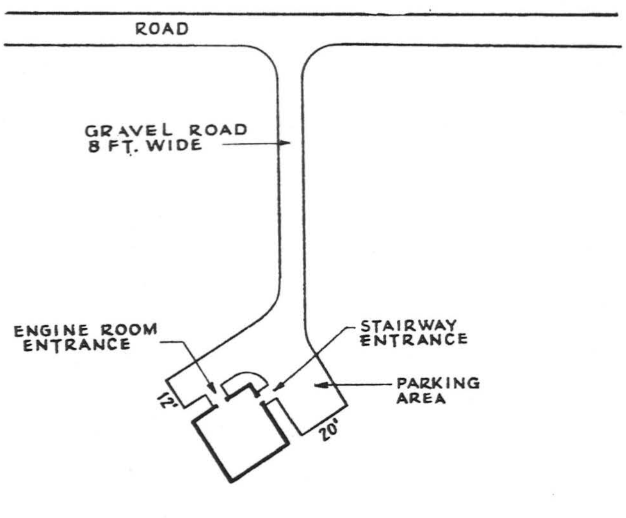


Fig. 5 - Typical Driveway Arrangement at a TD-2 Repeater Station

serious except in the immediate vicinity of airports and on certain parts of the airways system. The regulations change from time to time and latest information should be obtained from the C.A.A. In filing construction permits with the F.C.C. it is necessary to attach a form which is forwarded to the C.A.A. for their approval. The matter of obstruction lighting is discussed in paragraph 4.05.

4. BUILDINGS AND TOWERS

4.01 Square reinforced concrete buildings as shown in photographs A and B (pages 101 and 102) have been found to be the most economical and satisfactory. The selection of the reinforced concrete type of construction was largely determined by waveguide length and the necessity for a rigid structure. It is desirable for transmission reasons to keep waveguide lengths to a minimum. It was, therefore, considered advisable to locate the room housing the radio and video equipment within the tower and at a point as high as practicable from the standpoint of being reached without elevators, by the operating and maintenance personnel. Optimum transmission would be obtained by locating the radio equipment room at all buildings immediately under the lower antenna platform. Such an arrangement might not be practicable without the use of an elevator which is considered undesirable from cost and maintenance standpoints. Consideration given to the maximum walk-up height indicated that the top equipment room should not be located higher than about 100 feet above ground level. A rigid structure is required as the movement of the antennas should not be more than 1 degree in any azimuth under high wind conditions. This is necessary for transmission reasons due to the high directivity of the antennas.

4.02 Steel towers are also being made available for use where very high structures are required over flat terrain in order to minimize building costs. In these cases the antennas atop the tower are connected by waveguide to the radio equipment located in a single floor building at the base of the tower as illustrated by photograph C (page 103). This type of construction results in some impairment in system performance, but it is believed to be warranted by the reduction in building costs.

4.03 Sectional views of the four reinforced concrete building design types including the relation of waveguides, antennas and associated equipment are shown in Fig. 6. Building type 1 has been designed to care for locations on elevated ground and where minimum height is required to clear the tops of trees or other nearby obstructions. The height of that type (60') is determined by the height

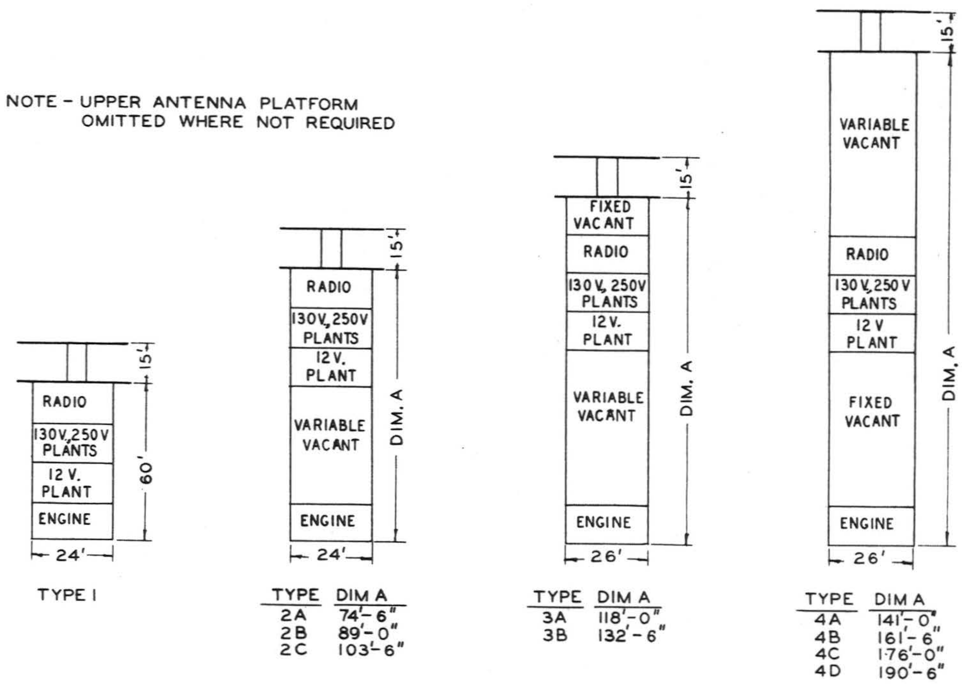


Fig. 6 - Standard Square Buildings - Elevation Plans Radio Repeater Stations

of the four equipment rooms. The radio equipment room is located directly under the antenna platform. Type 2 design is arranged for heights of 74'-6", 89' and 103'-6" with the radio equipment room in all cases located immediately below the antenna platform. Both types 1 and 2 buildings are 22' square inside dimensions with 12" walls. The Type 2 building at maximum height of 103'-6" represents the highest level considered practicable from a structural standpoint with a floor plan of 22' square and with 12" thick walls. Type 3 buildings vary in height from 118' to 132'-6" in one floor steps of 14'-6" each and Type 4 buildings vary in height from 147' to 190'-6". Both buildings have 24' square inside dimensions. The Type 3 building has 12" walls throughout while Type 4 buildings have 12" walls in the upper section and 16" walls in the base section varying in height from 30'-6" in the lowest building to 74' in the highest building. The radio equipment room is located 103' from the ground for all heights of Types 3 and 4 buildings. All buildings are arranged for a second platform either at the time the buildings are erected or at a later date if required.

4.04 The assignment of equipment to the various floors is essentially the same for all standard type buildings. On the ground floor are the emergency engine-generator set and the commercial AC service entrance equipment. On the second occupied floor are the 12-volt battery, associated charging rectifiers and control equipment, and the small 24-volt battery plant. On the third floor are the 130-volt and 250-volt battery plants and in some cases the main bay of the alarm and order-wire equipment. On the fourth floor are the radio bays, IF patching and monitoring bays, radio test equipment, and associated auxiliary equipment such as a vacuum tube cooling system.

4.05 For delay lens antennas mounted at roof level, a low steel supported platform of subway type grating is usually required to obtain a clear path over parapet walls. The method of supporting the antennas on the structure varies with the designer but, in general, beams are set in the structure under the front and rear antenna mountings. The area occupied by such a structure varies with the number of antennas and the angles between the antennas and the lines of supporting columns, which are determined by the building. In general, a platform about 14' or 18' by 24' will be required for two antennas, about 26' by 26' for four antennas and 30' by 36' for six. It is important that the antennas be located accurately with respect to the transmission path established to the next station. Since the mounting bolts for the antennas are usually built into the platform structure this requires that they be properly oriented. While most architect's plans for buildings have a north pointing arrow, its accuracy is open to question. It is usually based on magnetic north rather than true north and in many cases is a nominal indication only. In order to obtain the accuracy desired a true north bearing on the building should be established by a surveyor at the time the tower plans are being developed.

4.06 Two types of obstruction lighting are covered for TD-2 buildings to meet CAA specifications. For the lower type buildings away from airfields, a single lamp (111 watts approximate) provides a warning light. This lamp is lit 24 hours a day and is arranged for automatic transfer to a standby lamp in case of failure with an alarm to indicate such failure or loss of its 115-volt power supply. This is known as duplex obstruction lighting. For the higher buildings and those near airfields, a 300 millimeter flashing beacon of approximately 1240 watts is provided. This beacon is operated continuously at a flashing rate of 40 times per minute. Failure of either or both of the two lamps which provide the beacon, as well as loss of their 115-volt a-c power supply will cause an alarm. Both types of obstruction lighting obtain their 115-volt supply from the engine service distribution cabinet in the engine room. When the commercial service is connected 3-phase 3-wire with building lighting 230/115 volts, it will be necessary to furnish a 230/115-volt transformer. If this were not done, the phase to ground voltage during engine operation would be excessive when the engine phase voltages are set to match the 230-volt service voltage.

4.07 For steel towers, the same lighting as described for high buildings is provided, also side lighting consisting of four single obstruction lights. Two are located at a point 1/3 the way up the tower on opposite sides and two 2/3 the way up the tower on opposite sides but 90 degrees to the lower two.

4.08 An extensive grounding system to provide lightning protection and afford a low resistance power ground return system involves the use of a No. 0 bare copper wire ring ground buried in the earth at the building footings. This ring serves as the common station ground with all grounds coming to earth at this point. Two vertical 1/4" by 2" busbars are tied to this ring and rise to the top of the building. These busbars are tied to the building ironwork at all floors and to the exposed ironwork at the top of the building. Also tied to the ring ground are such grounds as the building power service entrance neutral, the gasoline fuel tank pipe and water pipe. These grounds are furnished as part of the building. In the case of steel towers a No. 6 ring ground is used around the single floor building and a No. 2 around the tower footings.

5. ANTENNA AND WAVEGUIDE

(A) KS-5759 Antenna

5.01 Description - The KS-5759 Antenna, shown in photograph D (page 104) is a broadband antenna capable of handling the entire 500 mc band assigned in the 4000 mc region for radio relay service. Only one transmitting and one receiving antenna is required for each direction. A repeater station on a main route with transmission in two directions and without spurs, will therefore have four antennas. The antenna is a pyramidal aluminum horn approximately 10' by 10' square at the mouth, 10' deep and weighs 2000 lbs. The triangular roof space occupied is 10'-6" across the face and 11'-6" in depth. There is an aiming adjustment of ±5 degrees in both the horizontal and the vertical planes. The antenna is designed for connection to waveguide of 2.290" by 1.145" inside dimensions. A microwave delay lens is mounted in a rectangular housing at the mouth of the horn. This plano-convex lens is constructed of spaced aluminum strips held in place by low-loss styrofoam blocks. The lens is tilted slightly in the vertical plane so that reflections are not focused back into the throat where they would affect the standing-wave-ratio. The action of the electric field is to "polarize" the conducting strips which affects the dielectric constant and the refractive index of the lens-shaped array resulting in a focusing of the electromagnetic waves. The spacing of the elements is small compared to the wavelength. An iris between the feed horn and the waveguide reduces reflection caused by the discontinuity. The antenna is discussed more fully in BSP R40.160.

5.02 Transmission Characteristics - The antenna is set up to produce a field with the E vector vertical.

Gain (with respect to isotropic radiator	4200 mc	39 db
	3900 mc	39.7 db
	3700 mc	38 db

Beam Width (3 db points at 4000 mc)	
Horizontal plane	2°
Vertical plane	1.5°
Average Ratio of Maine Lobe to Minor Lobe Peaks	
±20° to ±60°	40 db
90° to 270°	68 db
Average Return Loss	
3780 mc	30 db
3950 mc	40 db
4260 mc	32 db

(B) Waveguide

5.03 The connection between the antennas on the building roof and the radio equipment below is by means of waveguide with inside dimensions of 2.290" and 1.145". The position of the radio equipment relative to the passage through the ceilings and the roof, and the position of orientation of the antennas necessitate the use of a variety of waveguide parts. Between the antenna and the waveguide run feeding it, a flexible section is used because of the need to aim the antenna over small vertical and horizontal angles after the waveguide is attached and also because of the slight relative motion resulting from temperature changes and the wind. A flexible section is also used at the lower end of the waveguide run to connect to the radio equipment. The main vertical part of the waveguide run will be suspended from the weather seal device located on the roof top so as to avoid relative motion at this point due to differential thermal changes. Restrainer assemblies, primarily for positioning, anchor the waveguide runs to the walls and ceiling. Flanges attached to the waveguide sections are of stainless steel with a molded rubber gasket of circular cross-section trapped in a groove milled in the flange face. Dents and other deformations of the waveguide and flanges, even when relatively minute, are likely to result in impedance irregularities and must be guarded against.

(C) Waveguide Pressure System

5.04 At points near the antenna and near the radio equipment, the antenna waveguide is equipped with barriers called pressure windows, so that the greater portion of the run can be filled with dry nitrogen gas at low pressure to avoid condensation of moisture in the guide. The pressure window at the equipment end is installed after the remainder of the run is complete to avoid the possibility of foreign material falling down the guide and resting on the mica barrier. It is not practicable to repair pressure windows in the field so that the sloping flange connections should not be disturbed. Holes in the mica barrier fixture permit the installation of a pressure gauge and a filter valve stem. The gauge is fitted with a contact which closes an alarm circuit when the pressure drops to 1 lb. per sq. in. A nigrogen gas cylinder equipped with a pressure regulator and a nipple-equipped hose similar to that used for filling automobile tires, is mounted on a small hand trunk and is used for charging the waveguide run to a pressure of 3 lbs. per square inch. This equipment is normally disconnected except when charging.

6. RADIO TRANSMITTER-RECEIVER EQUIPMENT (J68331A)

6.01 General - A photograph of the J68331A Transmitter-Receiver Equipment is shown in photograph E (page 105). A detailed discussion of this unit is given in Bell System Practice R90.310, J68331A Radio Transmitter-Receiver Bay.

6.02 <u>Equipment Features</u>

(a) The J68331A Radio Transmitter-Receiver Bay consists of a 9 foot duct-type framework. The depth of the bay is approximately 15 inches and the width 22-3/8 inches. The bottom half of the bay is occupied by units arranged for 19 inch panels which project 9 inches from the front of the uprights. These units, starting at the botton of the bay, are:

Transmitter Microwave Generator
40-megacycle Shifter (or Receiver Microwave Generator at Terminal and Main Stations)
Transmitter Control Unit
Receiver Control Unit

The upper half of the bay is occupied by the receiver IF and transmitter waveguide components and is enclosed with hinged-type casing doors. The receiver equipment mounted within this casing consists of the IF main amplifier, receiver-converter and IF preamplifier unit, and the image suppression filter.

The transmitting portion includes the buffer amplifier (at switching point), modulator, amplifier, and directional coupler. The channel-dropping filters for the transmitter and receiver are mounted at the extreme top of the bay in a horizontal position and are arranged for waveguide coupling to the antenna for the first bay in the lineup, or to preceding and succeeding filters in adjacent bays for an intermediate frame of a lineup. A removable cover, held in place with quick release fasteners, is provided in front of the channel-dropping filters. A low-pressure air supply is required to provide forced air cooling to the 3-stage transmitter-amplifier 416A vacuum tubes, to the 416A tube of the modulator, to the 416A tubes in the microwave generator, to the 2C43 tubes in the microwave generator, and the 418A tube in the IF main amplifier.

(b) The local cable wiring between units on the bay is run in local cable forms stored in the ducts at the right and left side of the bay. Separate cables are provided for the receiver and the transmitter in order that only the wiring required need be furnished where only a receiver or a transmitter is furnished. The cable connections to the units are made by means of plugs and jacks to facilitate removal of the units for bench maintenance. Coaxial cables, with the exception of direct patches between units, are also stored in the regular wiring ducts. Application schematics of the interunit connections are shown on SD-59403-011, -012 and -013, pages 129, 130, and 131.

(c) <u>Power Drain (max.)</u>

250 Volts	0.37 Amps
130 Volts	0.43 Amps
12 Volts	23.5 Amps

(d) <u>Tube, Varistor and Crystal Complement</u>

	Tube Types										Varistors		Crystals	
	2C43	6AQ5	6AU6	313C	396A	404A	416A	417A	418A	VR150	405A	405B	KS-13978L1	KS-13978L2
Transmitter Modulator							1							
Receiver Converter											2			
IF Preamplifier								2						
IF Main Amplifier						6		1	1					
Receiver Control Unit				2	2									
IF Buffer Amplifier									1					
Transmitter Amplifier							3							
Microwave Generator (REC)	2		2		1		1			1			1	
Microwave Generator (Trans)	2		2		1		2			1			1	
40 mc Shifter		1			1							2		1

6.03 <u>Circuit Description - General</u>: A block diagram of the radio transmitter-receiver bay is shown on page 116. Application schematics of interunit connections are shown on pages 125, 126, and 127, respectively.

6.04 <u>Circuit Description - Receiver</u>: At a receiver the incoming microwave signal from a distant station may contain any combination of 1 to 6 channel signals. This complex signal is received by a highly directive antenna and is carried through waveguide to the transmitter-receiver bay in the radio room. Located in the waveguide at the top of each frame is a receiving channel separation filter (network) which selects the particular signal required for that receiving channel. Frequencies for other receiving channels pass through the first filter and are dropped at successive filters in numerical order with the lower frequencies first. Six frames, lined up side by side with the horizontal filter runs across the top, provide for the maximum arrangement of six channels in one direction. The incoming single-channel signal, after leaving the channel separation filter, passes through a waveguide image suppression filter. This filter prevents IF interference due to the image frequency which is 140 megacycles removed from the incoming carrier. The local generated frequency, combined with the carrier to obtain IF, may be either 70 megacycles above or below the incoming carrier. Likewise, the image frequency, which produces an unwanted 70 megacycles IF, is also above or below the carrier in the same direction as the local generated signal. The output from the image suppression filter is coupled by waveguide to the receiver-converter and IF preamplifier unit. In this unit, the incoming signal is combined with the locally generated frequency from the receiver microwave generator or the 40-megacycle shifter which has a frequency of 70 megacycles removed from the incoming carrier. One of the products resulting from this combination is the desired 70-megacycle modulated intermediate-frequency signal which is amplified in the preamplifier section of the unit. The output of the preamplifier is patched by means of coaxial cable to the input of the main IF amplifier where additional IF gain is provided. An automatic volume control circuit is provided on the receiver control panel to compensate for fading and variations in transmission. The IF output from the main IF amplifier may be patched in the coaxial cable to the transmitter section of the transmitter-receiver bay when the bay is used as a repeater, or it may be cabled to the IF patching bay at terminals and main stations. By inserting distribution and switching amplifiers in this IF output circuit at the patching bay, switching, monitoring, terminating, and distribution taps may be provided for flexibility in establishing and maintaining a network.

6.05 Circuit Description - Transmitter: In the transmitter, the frequency modulated, IF signal from the IF main amplifier, at an auxiliary station, or from a buffer amplifier at a switching point, or from an FM transmitter terminal is introduced by means of coaxial cable to the transmitter modulator. In the modulator, the 70-megacycle IF signal is combined with the output of the local transmitter microwave generator to produce a signal of the frequency to be transmitted. At the output of the modulator is a waveguide bandpass filter which passes the desired microwave transmitting signal and rejects all other undesired products of modulation. This filter is coupled, by means of waveguide, direct to the 3-stage microwave transmitter-amplifier which amplifies the signal to its final level. The amplified signal passes through the channel-dropping filter where it enters the transmitting system of filters which parallels the receiving group at the top of the frame. This channel may then be combined with a maximum of five other transmitter channels and is carried by means of a waveguide to the transmitting antenna. A directional coupler is introduced in the waveguide system after the transmitter-amplifier for sampling a small amount of power to provide a means for power measurement, and to energize alarms in the event of output failure.

6.06 Circuit Description - Beating-Frequency Supplies: Two arrangements are provided for obtaining the local microwave frequencies required for combining with the received signal in the receiver converter to produce the 70 mc IF frequency and for combining with the 70 mc IF signal in the transmitter modulator to produce the signal of the frequency to be transmitted. The arrangement applicable to unattended auxiliary repeater stations employs a single microwave generator and a 40 mc shifter. With this arrangement, the output of the microwave generator is fed to the 40-megacycle shifter where the signal is divided, one part being fed through an attenuator to the transmitting modulator and the second part combined with a 40-megacycle source to produce a supply 40 megacycles removed from the microwave generator frequency, for use with the receiver converter. The primary advantage of the single generator, with the closely controlled 40-megacycle shift, is that any variation in the frequency of the generator from the nominal desired value does not affect the transmitted carrier frequency. Thus, in a long-haul system, the use of such an arrangement avoids cumulative carrier frequency drift. To illustrate this, assume an incoming 3730-megacycle signal. The local microwave generator may have a nominal frequency of 3840 megacycles. The generator output is fed to a 40-megacycle shifter of closely controlled frequency, to produce a new frequency of 3840 - 40 = 3800 megacycles. This is mixed in the receiver converter with the received 3730-megacycle signal to produce a 70-megacycle intermediate frequency. This 70-megacycle and the 3840-megacycle generated frequency are combined in the transmitter modulator to produce 3840 - 70 = 3770 megacycles transmitted carrier. It can be seen, therefore, that drift in the microwave generator frequency results in a corresponding change in intermediate frequency but not in transmitted carrier. When separate generators are used, any variation in frequency in the two separate generators may result in carrier frequency variations. At terminals and main stations involving switching of circuits, the relationship between the received and transmitted signals may not be such that a single generator will suffice and, in general, more flexibility is desired. Two separate microwave generators are therefore provided: one to supply the converter and one to supply the modulator. Since less power need be supplied the converter than the modulator, the receiver microwave generator does not require the V6 stage (a 416A tube).

6.07 Transmission Characteristics: The transmission characteristics of the transmitter-receiver bay are as follows:

Frequency Range	3700-4200 mc
Frequency Transmission Band (0.1 db down)	20 mc
Output Power	0.5 watt
Minimum Signal Input for Normal Output (Based on maximum main IF amplifier gain of 63 db)	-57 dbm

7. FM TERMINAL EQUIPMENT

(A) General

7.01 The FM terminal equipment consists of a J68336A FM Terminal Transmitter and a J68336G FM Terminal Receiver. The transmitter translates an input signal to a 70 mc frequency modulated signal which is fed to the input to the TD-2 radio transmitter. The receiver accepts a frequency modulated 70 mc signal, detects and delivers the base band signal to a balanced 110 ohm line. The base band may be either a standard RMA black and white television signal or a frequency division multiplex multi-channel telephone signal. These equipments are shown in Photographs F and G (pages 106 and 107). The FM transmitter is discussed in more detail in BSP R10.300, J68336A FM Terminal Transmitter and the FM receiver is discussed in BSP R20.360, J68336G FM Terminal Receiver.

(B) FM Transmitter

7.02 Equipment Features:

(a) The J68336A FM Terminal Transmitter consists of a 31-15/32" high unit, with removable dust covers, designed for mounting on 19" wide duct-type framework. The transmitter incorporates five fundamental components namely, a J68336B FM Generator, a J68336C Video Amplifier, a J68336D Control Panel, a J68336E Automatic Frequency Control Unit and a J68336F Limiter Amplifier. The AFC unit and the limiter amplifier mount as removable sub-panels on the control panel. The FM generator and video amplifier are individual panel type units with dust covers. Connections to plate and heater batteries, and individual alarm circuits are made by means of solder-type terminal strips mounted on the control panel. Power and transmission connections between the various components of the transmitter are made by means of plugs and jacks.

(b) All vacuum tubes required for the FM Terminal Transmitter are provided installed in their respective sockets. A complete tube complement is shown in the following table:

	Vacuum Tubes								
Equipment	396A	403B	404A	412A	418A	421A	423A	D-178461	6AL5
FM Generator								2	
Video Amplifier	4	2	4						2
Control Panel	2	1		1		1	3		
AFC Unit	1	3							1
Limiter Amplifier		3	3		1				
Totals	7	9	7	1	1	1	1	2	3

(c) The power requirements for the J68336A FM Terminal Transmitter are approximately 250V 0.25A; 130V 0.17A, 12V 12A.

7.03 Circuit Description:

(a) The J68336A FM Terminal Transmitter is designed to accept an input signal which is normally 0.2 volt peak-to-peak for television but it may be as high as 2.0 volts peak-to-peak. For frequency division multiplex transmission, the normal operating level is -34.5 dbm but it may be as high as -14.5 dbm. The FM terminal transmitter delivers a frequency modulated signal centered about 70 mc to the IF patch bay of the TD-2 Radio System. The output level is +13 dbm at an impedance of 75 ohms unbalanced. For television transmission the normal deviation is 8 mc with the tip of the synchronizing pulses at 74 mc and picture whites at 66 mc. For frequency division multiplex telephone signals the nominal deviation is ±4 mc centered at about 70 mc. The output of the terminal is free from amplitude modulation. A 70 mc monitor point is provided.

(b) The general block diagram of the terminal transmitter is shown on Fig. 7, with the application schematic SD-59361 on page 117. The unbalanced circuit carrying the incoming signal is transmitted through a variable attenuator for gain adjustment to the input of the video amplifier. Provision is made for monitoring the output video signal applied to the FM generator on a cathode ray oscilloscope by plugging into a monitor jack which connects to the video amplifier output. For television transmission, the output is automatically clamped to a predetermined voltage at each synchronizing pulse of the television signal. A monitor jack is provided for observing the operation of the clamping circuit on a cathode

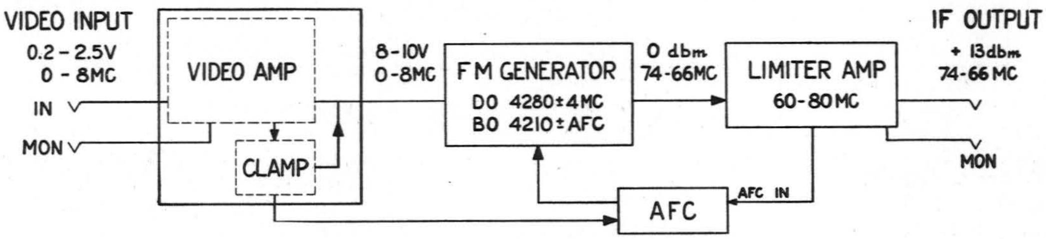


Fig. 7 - Simplified Block Diagram of the FM Terminal Transmitter

ray oscilloscope. The video amplifier output is applied to the repeller of a 4280 mc reflex klystron deviation oscillator in the FM generator unit. Variation of the repeller voltage modulates the output frequency of the oscillator. The output of the deviation oscillator feeds an unbalanced crystal converter where it is mixed with the output of a 4210 mc beat oscillator and a 70 mc difference frequency is produced. To compensate for drifts of the deviation oscillator a slow operating automatic frequency control circuit (AFC) varies the frequency of the beating oscillator from its nominal 4210 mc to maintain a constant frequency difference. This circuit compensates for slow drifts in frequency of both the deviation and the beat oscillators. The limiter amplifier amplifies the 0 dbm output of the crystal converter to +13 dbm. An instantaneous amplitude limiting circuit removes whatever amplitude modulation may accompany frequency modulation of the deviation oscillator. The limiter amplifier also provides 2 auxiliary outputs of lower level. One of these provides input signal for the AFC circuit; the other is an IF monitor point at the terminal transmitter output. The AFC circuit performance is substantially different for telephone and television transmission. For telephone transmission the AFC circuit measures the average frequency at the output of the limiter-amplifier and corrects the frequency of the beating oscillator so that this frequency is maintained at 70 mc. For television transmission, the AFC circuit measures the frequency at the output of the limiter-amplifier only during the horizontal synchronizing pulses of the television signal and controls the frequency of the beating oscillator so that the output frequency during this portion of the signal is maintained at 74 mc.

7.04 Transmission Characteristics:

(a) Video frequency characteristics are as follows:

Input impedance	Unbalanced 75 ohms
Video signal input (synchronizing pulse negative)	0.2V peak-to-peak
Multiplex telephone input transmission level	-34.5 db
Video amplifier (V1-V6) max. gain	42 db
Video attenuation adjustment	0-20 db continuous
Video amplifier bandwidth 0.1 db points	30 cycles to 8 mc
Video amplifier and normal bandwidth	Transmits components of video signal down to d.c.
Video amplifier output	10V peak-to-peak (corresponds to 8 mc deviation)
Min. video amplifier output (TV)	3V peak-to-peak
Video amplifier load capacity (TV)	30V peak-to-peak
Video amplifier modulation (10V peak-to-peak output)	
250 kc	500 kc more than 56 db below 250 kc 750 kc more than 65 db below 250 kc
2 mc	4 mc more than 52 db below 2 mc 6 mc more than 62 db below 2 mc

(b) Transmission characteristics of the FM generator are as follows:

Deviation oscillator frequency (TV)	4284 mc
Deviation oscillator frequency (TEL)	4280 mc
Beating oscillator frequency (TV or TEL)	4210 mc

Type of modulation	Frequency modulation
Direction of modulation (TV)	Sync pulses correspond to max RF frequency
Deviation oscillator modulation sensitivity	Approx. 1 mc per volt (varies with klystron)
Normal frequency deviation (TV)	8 mc total
Linearity of deviation characteristic	± 1% in slope over 10 mc band
Deviation oscillator output	+17 dbm
Beating oscillator output	+17 dbm
Directional coupler loss	11 db
Crystal converter output (70 mc)	0 dbm
D-c rectified converter current	15 ma

(c) 70 mc characteristics of the FM Terminal Transmitter are as follows:

Intermediate frequency	70 mc (for TV sync pulse = 74 mc; picture white = 66 mc)
Limiter amplifier input level	0 dbm
Limiter amplifier output impedance	75 ohms unbalanced
Limiter amplifier output level	+13 dbm
IF monitor level	0 dbm
AFC input level	0 dbm
Bandwidth (0.1 db points)	60-80 mc
Normal limiter current	9 ma

(d) AFC characteristics are as follows:

Input level	0 dbm
Controlled oscillator	Beating oscillator in FM Generator
Control frequency (TEL)	Average frequency - 70 mc
Control frequency (TV)	Sync pulse tip = 74 mc
AFC gate pulse width	1.5 microseconds (synchronized with sync pulse of TV signal)
Range of AFC control	±15 mc

(C) FM Receiver

7.05 Equipment Features:

(a) The J68336G FM Terminal Receiver consists of a unit 13-31/32" high, with removable dust covers, designed for mounting on a duct-type framework 19" wide. The receiver incorporates three components, namely, a J68336H Limiter Detector, a J68336J Video Amplifier and a meter and control panel. The limiter detector and the video amplifier mount as removable sub-panels on the major receiver assembly.

(b) Signals impressed upon the receiver are carried by unbalanced coaxial cable which is plugged directly into the limiter detector (see Fig. 8). Output video signals are derived from a balanced coaxial jack mounted on the video amplifier. An auxiliary balanced jack, used for video monitoring purposes, is also mounted on the video amplifier. Three d-c meters are mounted on the hinged panel of the receiver. Two of these are permanently connected to read rectified currents in the two limiter stages. The third meter, associated with a selector switch, can be used to read supply and bias voltages at ten points in the receiver circuit, as well as to indicate the peak-to-peak video voltage delivered to the outgoing balanced line. A 3-position key permits the selection of three degrees of meter sensitivity. Also included on the control panel are a key and associated lamp for making in-service tests of filament activity of the tubes within the limiter detector.

(c) The tube complement is as follows:

Equipment	Vacuum Tubes 396A	403B	404A	418A	423A	6AL5
Limiter Detector			4	2		1
Video Amplifier	6	1	4			
Bias Supply					1	

(d) The power supply requirements are as follows:

11 volts d-c or a-c	6 amperes
130 volts d-c or a-c	300 milliamperes
250 volts d-c or a-c	100 milliamperes

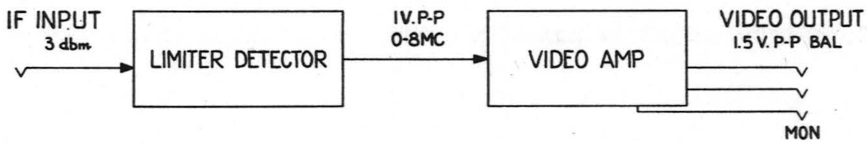


Fig. 8 - Simplified Block Diagram of the FM Terminal Receiver

7.06 Circuit Description:

(a) The application schematic of the FM receiver, SD-59365, is shown on page 118. The limiter detector consists of two stages of broadband amplification, two limiter stages, two amplifier stages associated with discrimination and a double diode detector. Associated with the limiter stages are four silicon varistors. The output of the second limiter is impressed simultaneously upon the grids of two independent amplifier stages, the plate load in each case being a simple antiresonant circuit. For one stage, the antiresonant circuit is tuned to a frequency of about 55 mc and for the other stage the frequency is about 85 mc. In the range from 60 mc to 80 mc the transmission characteristics of these stages have slopes of about equal magnitude but of opposite sign. With frequency modulated signals, the frequency deviations will produce amplitude variations in the outputs. Following this frequency-to-amplitude modulation conversion process, the signals are impressed upon diode detectors. The video signals are then delivered to the video amplifier.

(b) The video amplifier consists of a three-stage (8 tubes) balanced feedback amplifier. Capacitors in both the input and the output remove the d-c components. Three tubes constitute a vacuum tube peak-to-peak voltmeter for indicating the level of television signals appearing at the main output jack.

7.07 Transmission Characteristics:

(a) The transmission characteristic of the limiter detector are as follows:

Input Impedance:	75 ohms unbalanced
Output Impedance:	2000 ohms balanced
Normal Input Power Level:	+3 dbm
Transmission Band:	60 to 80 mc
Maximum Frequency Deviation of Input Signal:	±4 mc
Video Output Voltage for ±4 mc deviation:	1.1 volts peak-to-peak

(b) The transmission characteristics of the video amplifier are as follows:

Input Impedance:	0.48 megohm balanced
Output Impedance:	110 ohms balanced
Transmission:	Essentially flat from 5 cycles to 8 megacycles
Maximum voltage amplification from input to terminated output:	2.4 times
Range of gain control:	8 db
Normal video output level:	2 volts peak-to-peak

8. SWITCHING AND MONITORING EQUIPMENT

(A) General

8.01 The switching and monitoring requirements vary considerably with stations and consequently the equipment supplied will vary accordingly. For instance at many auxiliary stations with a spur bridged to the through circuit, a connection from the monitoring jack of the IF main amplifier together with a switching and an auxiliary amplifier may be adequate. At main repeater stations where only provision for switching between regular and spare channels is required, the equipment assembly will be simpler than in cases where branch circuits are also involved. At terminal stations, video switching will surely be required. However, there are certain standard units which comprise these various assemblies.

(B) Patching Bay

8.02 The patching bay is a 9 foot bay with twenty sets of distributing (J68338B) and switching (J68338A) amplifiers, an IF auxiliary amplifier (J68338C), fuse panels, etc. The switching amplifier has two inputs and a common output with one tube in each branch. The application of the proper bias will enable one or the other of the inputs and thereby permit a quick switch from one signal source to another. Remote control of switching is provided for. The distributing amplifier has a single input and three outputs with one tube in each input and output branch. The dimensions of these amplifiers are 3-1/4" by 5" with a depth of 9". The amplifiers are easily removed for servicing. The IF auxiliary is a 4-stage 70 mc amplifier similar, except for the number of stages, to the IF main amplifier in the radio transmitter receiver bay. The application schematics (SD-59389) are shown on pages 120, 121, 122 and 123.

(C) Monitoring Bay

8.03 The monitoring bay is used at points where it is desirable to monitor the television picture. This is a 9' bay with a standard FM terminal receiver, a video monitoring amplifier (J68338D), a KS-5799 picture monitoring scope, a video jack field and miscellaneous terminating equipment for the alarm and order wire circuits. Application schematics for the video (SD-59367) and the monitoring equipment (SD-59391) are shown on pages 119 and 124, respectively.

(D) Switching Application

8.04 An example of the application of the switching and distributing amplifiers for switching from a regular to a spare channel over a section between two main repeater stations is shown in Fig. 9. An example which involves a branch channel is shown in Fig. 10.

9. POWER SUPPLIES

(A) General

9.01 Four different power supply voltages are required for TD-2 equipment as follows:

-12 volt d-c	Filament Supply
-24 volt d-c	Alarms, Order Wire and Controls
+130 volt d-c	Plate Supply
+250 volt d-c	Plate Supply

These voltages are obtained from batteries which are floated on the line by means of rectifiers operating from commercial 60-cycle power. In order to insure reliable operation and dependability of service, a standby gas engine alternator is provided to carry the load in the event of failure of the commercial power. In the event of failure of both commercial power and the engine alternator, the battery reserve will carry the load for six to eight hours, dependent upon the capacity of the battery provided. The plants are designed for unattended automatic operation with alarms to the maintenance center to indicate abnormal conditions. Fig. 11 shows the overall plan of the power supplies with a block diagram shown in Fig. 12. These power supplies are coded 425A Power Plants (J86435). References to pertinent information relating to these plants are given below:

12 Volt Plant	J86439	SD-81086-01	BSP A301.823
24 Volt Plant	J86440	SD-81081-01	BSP A301.824
130 Volt Plant	J86437	SD-81084-01	BSP A301.821
240 Volt Plant	J86438	SD-81085-01	BSP A301.822
Engine Alternator	J86616	SD-81104-01	BSP A301.247
		SD-81108-01	BSP A401.247

Photograph H (page 108) shows the 12-Volt Control and Distribution Bay. The plants are fully automatic in that when the commercial power is restored after power failure, the rectifiers are automatically controlled to prevent overloading and operate at full output until the high float voltage is reached, whereupon normal float regulation is resumed. The plants are so arranged that by momentarily operating a key, an attendant can set up the circuit to automatically give the battery a 1 to 6 hour charge at approximately 2.23 volts per cell. At the end of the chosen period, the timer automatically returns the battery to normal float condition.

9.02 Alarms are provided to indicate trouble conditions whether due to rectifier failure, fuse failure, high- or low-float voltage and high- or low-load voltage. A number of the alarms are so arranged that their signals are delayed in transmission in order to minimize premature alarm indications in the distant attended office.

9.03 The charge-discharge equipments are assembled in enclosed-type aluminum cabinets 8' high, 2'-6" wide, and 1'-8" deep. The rear of the cabinet is enclosed with removable covers while the front of the cabinet generally consists of fixed panels and equipment units with removable covers. The basic mounting structure is a 23" bulb-angle framework which can be completely divorced from the enclosing cabinet for shipment. With this arrangement a fully assembled and wired bay equipment is shipped to the job less the cabinet, which is shipped as a separate item.

(B) 12-volt Plant

9.04 The 12-volt plant consists of rectifier control apparatus, two or more 200-ampere rectifiers permanently connected to a positive grounded 1320 or 1680 ampere-hour battery in one or more 6-cell strings, and the distribution fuse apparatus. The initial charge-discharge bay mounts rectifier and control apparatus and charge fuses for a maximum of five charging rectifiers and 16 distributor fuse

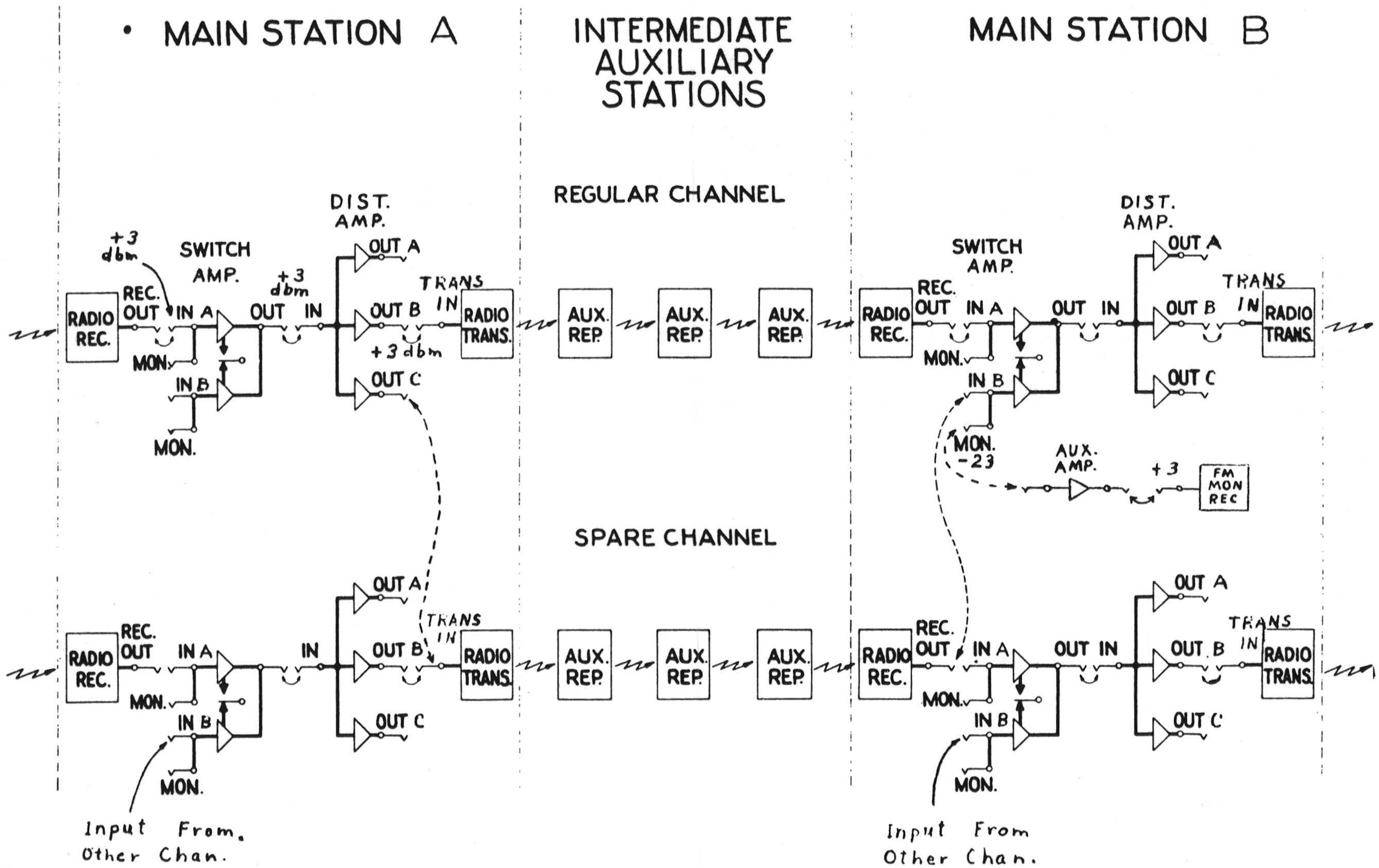


Fig. 9 - Illustrative Arrangement for Switching
From Regular to Spare Channel

W-E CHANNELS & CONNECTIONS THERETO ARE NOT SHOWN

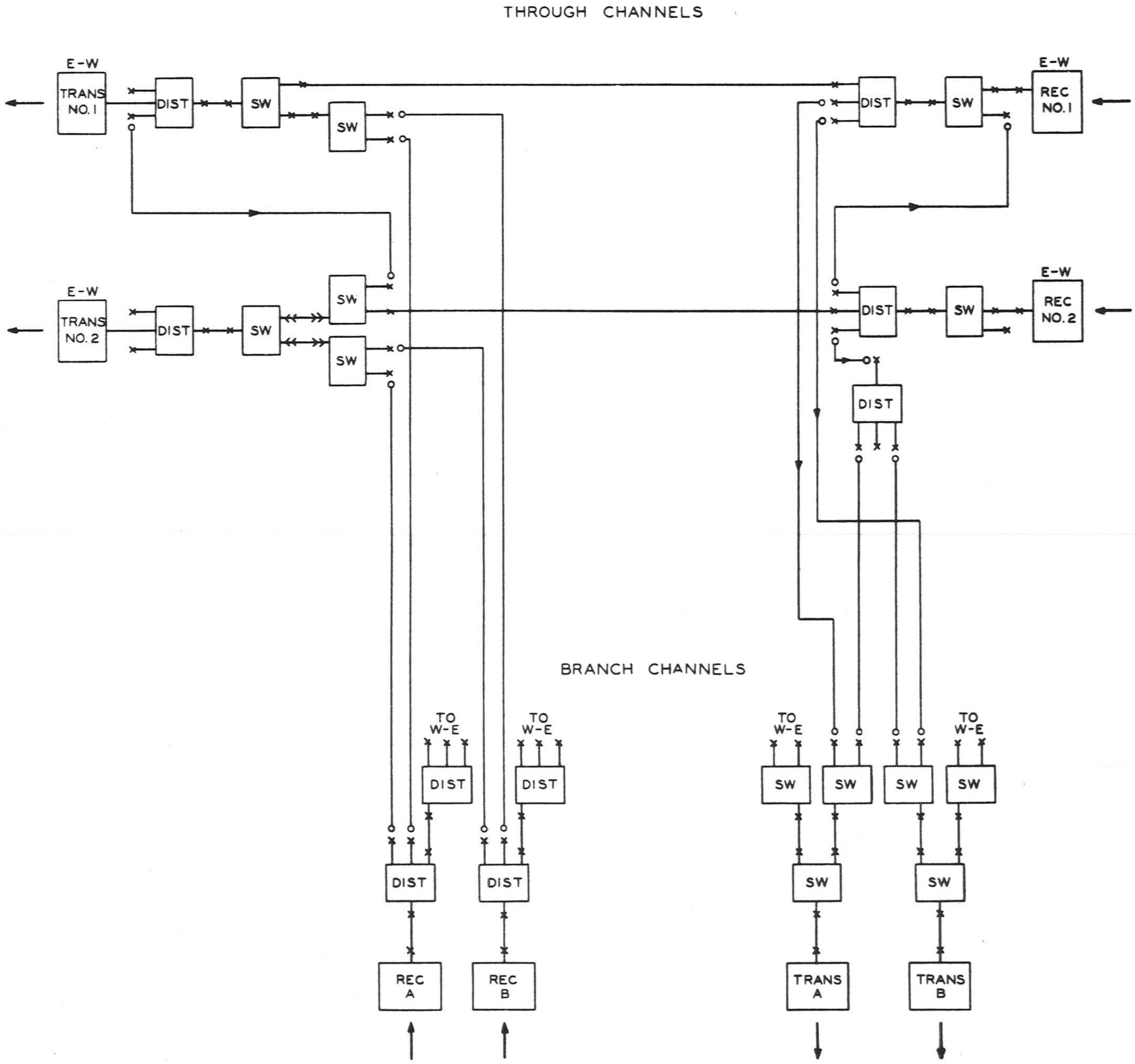


Fig. 10 Illustrative Switching Arrangements Involving Branch Circuits

circuits. The charging rectifiers, photograph I (page 110), are of the 120-volt, 200-ampere metallic type. The plant is designed to furnish a maximum of 800 amperes filament load. For this condition the arrangements furnished are based on the expectancy that five 200-ampere rectifiers will be sufficient for charging since failure of one rectifier would still leave sufficient capacity to float the load and charge the battery at a slower rate. The battery is made up of as many 6-cell strings (maximum of six) in parallel as are needed to carry the load for a particular number of hours. The cells are mounted on standard open type battery stands.

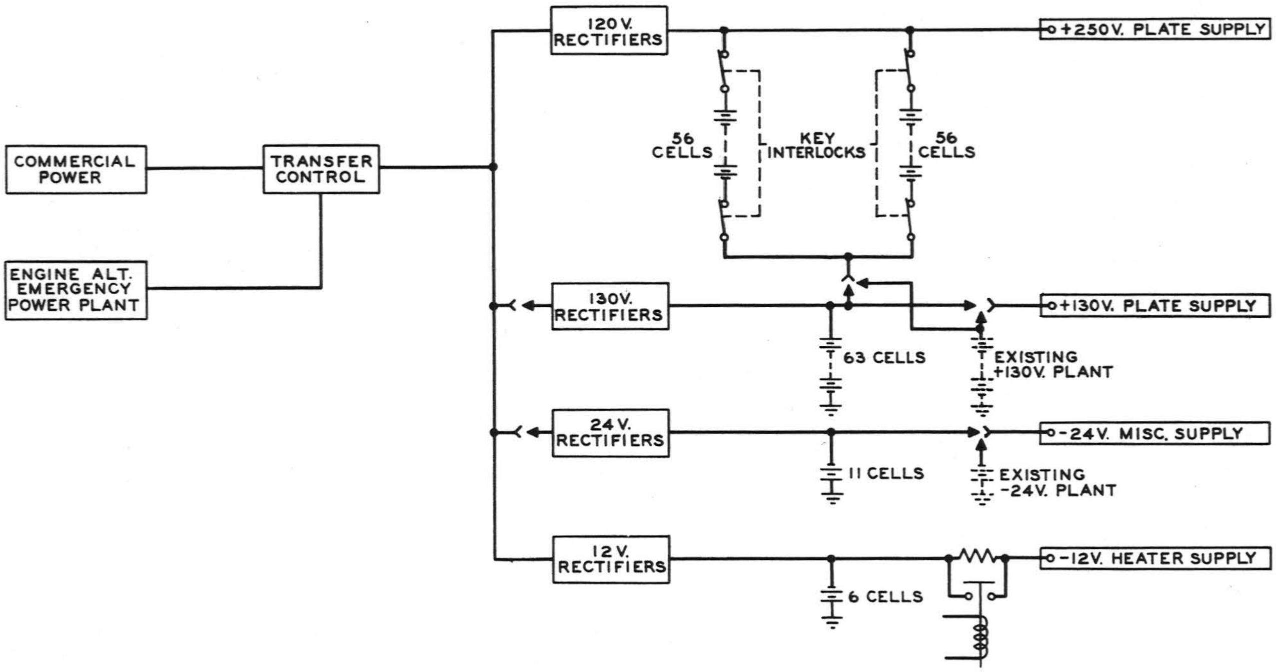


Fig. 11 - 425A Power Plant Block Schematic

9.05 Under normal operating conditions, the battery voltage of 13.0 volts is reduced through series-dropping resistors, bridged by a nonoperated contactor, to give as close to 11.0 volts as possible at the point of load distribution. Each discharge lead has its own individual adjustable series resistor and contactor. Under emergency conditions, when the battery voltage drops to approximately 12.5 volts the plant control equipment operates the discharge contactors which short out the series resistors thus raising the filament voltage at the load distribution points and permitting a lower battery discharge voltage to the 10.8-volt emergency limit.

(C) 24-volt Plant

9.06 The 24-volt plant is used for alarms, order wires and controls at stations where no 24-volt supply exists. This positive grounded plant employs a 9-ampere metallic-type rectifier for regulating and charging an 11-cell 100-ampere-hour battery for continuous loads up to six amperes or intermittent loads up to nine amperes. By the addition of a second rectifier and parallel operation, it may be used for constant loads up to 12 amperes and intermittent loads up to 18 amperes. Increased battery reserve may be obtained by the addition of a second 100-ampere-hour battery. The plant with the full equipment is housed in a 8'-0" by 2'-6" by 1'-8" cabinet. A space of approximately 35" at the bottom of the bay is available for the initial and supplementary 100 AH batteries. The relay-rack type battery shelf supports the initial three 3-cell and one 2-cell battery unit. Two battery-rack type shelves on the cabinet base plate will support the supplementary 100 AH battery also consisting of three 3-cell and one 2-cell unit.

(D) 130-volt Plant

9.07 The positive 130-volt plant furnishes a regulated and filtered plate supply from a 63-cell battery floated and charged from two or more 8-ampere regulated tube-type rectifiers. The plant has a capacity of 0.5 to 20 amperes at normal voltage limits of 135-136 ± 1 volt at the load fuse panel and at emergency voltage limits of 116 - 140 at the load fuse panel. The plant also serves as the lower section of a 250-volt plate supply and its charging requirements are of course based on the combined 130- and 250-volt loads. It is recommended that at least one rectifier be furnished in addition to the number required to just carry the load. Arrangements provide for a maximum of eight rectifiers. Two initial equipment bays each 8'-0" by 2'-6" by 1'-8" will mount up to four rectifiers which is sufficient for the majority of installations. Above this number, supplementary charge bays are required for each two rectifiers. All discharge distribution is supplied from the initial discharge bay with a maximum of 88 discharge fuses available.

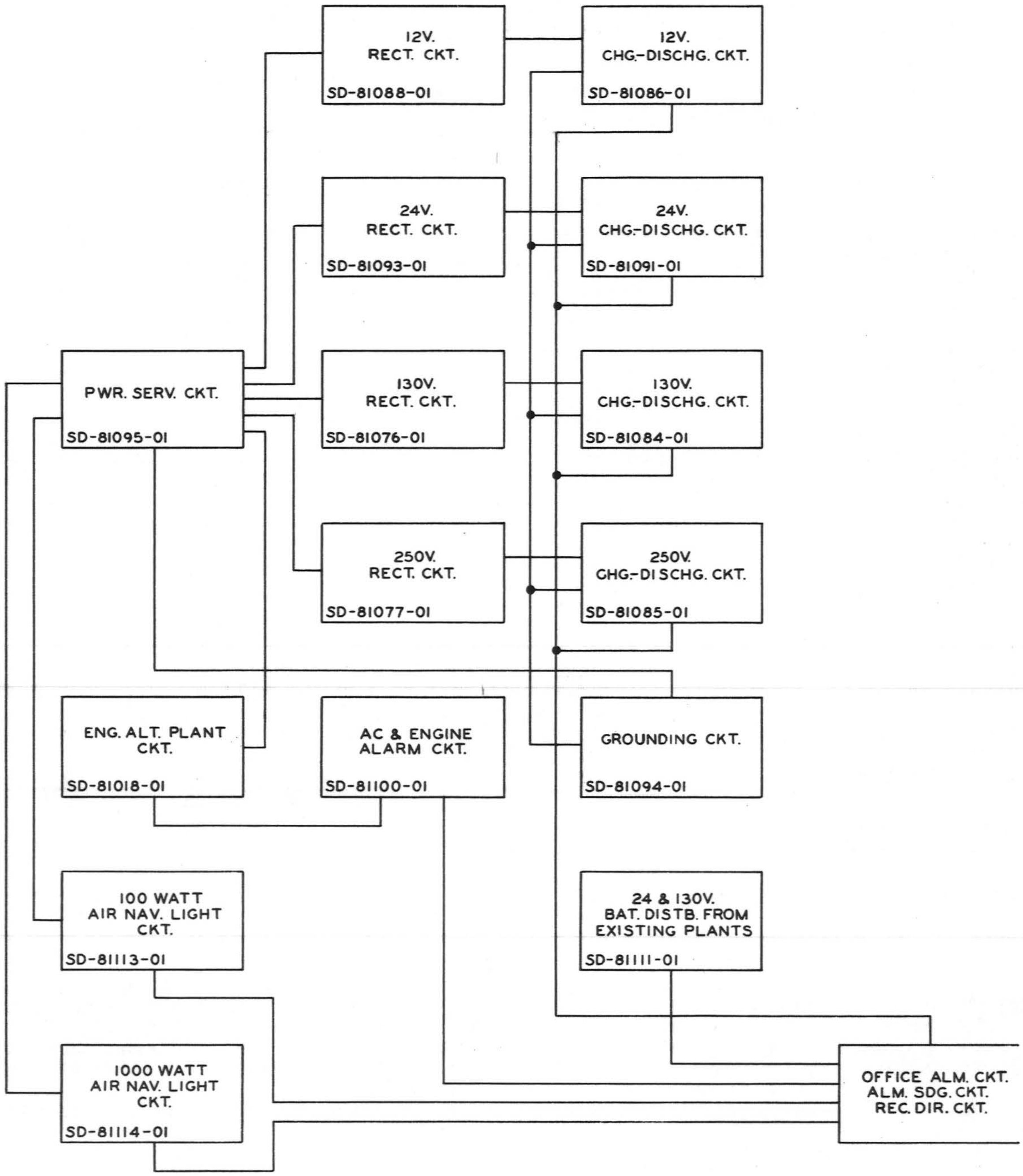


Fig. 12 - TD-2 Power Supply Circuits

(E) 250-volt Plant

9.08 Positive 250-volt plate supply is obtained by adding a 121-volt, 56-cell, regulated battery section to a positive 130-volt battery. The 250-volt battery section is regulated and charged from automatically controlled 8-ampere 120-volt regulated tube rectifiers. The plant is designed to furnish a maximum of 20 amperes plate load. For this condition the arrangements furnished are based on the expectancy that four 8-ampere rectifiers will be sufficient for charging since failure of one rectifier would still leave sufficient capacity to float the load and charge the battery at a slower rate. The rectifiers are designed for operation on 210-250 volts ±7 per cent, 60 cycles. Where the commercial power varies more than ±7 per cent it is necessary that an auxiliary line regulator be provided. The initial equipment bay includes two rectifiers and common plate supply filter with 52 discharge fuses for load distribution. A second bay for one or two additional rectifiers, additional common plate filter and 44 additional discharge fuses may be added when the capacity of the first bay is exceeded.

9.09 Duplicate 56-cell sections are provided for safety in battery maintenance. Each section or string of batteries is mounted in a separate locked cabinet 8' high, 3' wide and 1'-8" deep. A key interlocking system is employed to prevent access to a cabinet without disconnecting its battery from the circuit. Each section is equipped with a switch which must be thrown before a key can be obtained to open either the front or rear cabinet doors. A key must be obtained to unlock the switch and with the switch once thrown to its off position, this key is seized so that the switch on the other battery section cannot be opened. This feature guards against opening the load, which could happen if both switches could be operated simultaneously. When one of the cabinet doors is opened, its key is seized until the door is again closed and locked. This prevents reclosing the switch with the cabinet doors open. With the switch off, the battery section is ungrounded and the maximum voltage obtainable is less than 120 volts. The duplicate strings are normally connected in the circuit and floated in parallel and the battery reserve should be calculated on this basis. The cabinets need be opened only for such maintenance as adding water and making pilot cell voltage and gravity readings usually every three months.

(F) A-C Service Distribution

9.10 A-C service distribution to the power and radio equipment is supplied normally from two sets of fuses in the engine room service cabinet. One set of busses is connected to commercial power only and the other arranged for engine alternator standby. From each of these busses feeders run to fuse distribution cabinets in each power room. The service cabinet in the 12-volt power room, in addition to supplying 230/115 volts to the power bays on that floor, also mounts the alarm equipment which indicates commercial service failure and engine operate and failure alarms as well as the connection to the alarm sending circuit for remote starting of the engine. The service cabinet in the 130-volt power room in addition to 230/115 volts to the power bays, also supplies 115 volts a-c to the radio room for testing equipment and tube cooling motors. The busses in this cabinet which are connected for engine standby are regulated by a line-voltage regulator mounted in the cabinet when the commercial service voltage varies more than ±7 per cent. An emergency light control relay is also mounted in this cabinet to connect 130 volts d-c to the emergency lighting circuit during commercial service failure. Also in this cabinet is mounted low-voltage lightning protection. This protection across each phase lead to ground is connected to the fuses feeding the first rectifier of the 130-volt plant so that a fuse failure due to breakdown of the thyrite varistor in the protector circuit will cause a rectifier failure alarm and obtain maintenance.

(G) Engine Alternator

9.11 Automatic gasoline engine alternator plants from 20- to 60-kw capacity are available as reserve power plants. The 20-kw size is available in single-phase 230/115-volt output or 208/120 volt, 3-phase 4-wire and this set will usually have sufficient capacity as standby for TD-2 repeater stations by limiting the amount of charging equipment connected to the engine supply to the rectifiers required to normally carry the ultimate load and connecting the remaining rectifiers to the commercial power only. Larger sets 30-, 40-, 50-, and 60-kw are available in 3-phase 4-wire only. All sets are capable of delivering rated load at voltages up to 240 volts a-c so that their outputs may be adjusted to match the nominal commercial service voltage. These plants are completely automatic for unattended operation with alarms for maintenance from a distant point. If "ordered" to start from the alarm center for a weekly routine run, it will operate for 30 minutes after which the circuit will restore itself and be ready for automatic operation in case a power failure occurs.

10. C1 ALARM AND CONTROL EQUIPMENT

10.01 General - In order to insure reliability of service in a communication system involving stations which must be operated on a nonattended or partially attended basis, various trouble or abnormal conditions which originate in these stations (alarm sending stations) must be promptly reported to an associated station (alarm receiving station or alarm center) which is continuously attended. It is also desirable to perform certain functions at an unattended station on a remote control basis from the attended station such as checking the alarm system and starting and checking the emergency engine-alternator. The C1 alarm and control system provides these facilities. The following are pertinent Bell System Practices:

A820.011 C1 Alarm, Sequence Signaling and Order Circuit - Description

A320.571 C1 Alarm and Control - Tracing and Clearing Trouble

10.02 Equipment Features:

(a) The alarm and control receiving bay required at the alarm center is shown in the photograph J (page 111). A standard 11'-6" duct-type frame is used with all relays, controls, lamps and jacks mounted on the open duct side of the frame. On the key, jack and lamp panel are the keys for controlling the sequence signaling transmitter whereby a particular station may be directed to send in a complete report of all the circuits which are provided with alarm features. The results are indicated on the display shelf. The shelf is so arranged that an 8-3/8" by 10-7/8" data sheet (Fig. 13) may be placed over the lamps and crosses marked wherever lamps are lighted. The lamp bank incorporates 60 lamps. Six lamps are used to tell which of the six stations on the alarm line are reporting in. Two lamps are used to tell if the reports are coming in on the east or west alarm line. Forty-two lamps are used for alarm or circuit indications. Ten lamps are used for synchronizing. At the start of scanning, five synchronizing lamps are operated two on, one off, and two on. At the end of scanning the second five synchronizing lamps are operated two on, one off, and two on. If these

C1 ALARM RECORD

SERIAL NO.______

DATE		ACTION TAKEN			
TIME RECEIVED A P	BY				
SENDING OFFICE		TROUBLE FOUND			
RECEIVING OFFICE		DATE OK	TIME A P	BY	

	A	B	C	D	E	F
	STATION IDENTIFICATION					
1	1 / 7	2 / 8	3 / 9	4 / 10	5 / 11	6 / 12
	SYNCHRONIZATION - START					EAST
2	ON	ON	OFF	ON	ON	
	SYNCHRONIZATION - STOP					WEST
3	ON	ON	OFF	ON	ON	
	LOW MICROWAVE OUTPUT E-W OR N-S CHANNELS					
4	1	2	3	4	5	6
	LOW MICROWAVE OUTPUT W-E OR S-N CHANNELS					
5	1	2	3	4	5	6
	LOW MW OUT. BRANCH CHANNELS					
6	A	B	C	D		
	DISCH. FUSE	DISTRIBUTION FUSE			OBSTRUCTION LIGHTS	
7	12,24, 130 & 250V	RADIO 12V 130V 250V	ABS 24V 130V	MISC. 24V 130V	BOTH OFF	ONE OFF
	COM'L AC PWR.		HIGH-LOW VOLTAGE			
8	FAIL.	RESTORE	12V	24V	130V	250V
	GAS ENGINE			RECT. FAIL	H-L FLOAT	
9	FAIL.	OPER.	LOW GAS	12V 130V 250V	12, 24, 130 & 250V	OPEN DOOR
	HIGH-LOW TEMP.					
10	CRYSTAL OVEN	ROOM	TUBE COOLING FAIL.	WG LOW GAS PRESS.		
	A	B	C	D	E	F

Fig. 13 - Alarm Center Record Sheet

synchronizing lamps are not so operated the attendant knows that the sending and receiving circuits are not functioning in synchronism and that his report is not correct. The following indicate the types of alarms provided for:

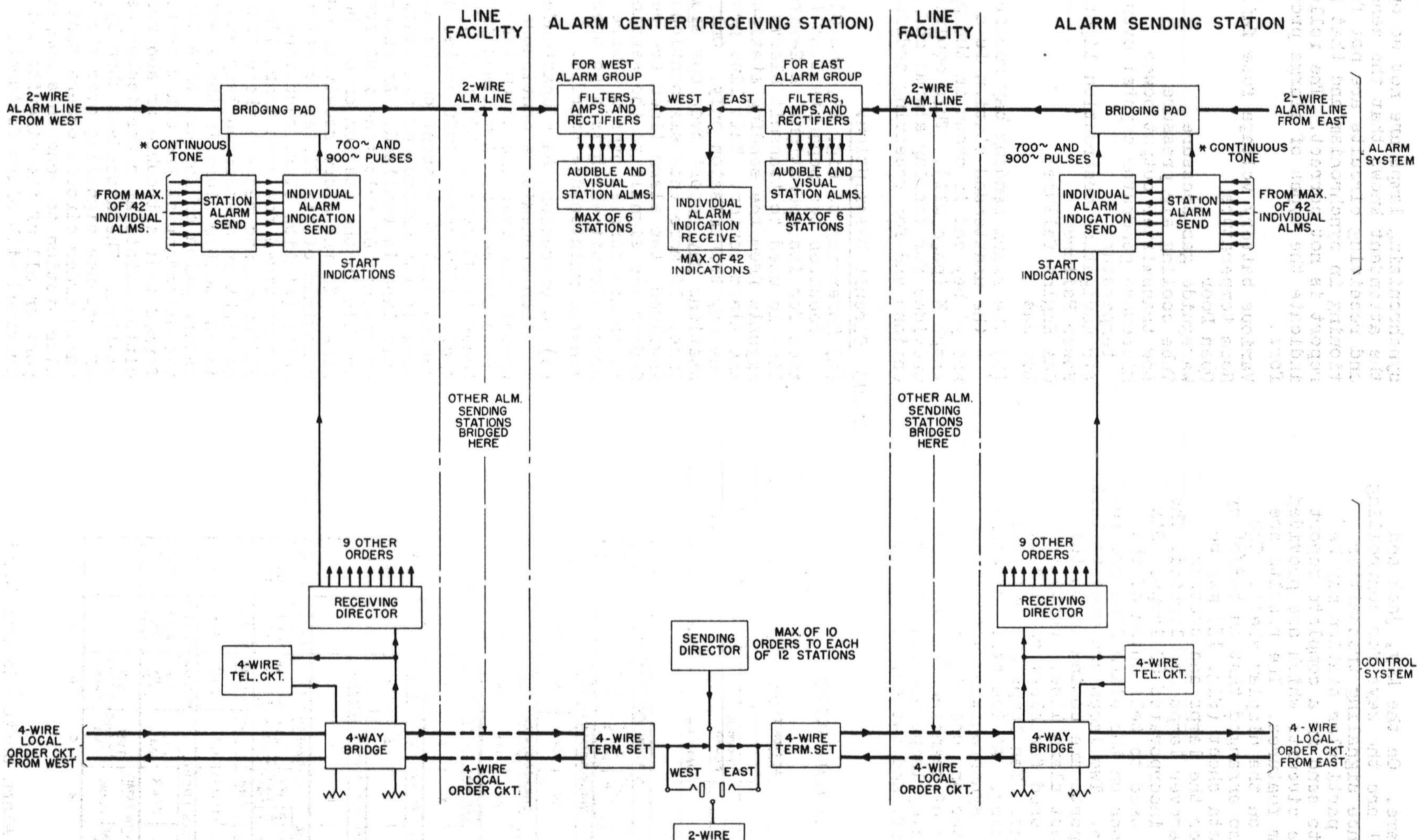
Various battery voltage fuse failures
Room temperature
Open Door
Waveguide gas pressure
Tube cooling air pressure
Low transmitter output power
Microwave generator crystal oven temperature
Air navigation obstruction lighting
Power Failure
Gas Engine failure
Low Gas

(b) The alarm sending bay required at the unattended station is a standard 9' bay and is shown in the photograph K (page 111). This equipment provides for sending alarms and indications and for receiving orders.

10.03 Circuit Description:

(a) Referring to Fig. 14, the C1 system requires two separate line facilities for its operation. A 2-wire alarm line is used to transmit alarms and signals from the sending stations to the alarm center. This line provides one way transmission only. Only six stations may report over one alarm line. If more than six stations are involved, two alarm lines are required. Orders and signals to the sending stations are carried over a 4-wire local order circuit which is also used for general maintenance traffic.

(b) In operation, each unattended station transmits a continuous individual tone over the alarm line into the alarm center. A maximum of six tones (1100 cycle, 1300 cycle, 1500 cycle, 1700 cycle, 1900 cycle, and 2100 cycle) will be present on the alarm line if the maximum of six stations on that line is realized. An interruption or absence of this tone indicates a trouble in the station or on the alarm line. In the alarm receiving equipment a maximum of six filter detector circuits (station alarm receiving circuits) are provided for each alarm line to differentiate between these tones and to light an associated lamp and bring in an audible alarm in the event of interruption or failure of a tone. Thus the attendant at the alarm center is informed that a trouble or abnormal condition exists at a particular sending station. The attendant then by means of sequence signaling over the local radio order circuit orders that particular station to send in a complete report on all of the circuits which are provided with alarm features.



*EACH OF THE MAX. OF 6 STATIONS ON ONE ALM. LINE IS ASSIGNED A DISTINCTIVE STATION FREQUENCY: 1100, 1300, 1500, 1700, 1900 OR 2100 CYCLES.

Fig. 14 - Block Diagram of C1 Alarm and Control System

(c) Since as many as 12 stations may be bridged on one local radio order circuit, and since each station is capable of receiving 10 orders, it is required that the alarm center be capable of sending 120 distinct signals. This is accomplished through a sequence signaling system incorporating an oscillator which generates a 1600-cycle carrier. This carrier may be modulated with any one of 12 different lower frequencies (277.5 cycles to 442.5 cycles in 15 cycle steps) under control of a relay switching circuit. By using any two of these modulated frequencies in sequence the 120 required combinations may be obtained.

(d) Each unattended station has a detection circuit bridged on the local order circuit. This circuit through use of reed-type selectors is capable of recognizing only the 10 orders with which it is concerned. Upon receipt of an order to report its alarm conditions, all of the alarm circuits (maximum 42) are scanned in order. For each circuit scanned, a 900-cycle pulse is sent out over the alarm line to the alarm center. If an alarm condition exists a 700-cycle tone is sent out simultaneously with the 900-cycle tone. In addition, pulses are sent telling which of the possible six stations is sending in the report and also synchronizing pulses to assure the attendant at the alarm center that the system is operating correctly. At the alarm center a detection circuit is provided to recognize these indications signals and to light lamps in a display lamp bank in synchronism with the incoming indication pulses.

11. LOCAL AND EXPRESS ORDER CIRCUITS

11.01 Local order circuits are required for local or sectional maintenance. These circuits terminate at a main repeater or terminal station and have appearances at the associated auxiliary repeater stations and the maintenance and alarm centers. Fig. 15 shows how this applies to the New York-Chicago circuit. The order circuit is also used to transmit the two short sequential tones directing certain operations to be performed at the auxiliary station as noted in connection with the Cl Alarm in Part 10. The order circuit is comprised of a 4-wire backbone circuit from which branch 4-wire circuits extend out to the auxiliary repeater stations. Signaling the auxiliary station is accomplished by means of the sequence signaling equipment of the Cl alarm system. To call the alarm center from the auxiliary station, a 900 cycle tone is applied to the line by means of a key for a period of time (about five seconds) appreciably longer than the length of the 900 cycle pulses used in sending in the indication signals. The station alarm receiving circuit will respond to this longer period by ringing a service bell and lighting a service lamp. Since signaling facilities are provided only between an auxiliary repeater station and its associated alarm center, loudspeakers are provided to enable the repeater stations to signal each other. A circuit description is given in CD-56227-01. BSP A320.572 covers Tracing and Clearing Trouble.

11.02 Express order wire circuits are required for systemwide maintenance of the radio system and for traffic control. These circuits terminate at the end terminal stations and have appearances at all intermediate main repeater and terminal stations and at all alarm and maintenance centers. Sequence signaling transmitting and receiving equipment is provided at each appearance of the order circuit. At alarm centers, the sequence signaling transmitter is provided as part of the Cl alarm system so that only the receiving equipment is additional. A circuit description is given in CD-56228-01.

12. TEST EQUIPMENTS

(A) General

12.01 Most of the equipment used for testing the equipment associated with the TD-2 Radio System is included in three assemblies, viz., the J68340A Test Bay (BSP R70.200), the J68333A Test Bench (BSP R70.210) and the J68337A FM Test Console (BSP R70.160). The 72A Frequency Meter used in testing equipment associated with the Cl alarm (BSP E40.571) is not included in the above.

(B) Test Bay (J68340A)

12.02 The test bay consists of several units of test equipment mounted in a rack in a movable 7'-6" cabinet, as shown in photograph L (page 112). The base of the test bay is 33-7/8" wide and 24" deep. With all the panels in place, the bay weighs about 400 lbs. The power required is approximately 10 amperes at 110-120 volts, 60 cycles, single phase, 3-wire ac. There are two versions of this equipment, one of which is used to test the over-all radio transmitter-receiver bay at auxiliary stations and to localize trouble therein. This equipment does not include an IF sweep oscillator and leaves out two of the four IF attenuators which are found in the more complete equipment. The other type of test bay, which includes the units mentioned above, is used at main stations and terminals; and, in conjunction with the J68333A test bench, at repair centers. The units included in the test bay are discussed briefly below with a more complete discussion in BSP R70.200, J68340A Test Bay.

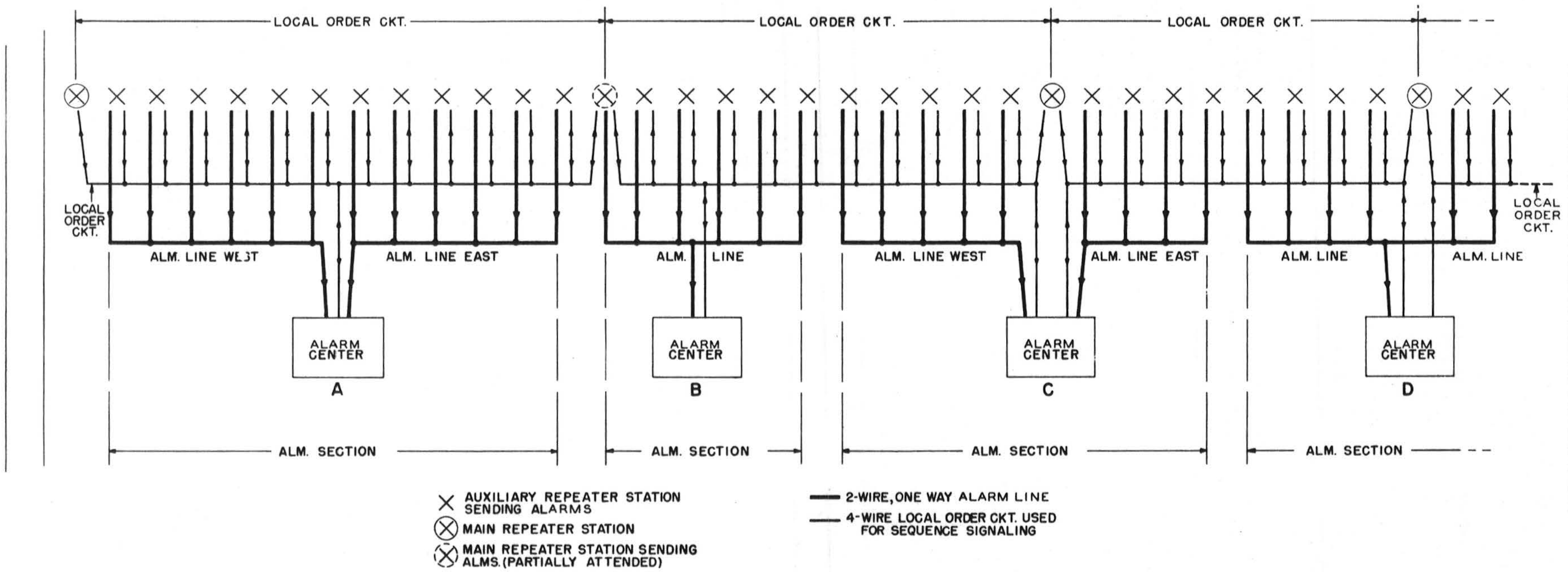


Fig. 15 - Typical Alarm Lines and Local Order Circuits Used for C1 Alarm and Control System

12.03 The J68340J Filament and Bias Supply is a 3-1/2" panel on which are mounted a single 396A rectifier tube and associated circuits for providing filament and bias supply for the oscilloscope preamplifier.

12.04 The J68340K Power Supply provides the 6.3 volts a-c and 180 volts regulated dc for the J68340E Power Meter. The tube complement consists of one tube each of the following types: 6X5GT, 6V6, 423A, and 12AX7.

12.05 The J68340H 4000 MC Sweep Oscillator provides a test signal (max. 1 watt) in the range 3700-4200 mc which may be either a steady signal or swept over a band of 80 mc or less. The unit employs a 402A vacuum tube of the velocity-variation type.

12.06 The Dumont 2551 Oscilloscope is a standard commercial type with provision for 60-cycle blanking of the return trace.

12.07 The J68340E Power Meter enables power measurements of either IF or microwave signals. When measuring IF power, the coaxial input jack IF IN is used. When measuring microwave power, a J68340F Measuring Head is used which is separate from the power meter and is connected to the panel jack RF IN through a flexible cable. This head permits direct connection to .290" by 1.145" waveguide. The range is from -10 to +6 dbm.

12.08 The IF attenuator panel includes four pushbutton attenuator units. Two of these are omitted in List 2 of the test bay.

12.09 The J68340D IF Detector Panel includes two separate IF detectors, and IF frequency meter and a preamplifier for the oscilloscope.

12.10 The J68340C IF Sweep Oscillator provides a test signal which may be either a single frequency or may be swept over the range 50-90 mc. This unit also has incorporated with it a 30-cycle switch which enables both the reference trace and the test output signal to be viewed on the oscilloscope. In List 2, which omits the IF sweep oscillator, a J68340M 30-cycle switch must be provided.

12.11 The J68340B Meter and Control Panel, a J68225A 150-volt rectifier and a KS-5789 1500-volt rectifier complete the equipment units. However, a number of demountable waveguide fittings and calibrated waveguide attenuators which are used in various combinations for various types of tests are supplied with the test bay.

<u>(C) Test Bench (J68333A)</u>

12.12 The J68333A Test Bench is pictured in the photograph M (page 113). On the work bench are mounted a J68330H Shifter (less the 40 mc generator), a J68333E Control Panel, a J68330M Transmitter Control Panel, a J68330B Receiver Control Panel and a J68330G Microwave Generator. Crystals for all the frequencies in the maintenance area will need to be provided. In addition, the bench is equipped with miscellaneous waveguide sections, attenuators, patch cords, an IF directional coupler, signal inserter, jacks, plugs, etcetera. The bench is discussed in detail in BSP R70.210, J68333A Test Bench.

<u>(D) FM Test Console (J68337A)</u>

12.13 The J68337A FM Test Console, shown in photograph N (page 114), is used to maintain and align the FM terminal transmitter and the FM terminal receiver. The principal tests are those of linearity, frequency checking, frequency deviation, video-frequency wave form and voltage measurements. The console stands approximately five feet high on four caster wheels and is about 30" square. Removable doors are provided on all sides. The top surface is sloped from front to back at 40 degrees to provide a convenient control area. Here are located the KS-5782 Signal Generator, the J68650A Oscilloscope and the control panel. Below are located the J68337C Linearity Test Set and the J68336G FM Terminal Receiver. The J68337B Electronic Switch and power supplies are located inside the console to the rear. The test console is discussed in more detail in BSP R70.160, J68337A Test Console.

12.14 The KS-5782 Signal Generator is used for testing the intermediate-frequency circuits of the TD-2 Radio System. The generator is continuously tunable from 50 to 90 mc. The maximum output is 0 dbm with a continuously variable attenuator providing a 120 db range in output power. The signal generator is mounted on a 19" panel 10-15/32" high and projects 9-1/2" behind the panel. The generator operates from 117 volts, 50/60-cycle power source and requires about 100 watts. The unit is discussed in detail in BSP R70.190, KS-5782 Signal Generator.

12.15 The J68650A Oscilloscope is a modified RCA WO-79A oscilloscope. This unit is described in RCA Instruction Manual 1B-4179-1, WO-79A Oscilloscope.

12.16 The J68337C Linearity Test Set is designed primarily to measure the repeller voltage versus frequency characteristic of the FM transmitter, the linearity of the frequency versus output voltage characteristic of the FM receiver and the linearity of the over-all TD-2 system. The panel is designed for 19" rack mounting and is 8-1/2 inches high. The power requirements are 117 volts, 60 cps, 150 watts. The unit is discussed in detail in BSP R70.180, J68337C Linearity Test Set.

12.17 The J68336G FM Terminal Receiver is a standard FM receiver such as is used in the FM terminal, and mentioned in Pars. 7.05, 7.06, and 7.07. The unit is described in detail in BSP R20.360, J68336G FM Terminal Receiver.

12.18 The J68337B Electronic Switch is a broadband IF amplifier which switches automatically between two input signals and delivers alternate samples of these two signals at its output. The unit is contained in an 8-3/4" by 19" panel and includes a regulated rectifier for plate supply. The set operates on 105 to 125 volts, 50-60 cycle a-c and requires an input of approximately 50 watts. This unit is discussed in detail in BSP R70.170, J68337B Electronic Switch.

12.19 The J86225D 130-volt Rectifier (BSP A301.325) and the J86226D 250-volt Rectifier (BSP A301.326) are located inside the console.

12.20 The tube complement of the J68337A FM Test Console is as follows:

Equipment	Vacuum Tubes													
	396A	403B	404A	409A	412A	418A	421A	422A	423A	6AL5	6AQ5	12AX7	OA2	OA3
Electronic Switch	1		2	2	1				1		2	2		
Linearity Test Set	4				1				1		3	3		
FM Receiver	6	1	8			2			1	1				
130V Rectifier		2					1	1						1
150V Rectifier		2					1	1					1	

Equipment	Vacuum Tubes												
	2X2A	3KP1	5U4G	5Y3GF	6AC7	6AG7	6AL5	6C4	6H6	6SH7	6SN7GT	OD3	VR105
Oscilloscope	1	1	1		3	4			1	1	3	1	
Signal Generator				1			1	1					1

(E) Miscellaneous Test Equipment

12.21 The J64001AK Tube Test Set provides means for testing the cathode activity of 404A tubes used in the buffer, auxiliary, switching and distributing amplifiers while those amplifiers are in service. Means are provided for changing the heater voltage of the vacuum tube under test from normal to 10% below normal and then measuring the change in the grid-cathode voltage. The unit is described in BSP R70.270, J64001AK Tube Test Set.

12.22 The J64072A Frequency Meter is used in connection with tests of the C1 Alarm and Control System. The frequency meter may be used as a source of frequencies in the range 100 to 4000 cps or it may be used to measure an unknown frequency. The accuracy is ±1 cps at the lower frequencies and ±1/10 of one per cent at the higher frequencies. The unit is described in BSP E40.571.

12.23 The 61B Signal Generator consists of two independent signal generators in one test set, and is used for making point-by-point gain-frequency measurements over the video band on the FM terminal equipments and on the over-all system:

(a) A sine-wave generator continuously variable from 300 kc to 10 mc in five bands selected by push buttons. In addition, fixed frequencies of 60 cycles, 5, 10, 25, 50, 75, 100, 150, 200, and 250 kc, and 2 and 4 mc are available on push-button keys. The output level of the oscillator is controlled by a precision attenuator from +10 dbv to -60 dbv in 1-db steps. Output impedances of 75 ohms unbalanced or 110 ohms balanced are available. A vacuum tube voltmeter is provided to permit accurate adjustment and continuous monitoring of the power delivered to the attenuator. The frequency accuracy is ±3 per cent, harmonic level -40 db, absolute output level accuracy ±0.25 db, and differential frequency distortion ±0.1 db. This oscillator is used to transmit signals of known levels into the television loop when making transmission measurements over the video-frequency band. The fixed frequencies are those most often required when adjusting the circuit equalization.

(b) A 15.75-kc video signal generator delivers a 2-volt peak-to-peak maximum output into a 75-ohm unbalanced impedance. This signal consists of a wave which changes polarity abruptly in two successive steps in each cycle. The cycle starts at the extreme negative polarity where it remains for approximately 5 microseconds, after which it sharply rises positively about 25% of its amplitude, where it remains for an interval variable between 10 and 45 microseconds. It then sharply rises to the maximum positive value where it remains until the end of the cycle, at which time it sharply drops to the extreme negative value for the start of the next cycle. The 5-microsecond portion of the signal simulates a synchronizing pulse and the 10-45-microsecond portion simulates a picture signal. Controls are provided for varying the amplitudes and widths of the sync and picture signals. The rise and decay time of the effective portion of the video signal is less than 0.2 microsecond. A 60-cycle square-wave modulation of the video signal is provided under control of a switch, for the purpose of introducing the frame frequency present in a television signal. This is necessary when testing clamper circuits. The 60-cycle wave alternately removes and restores the picture signal portion of the video signal while the sync pulse portion continues without interruption. The complete test set consists of a panel and several units, each of which may readily be disassembled from the main assembly for maintenance purposes without removing other units. All interconnections between units are carried through plugs and jacks to facilitate such disassemblies. The units contained in the 61B signal generator are as follows:

Sine-wave generator
Level monitor
Video signal generator
Power supply
Attenuator

The set is portable, and is arranged to operate from 105- to 125-volt, 60-cycle convenience outlets. The power input is approximately 125 watts. The unit is discussed in detail in BSP Section E47.404.

12.24 The 63A signal generator produces a composite signal similar to the standard television video signal except for the vertical synchronizing group. The negative synchronizing pulse is nominally five micro-seconds wide and is produced at a rate of approximately 15.75 kc but is not synchronized with the power frequency. It is adjustable over a considerable range. The positive "picture" signal follows the negative synchronizing pulse by about two micro-seconds, and consists of either a broad flat pulse having an adjustable duration of 15 to 50 micro-seconds, or a single, narrow, triangular spike approximately 0.3 micro-seconds wide at the base. The composite signal is modulated by a 60-cycle square wave so that the video signals are periodically disabled without interruption of the synchronizing pulses. The signal proportions are normally adjusted to give a peak-to-peak amplitude of one volt, with the synchronizing pulse equal to 30 per cent of the signal. The maximum peak-to-peak output is about two volts into a 75-ohm load. The set is portable, and is arranged to operate from 105- to 125-volt 60-cycle convenience outlets. The power input is approximately 125 watts. The unit is discussed in detail in BSP R70.540.

12.25 Other test equipment required for testing the C1 Alarm and Control Circuits include:

13A Transmission Measuring Set
5A Attenuator
35F or 35D Test Set
S1 Timer (with 24-volt clutch)

12.26 Other standard test equipment which will be required in connection with testing the TD-2 Radio System are

Weston Type 779 Analyzer
KS-5727 Tube Tester

13. TUBE COOLING SYSTEM

13.01 Cooling air for the 416A and the 418A vacuum tubes is provided from a central blower source and distributed by means of pipe and hose supported by the auxiliary framing in the radio equipment room. It is expected that this system will supply air to a maximum of 24 bays of radio equipment plus one test bench.

13.02 An air pressure switch KS-5793 is provided to actuate an alarm over the C1 alarm circuit. The switch is adjusted by the manufacturer to close contact at one ounce on decreasing air pressure and shall remain closed for any less pressure. The supplier includes a kit of orifices for each switch besides the one assembled but as either will work it is not necessary to change the one assembled. There is an adjusting screw to vary the contact pressure, but since a supply of test equipment is not available at the stations it is advisable to return defective units to the Western Electric Company for repair and readjustment. The pressure switch because of its sensitivity must be mounted on a wall or post that is free of vibration.

13.03 The blower is a three stage centrifugal device operated by a 1/4 H.P. AC motor, 115 volts, and is equipped with a fibre glass filter. Its capacity is 60 cu. ft. per minute at 3 ounces pressure (or 5 inches of water). An alarm is actuated when this pressure is reduced to 1 oz. The blower blades are mounted directly on the extension of the motor shaft. The motor for the blower has grease sealed ball bearings with an expected 3 to 5 year grease supply, it being necessary to add only 3 to 5 drops of an oil, supplied with the motor, once a year to restore the proper grease consistency. The removal of a small set screw located at the top of each bearing provides the means to add the special oil.

13.04 The filter has two fiber glass filters 20" by 20" by 2" thick as made by Owens Illinois Glass Co., (or an approved equivalent) that can be readily replaced by removing two clips held in place by bayonet pins and slots. They should not be used when clogged 50%. They can be cleaned somewhat by shaking or tapping on some firm object.

13.05 In case of failure of the AC motor due to power failure, a DC motor assembly carries the load operating from the 130 volt battery, at the same time bringing in a "motor failure" alarm into the C1 alarm and control system. If the failure is simply due to AC failure and AC power is restored the load is switched back automatically to the AC motor assembly assuming the air pressure has not dropped appreciably. The DC motor can be tested at the radio station by operating the AC FAIL TST switch and waiting 8 seconds for the DC motor to pick up the load. The PRESS FAIL TST switch should be operated to simulate a low air pressure alarm, such as due to failure of the 4C motor or the relay circuit, and in 27 seconds the DC blower should pick up the load. The DC motor will lock in should the air pressure be allowed to drop. It is then necessary for a man to go to the radio station and clear the trouble and when ready, operate the RLS switch to switch back from DC to AC operation. Since the motors are totally enclosed, their operation must be determined by the sound of the machine.

14. PHOTOGRAPH, DRAWING AND REFERENCE LISTS

(A) Photographs

(B) Drawings

Designation	Subject	Page
SD-59403-012	Application Schematic for Transmitter-Receiver Bay	126
SD-59403-013	Application Schematic for Transmitter-Receiver Bay	127

(C) References

(a) Radio FM terminal and Test Equipments

BSP R40.160	KS-5759 Antenna
BSP R10.300	J68336A FM Terminal Transmitter
BSP R20.360	J68336G FM Terminal Receiver
BSP R60.040	Patching and Monitoring Equipment
BSP R60.060	J68338A&B Switching and Distributing Amplifiers
BSP R60.070	J68338C IF Auxiliary Amplifier
BSP R60.080	J68338D Video Monitoring Amplifier
BSP R70.160	J68337A FM Test Console
BSP R70.170	J68337B Electronic Switch
BSP R70.180	J68337C Linearity Test Set
BSP R70.190	KS-5782 Signal Generator
BSP R70.200	J68340A Test Bay
BSP R70.210	J68333A Test Bench
BSP R70.230	J68340E Power Meter
BSP E40.571	J64072A Frequency Meter
BSP R70.270	J64001AK Tube Test Set
BSP E47.404	61B Signal Generator
BSP R70.540	63A Signal Generator
BSP R90.310	J68331A Radio Transmitter-Receiver Bay
BSP R100.010	Sitting of Fixed Radio Stations
1B-4179-1	RCA Instruction Manual W079 Oscilloscope
--	Polarad Instruction Manual KS-5799 Video Monitor

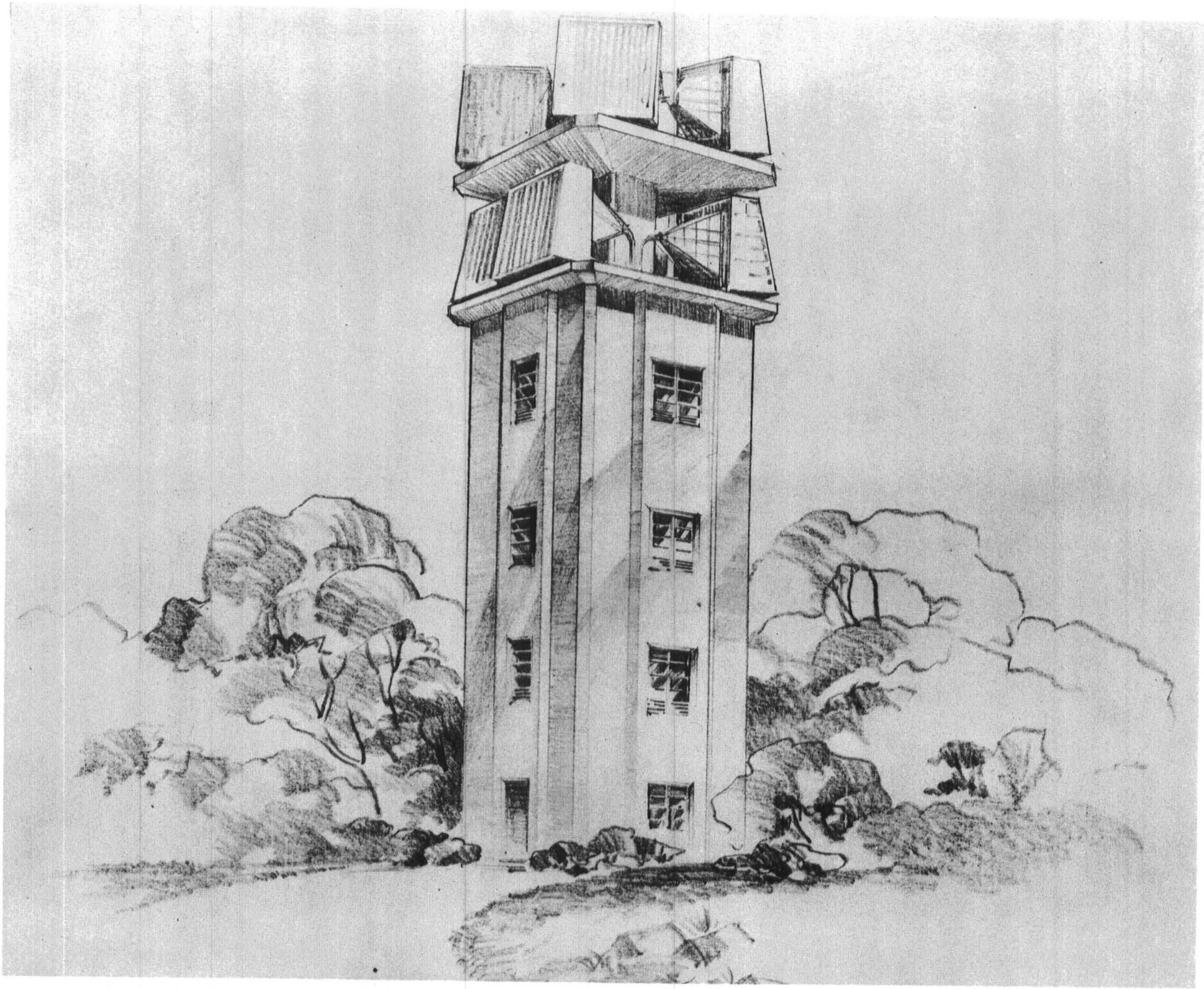
(b) Power Equipment

BSP A301.304 -	KS-5663 120-volt Rectifier
BSP A301.318 -	KS-5789 1500-volt Rectifier
BSP A301.325 -	J86225D 150-volt Rectifier
BSP A301.326 -	J86226D 200-volt Rectifier
BSP A301.332 -	J86240 130-volt Rectifier
BSP A301.335 -	J86243 24-volt Rectifier
BSP A301-336 -	J86244 12-volt Rectifier
BSP A301.247 -	KS-5636 Engine Alternator Operating Methods
BSP A301.247 -	KS-5636 Engine Alternator Apparatus Requirements and Adjustment Procedures
BSP A301.821	425A Power Plant - J86437·130-volt Plate Supply
BSP A301.822	425A Power Plant - J86438 250-volt Plate Supply
BSP A301.823	425A Power Plant - J86439 12-volt Filament Supply
BSP A301.824	425A Power Plant - J86440 24-volt Power Supply

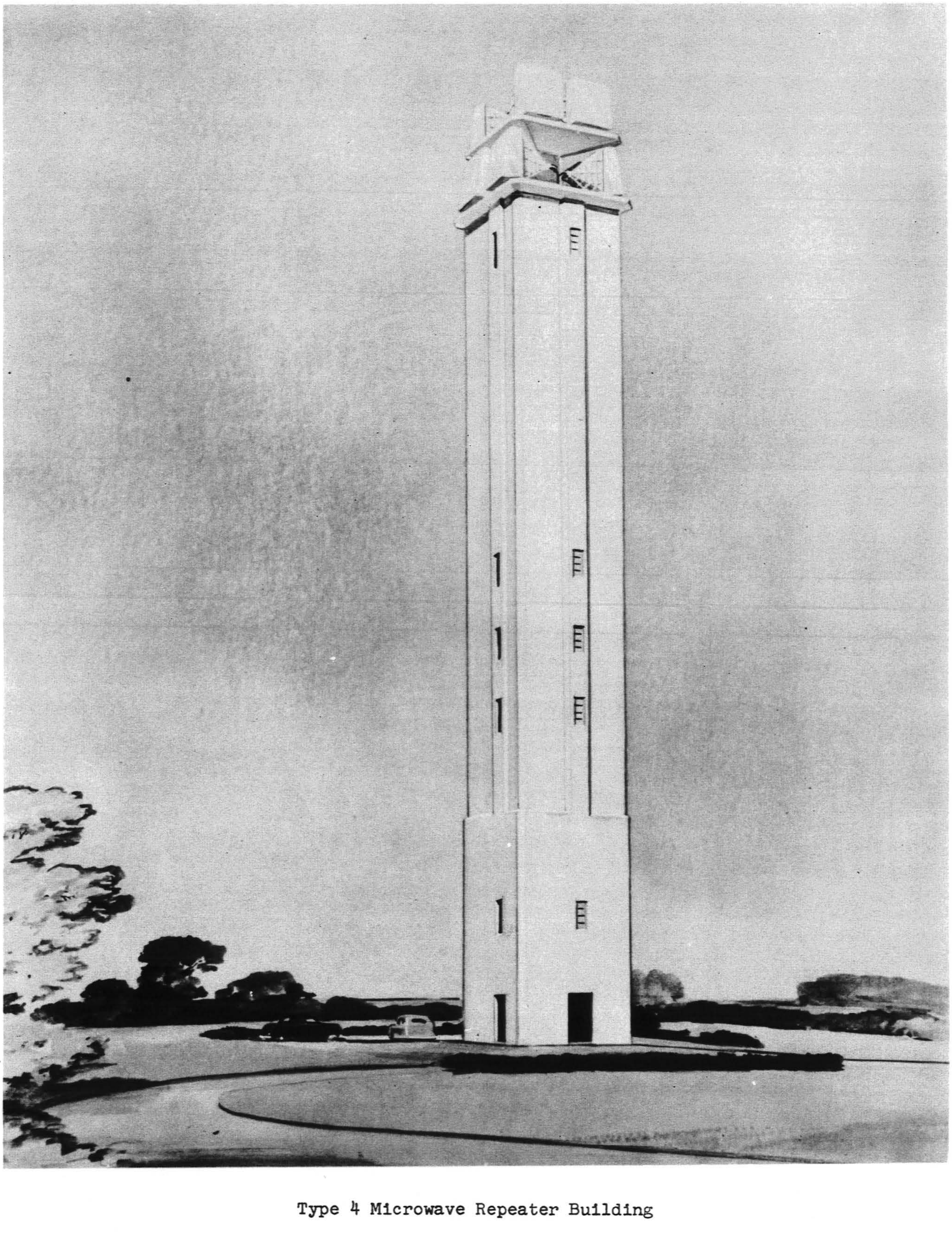
(c) Cl Alarm and Order Circuits

BSP A220.961	Cl Alarm and Control - Test and Inspection
BSP A220.962	Sequence Signaling and Order Circuits - Test and Inspection
BSP A320.571	Cl Alarm and Control - Tracing and Clearing Trouble
BSP A320.572	Order Wire Circuits - Tracing and Clearing Trouble
BSP A820.911	Cl Alarm, Sequence Signaling and Order Circuit - Description

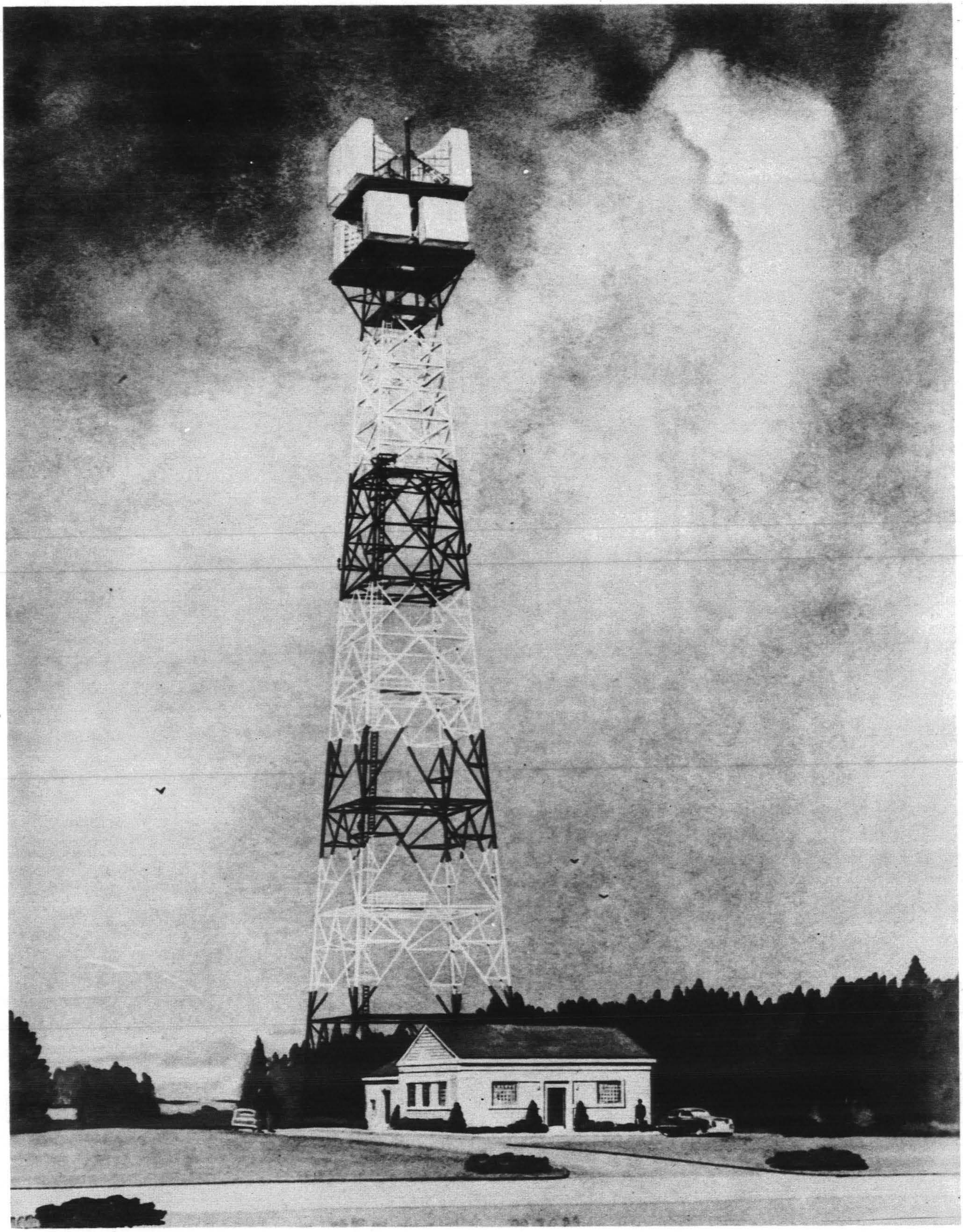
Bell Telephone Laboratories, Inc.



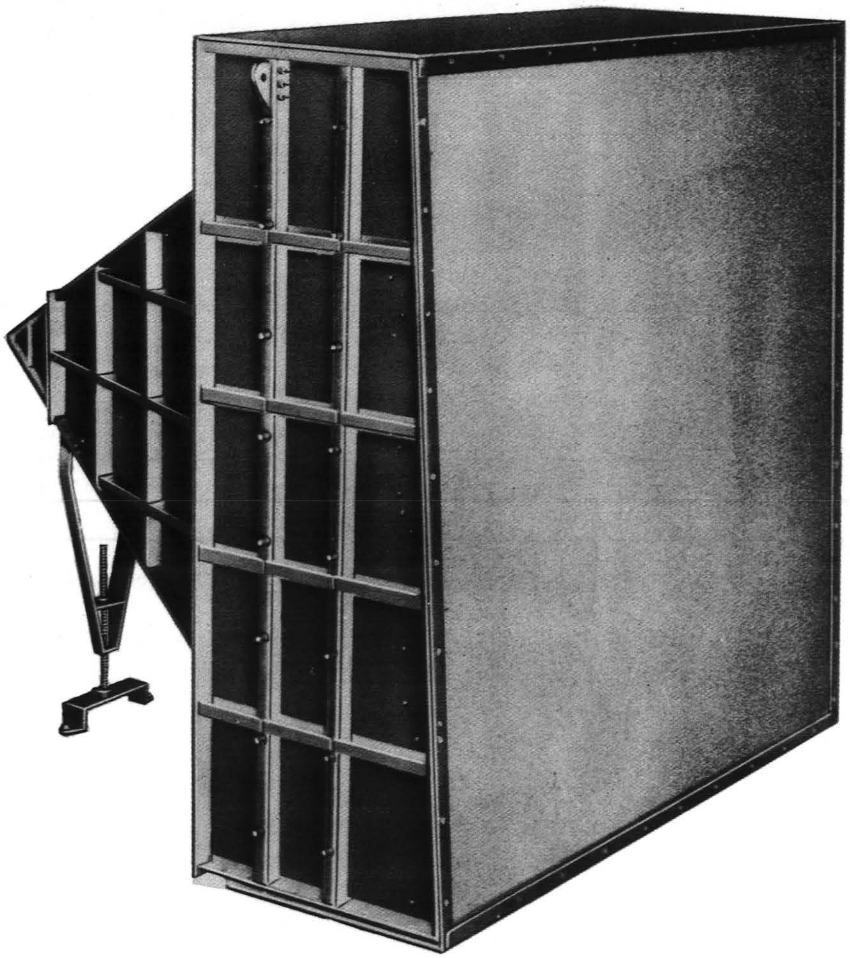
Type 1 Microwave Repeater Building



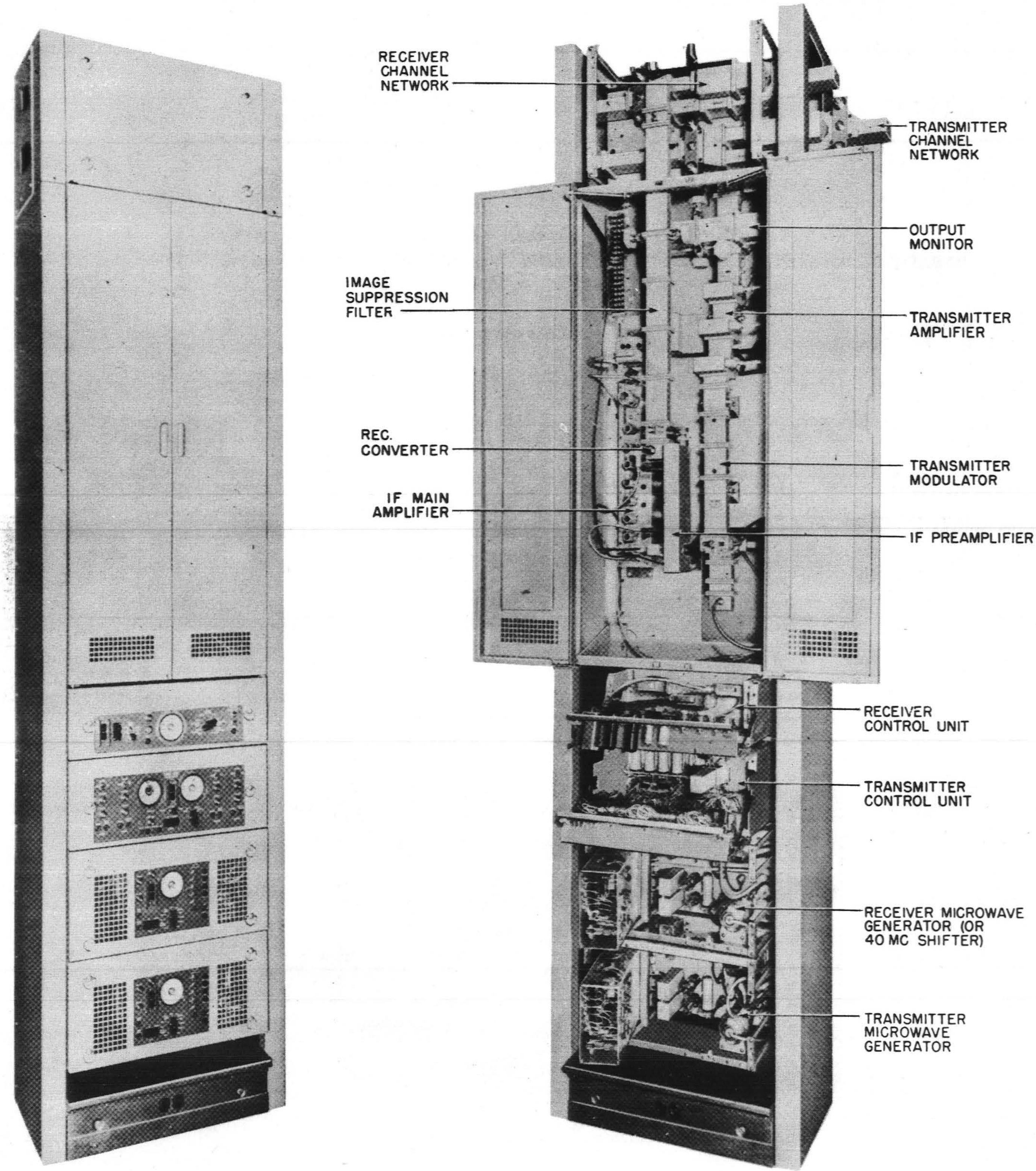
Type 4 Microwave Repeater Building



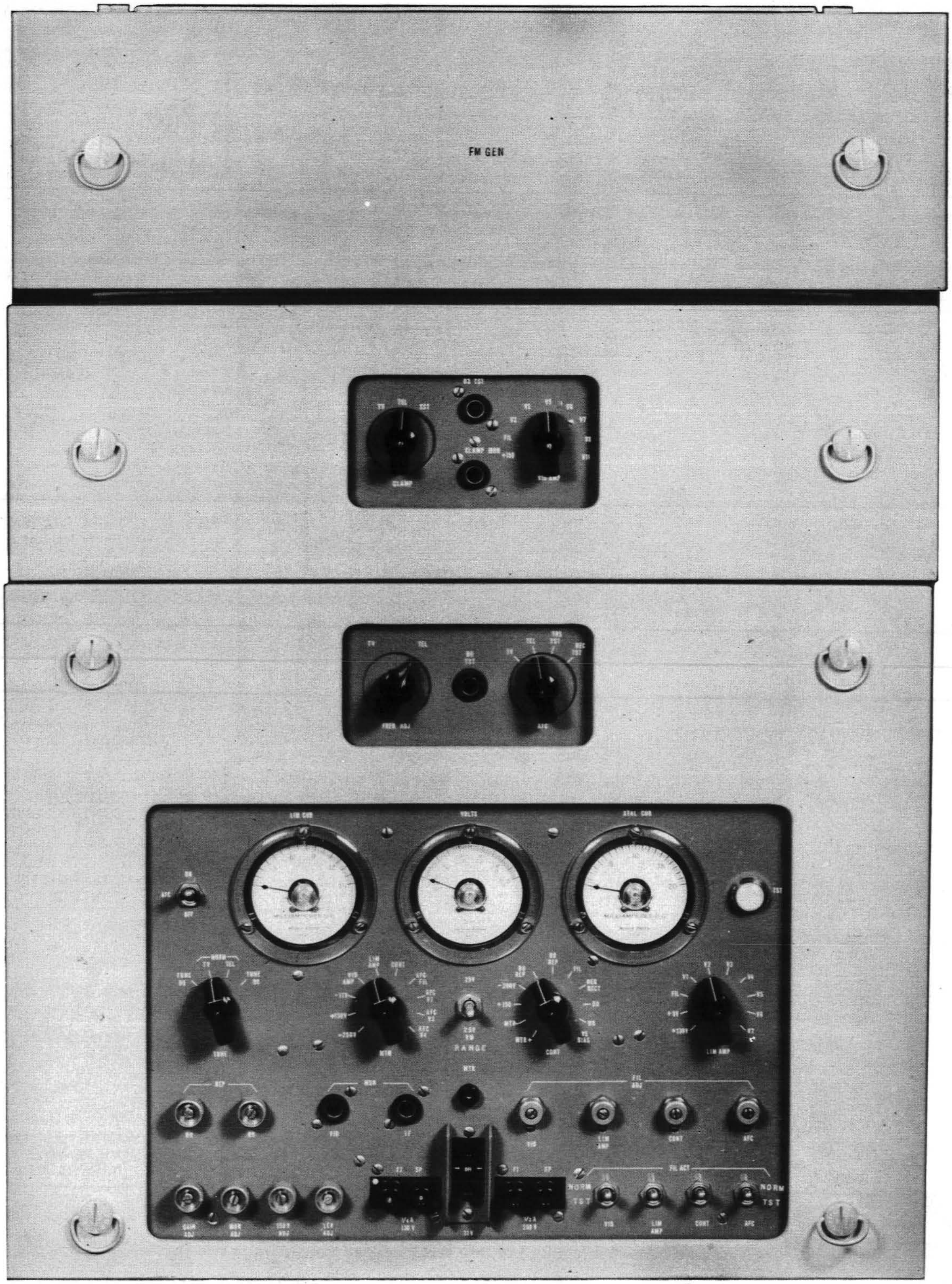
Steel Tower and Single Floor Building



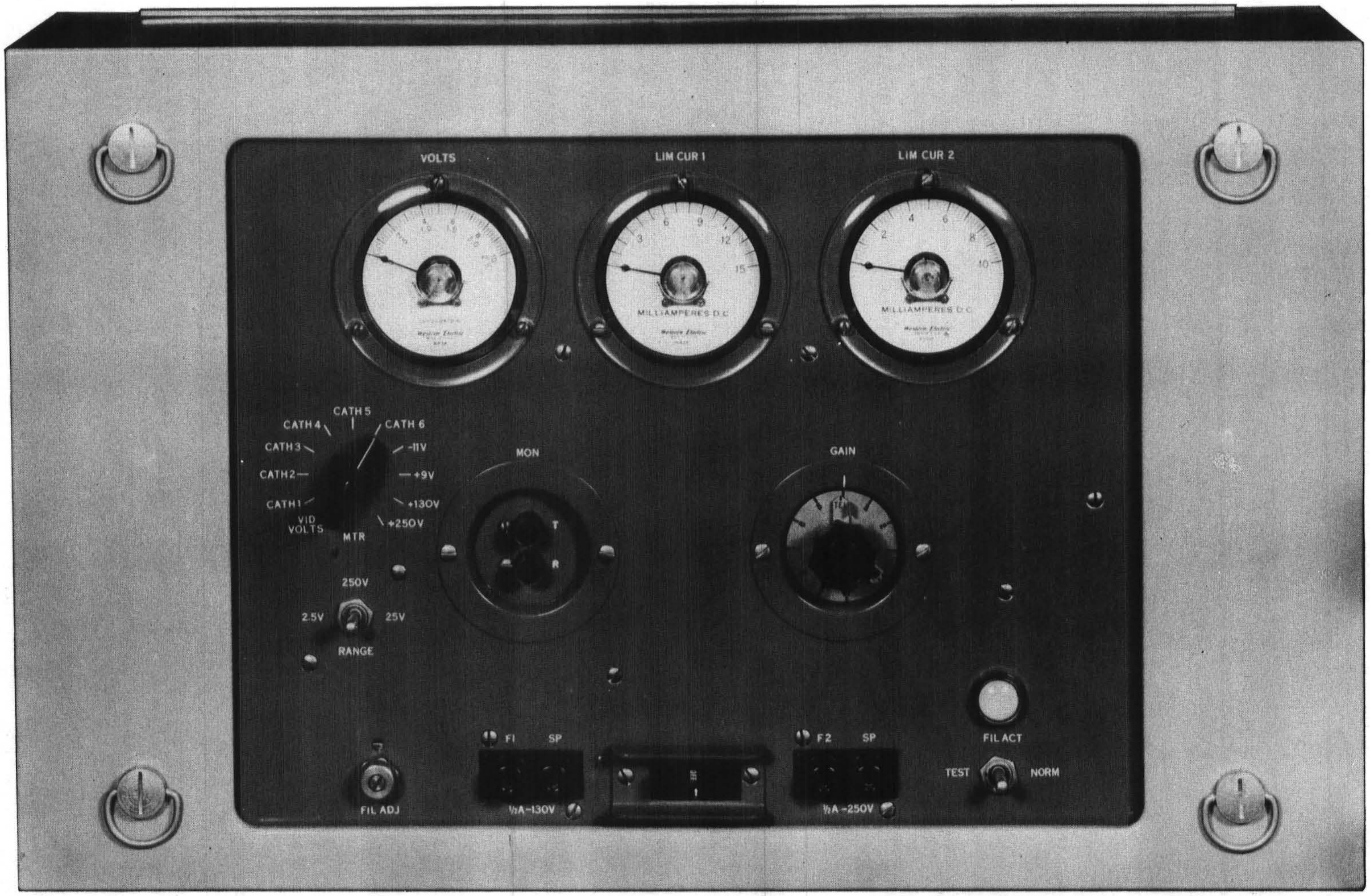
KS-5759 Antenna



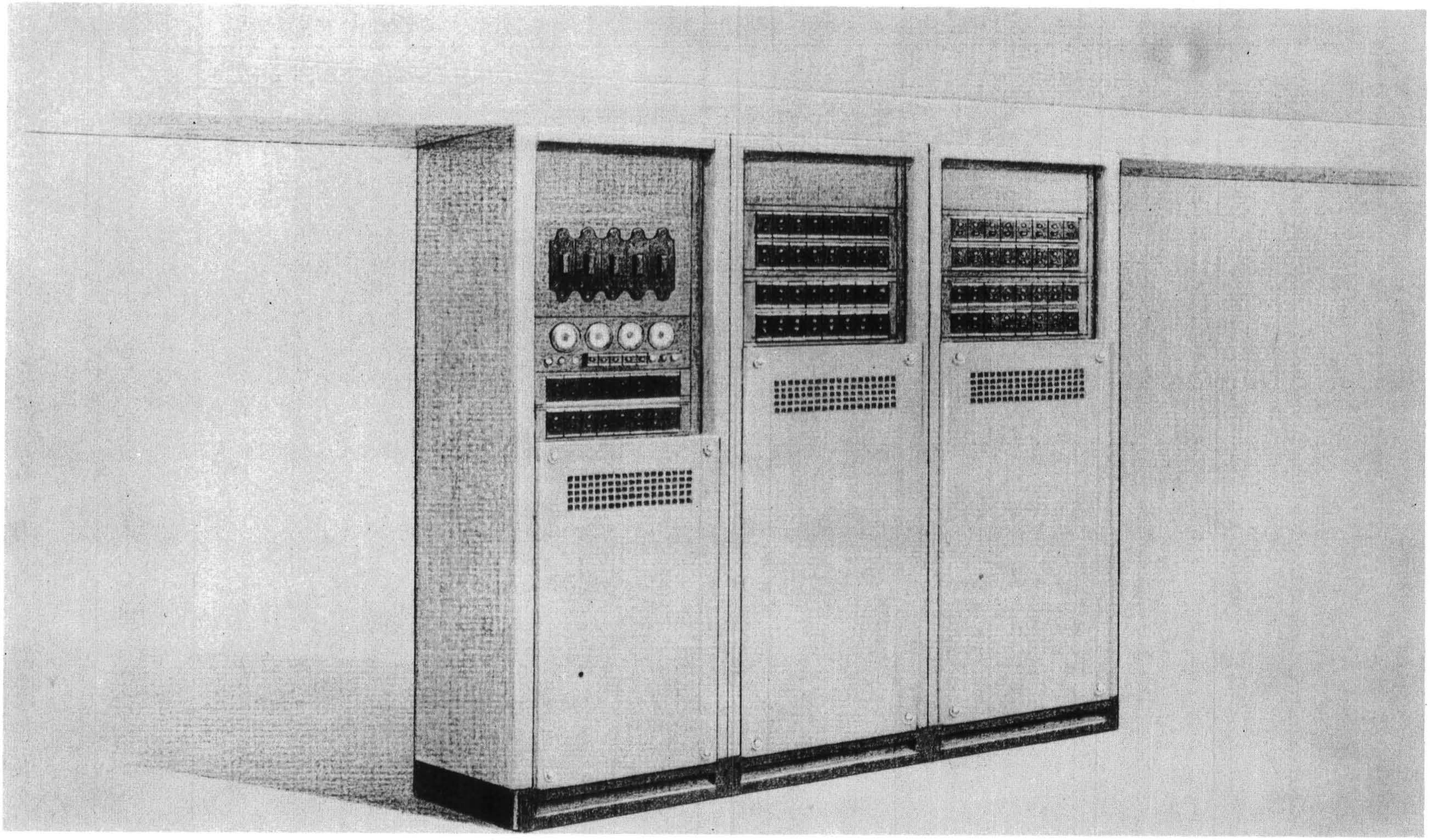
TD-2 Radio Transmitter-Receiver Bay



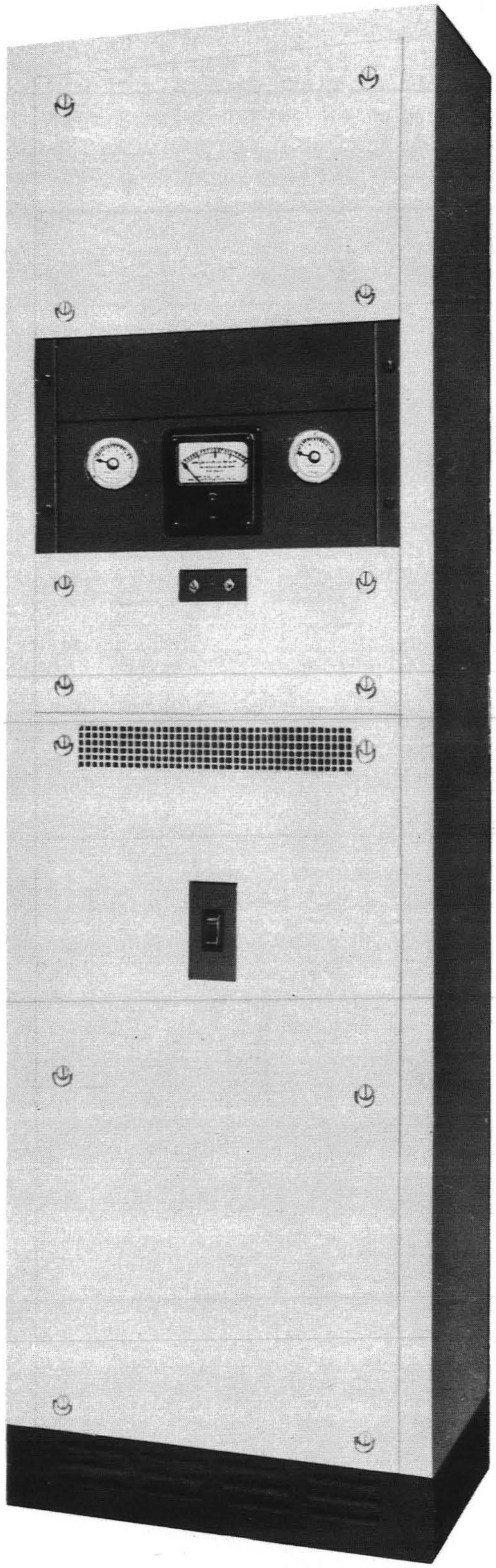
FM Terminal Transmitter



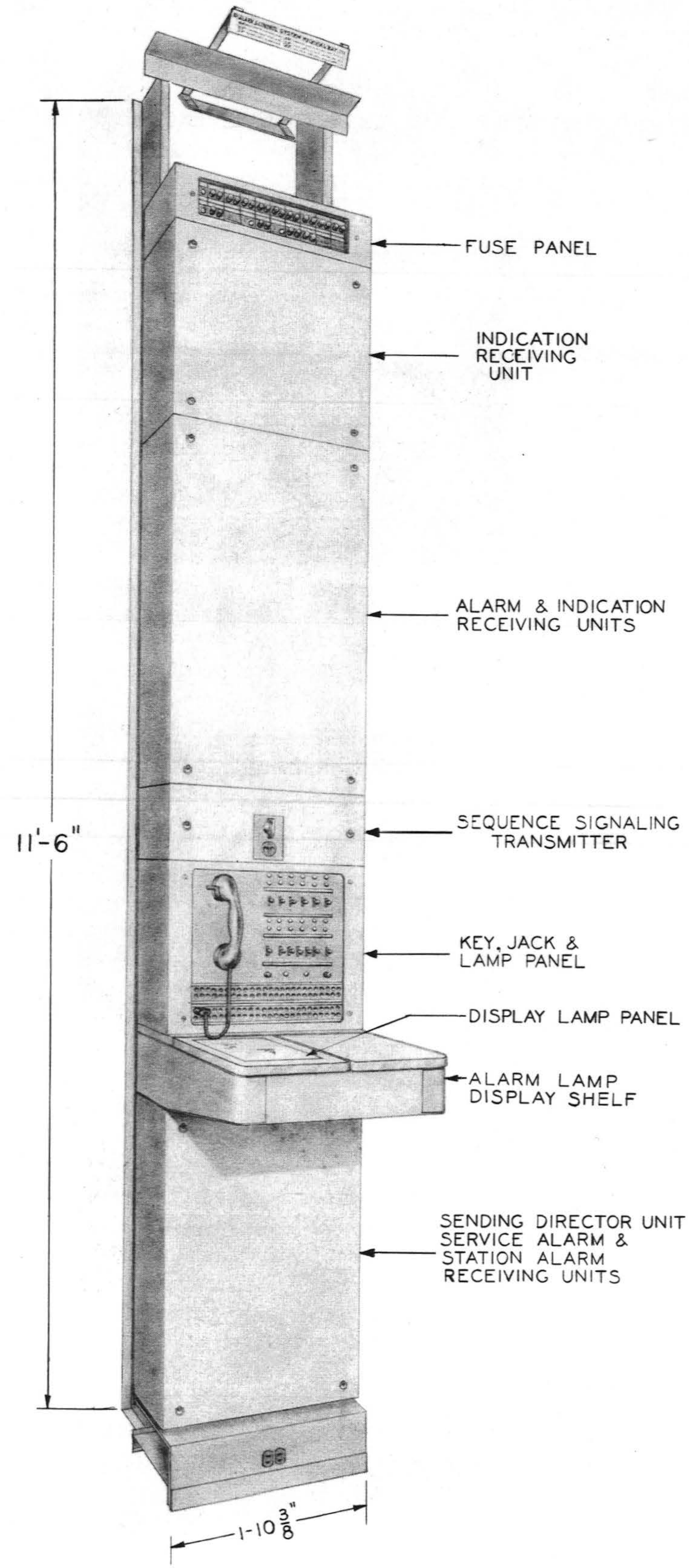
FM Terminal Receiver



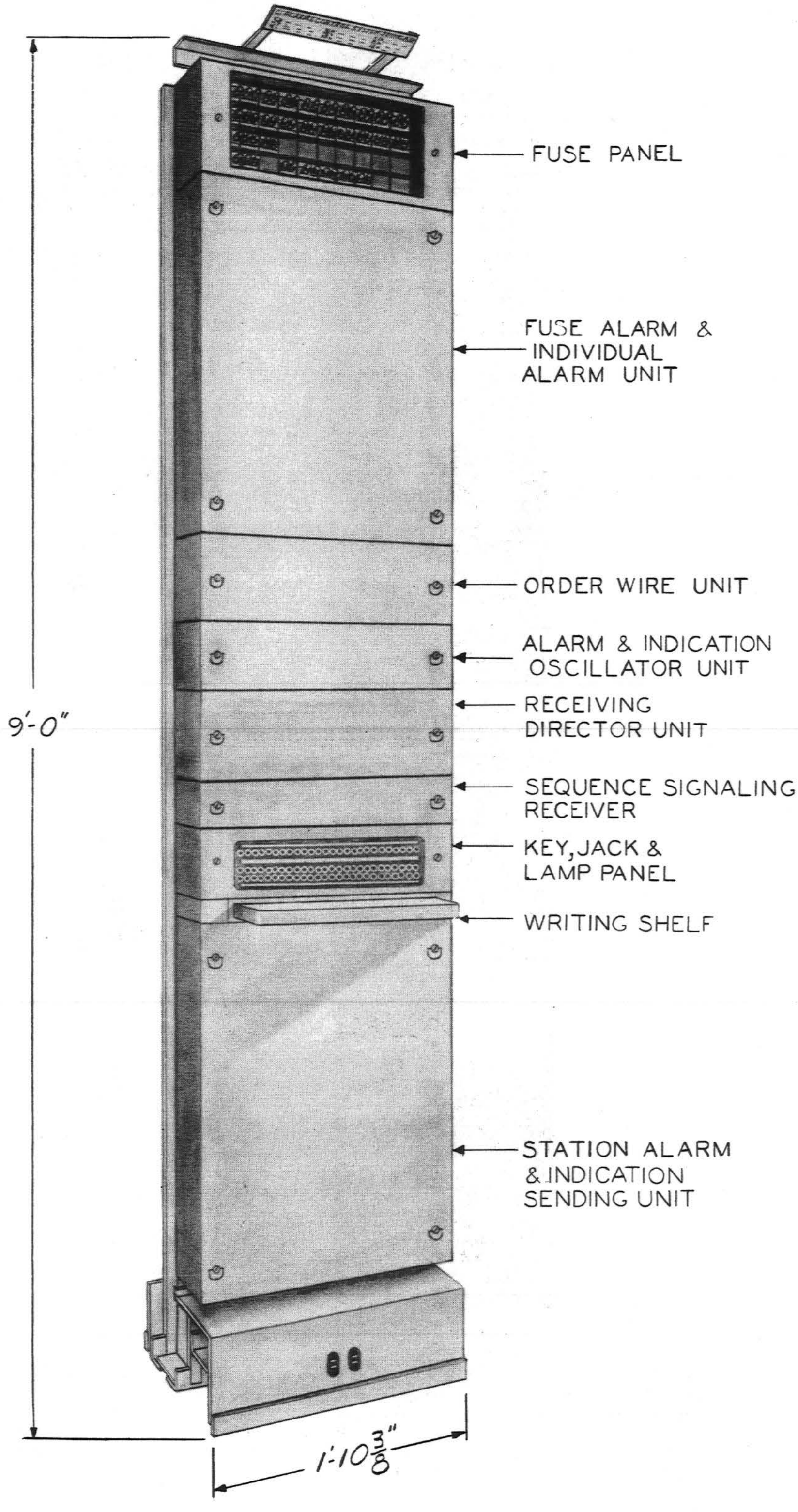
12-volt Control and Distribution Bay



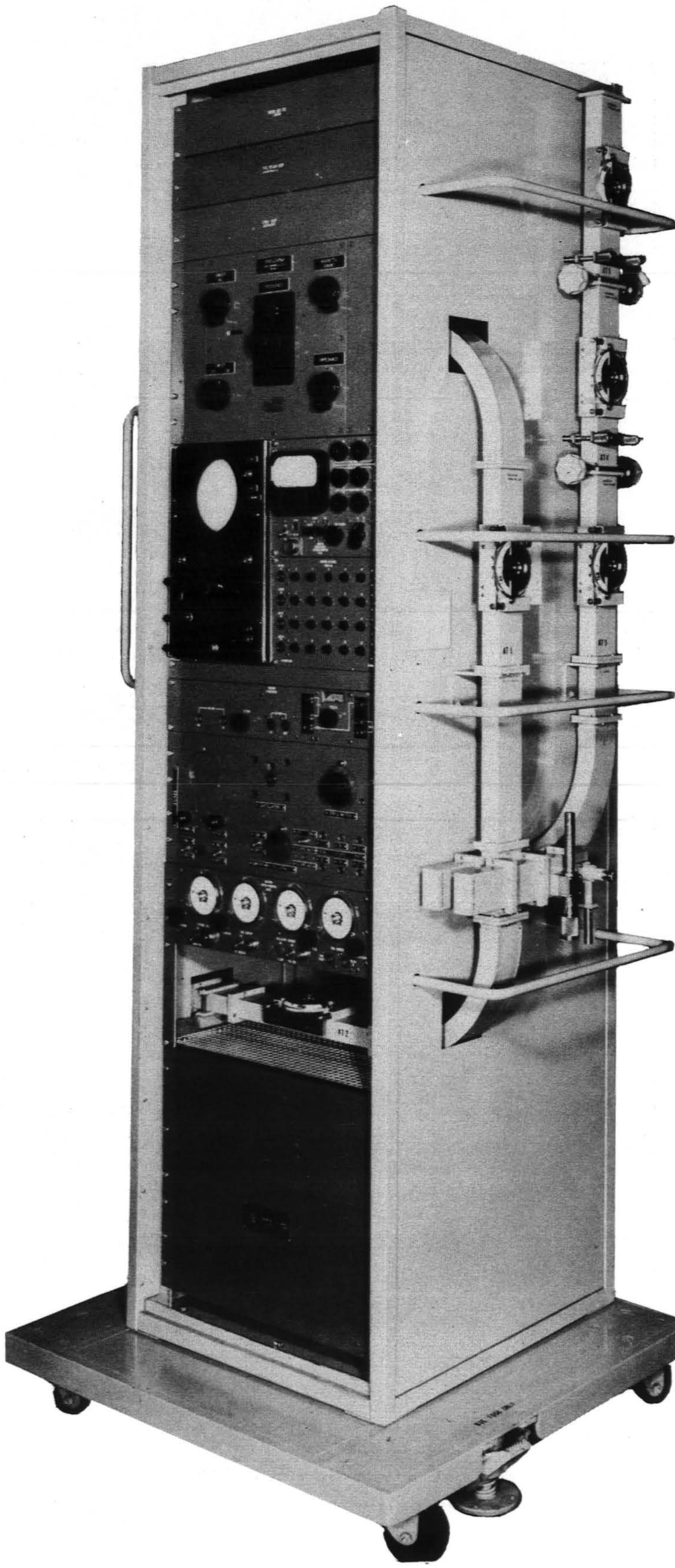
12-volt 200 Ampere Rectifier



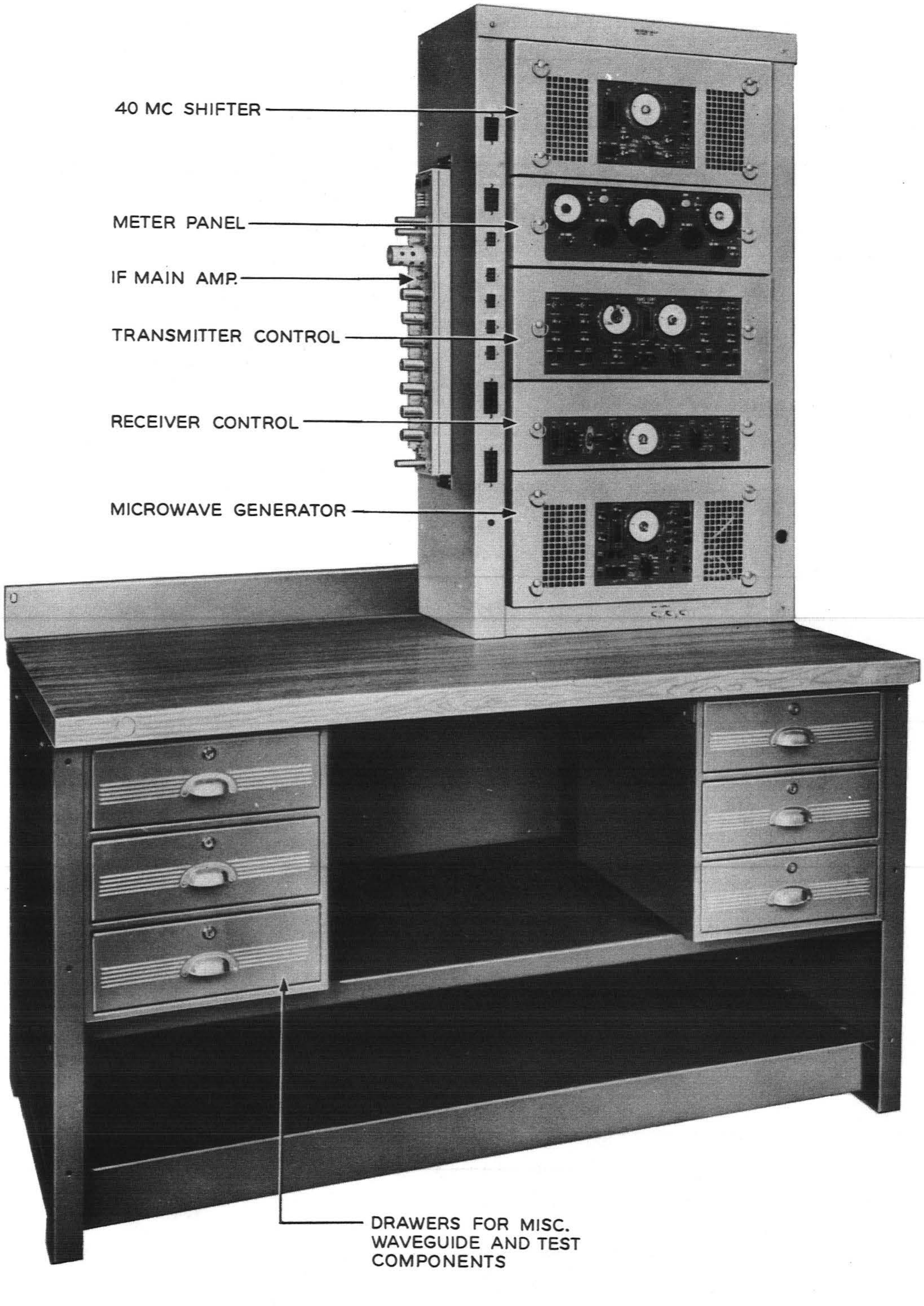
C1 Alarm Receiving Bay



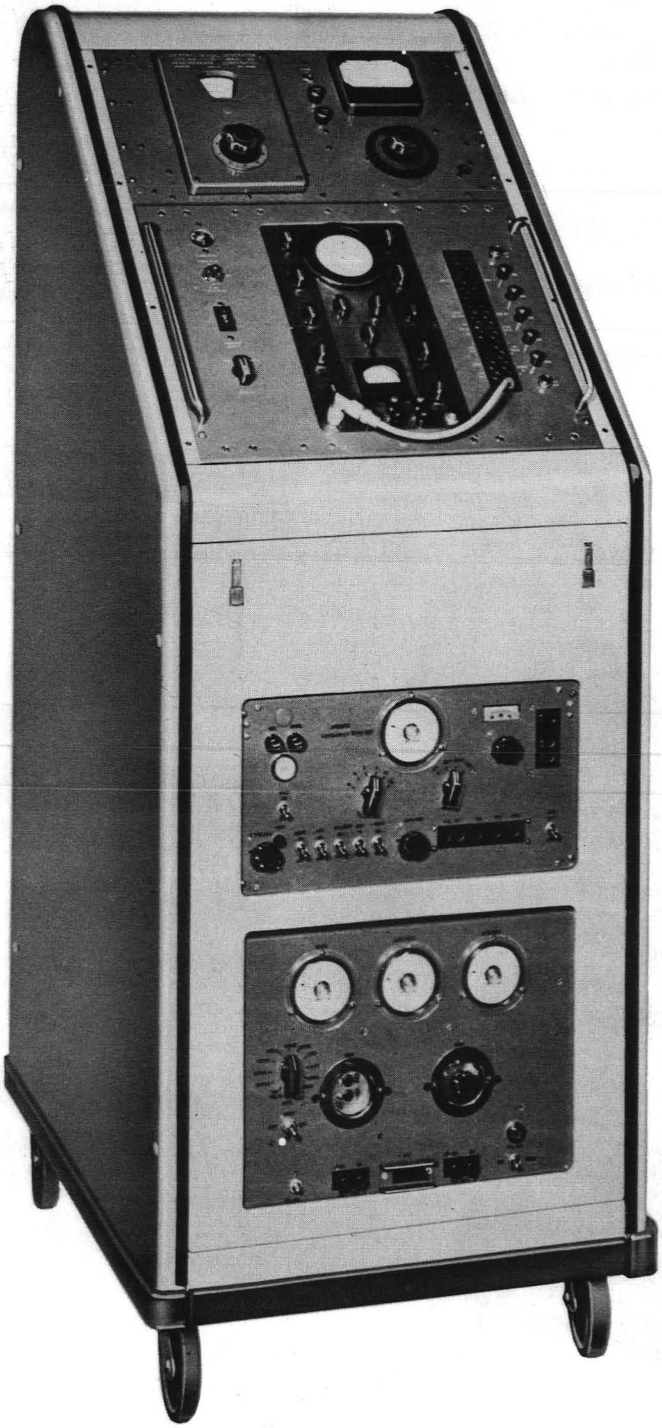
C1 Alarm Sending Bay



Radio Test Bay

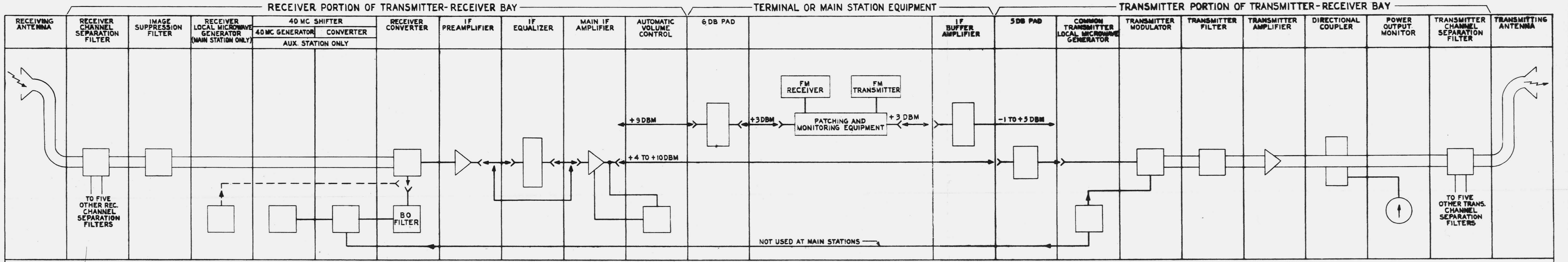


Radio Test Bench



FM Test Console


CHICAGO
TERMINAL
85 W. CONGRESS ST.
(ILL. BELL TEL. CO.)
ELEV. 755'
LAKE MICHIGAN
23.8 MILES
CHICAGO HEIGHTS
ELEV. 720'
34.8 MILES
16.5 MILES
VALPARAISO
ELEV. 867'
29.3 MILES
LA PORTE
ELEV. 917'
MISHAWAKA
ELEV. 925'
24.4 MILES
GOSHEN
ELEV. 970'
28.3 MILES
LA GRANGE
ELEV. 959'
18.1 MILES
ANGOLA
ELEV. 1120'
20.9 MILES
MICHIGAN
OHIO
BRYAN
ELEV. 900'
25.5 MILES
WAUSEON
ELEV. 778'
17.1 MILES
SWANTON
ELEV. 677'
16.1 MILES
TOLEDO
HQTRS BLDG
121 HURON ST.
(OHIO BELL TEL. CO.)
ELEV. 720'
ONTARIO
MICHIGAN
ONTARIO
OHIO
LAKE ERIE
GIBSONBURG
ELEV. 654'
25.5 MILES
SANDUSKY
CASTALIA
ELEV. 781'
24.2 MILES
BIRMINGHAM
ELEV. 874'
13.1 MI.
LORAIN
ELEV. 755'
24.5 MI.
CLEVELAND
HQTRS BLDG
750 HURON RD.
(OHIO BELL TEL. CO.)
ELEV. 1018'
16.8 MI.
RICHFIELD
ELEV. 1170'
20.5 MILES
SHALERSVILLE
ELEV. 1298'
AKRON
YOUNGSTOWN
31.9 MILES
WINONA
ELEV. 1400'
26.4 MILES
FAIRVIEW
ELEV. 1315'
OHIO
PA
TROY HILL RD.
ELEV. 1315'
3.8 MILES
PITTSBURGH
HQTRS BLDG
416 - 7TH AVE.
(BELL TEL. CO. OF PA.)
ELEV. 1082'
25.3 MILES
SALINA
ELEV. 1580'
30.8 MILES
JOHNSTOWN
ELEV. 2680'
JOHNSTOWN
ALTOONA
25.4 MILES
BALD KNOB
ELEV. 2900'
33.7 MILES
SIDELING HILL
ELEV. 2300'
21.2 MILES
CLARK'S KNOB
ELEV. 2300'
29.5 MILES
WAGGONERS GAP
ELEV. 1480'
HARRISBURG
36.6 MILES
YORK
HALLAM
ELEV. 1040'
29.7 MILES
LANCASTER
14.9 MILES
NEW HOLLAND
ELEV. 540'
THOMAS HILL
ELEV. 930'
33.1 MILES
READING
9.2 MILES
WYNDMOOR
ELEV. 420'
PHILADELPHIA
900 RACE ST.
(BELL TEL. CO. OF PA.)
ELEV. 127'
PA
DEL
17.7 MILES
BUCKINGHAM MTN.
ELEV. 520'
TRENTON
32.3 MILES
MARTINSVILLE
ELEV. 600'
30.2 MILES
NEW YORK
ELEV. 450'
TERMINAL
32-6TH AVE.
(N.Y. TEL. CO.)
SCRANTON
PA
NY
NY
PA
NY
PA
NY
NJ
PA
NJ
NJ
PA
NY
CONN
ILLINOIS
INDIANA
INDIANA
OHIO
FORT WAYNE
COLUMBUS
INDIANAPOLIS
SCALE
STATUTE MILES
10 0 10 20 30 40



FUNCTIONS

Receiving Antenna	Receiver Channel Separation Filter	Image Suppression Filter	Receiver Local Microwave Generator	40 MC Generator	Converter	Receiver Converter	IF Preamplifier	IF Equalizer	Main IF Amplifier	Automatic Volume Control	6 DB Pad		IF Buffer Amplifier	5 DB Pad	Common Transmitter Local Microwave Generator	Transmitter Modulator	Transmitter Filter	Transmitter Amplifier	Directional Coupler	Power Output Monitor	Transmitter Channel Separation Filter	Transmitting Antenna
RECEIVES TOTAL MICROWAVE BAND FROM 3700 MC TO 4200 MC. ANTENNA IS DESIGNED TO GIVE 39DB GAIN AND 2° DIRECTIVITY.	PASSES DESIRED MICROWAVE CHANNEL TO ASSIGNED BAY. ALL OTHER MICROWAVE CHANNELS DIRECTED TOWARDS FOLLOWING CHANNEL SEPARATION FILTERS.	REJECTS IMAGE FREQUENCY THAT IS 140 MC REMOVED FROM DESIRED MICROWAVE SIGNAL.	QUARTZ CRYSTAL CONTROLLED HARMONIC GENERATOR PRODUCES LOCAL MICROWAVE FREQUENCY THAT IS 70 MC REMOVED FROM INCOMING MICROWAVE SIGNAL	QUARTZ CRYSTAL CONTROLLED 40 MC OSCILLATOR AND AMPLIFIER	COMBINES 40 MC SIGNAL WITH COMMON MICROWAVE SIGNAL TO PRODUCE LOCAL MICROWAVE FREQUENCY THAT IS 70 MC REMOVED FROM INCOMING MICROWAVE SIGNAL	COMBINES INCOMING MICROWAVE SIGNAL WITH LOCAL MICROWAVE FREQUENCY TO PRODUCE 70 MC IF SIGNAL. THE BO FILTER SELECTS PROPER SIDEBAND AND REJECTS UNWANTED SIDEBANDS	PROVIDES IF AMPLIFICATION DIRECTLY AT OUTPUT OF CONVERTER TO GIVE LOWER NOISE FIGURE. (TO AVOID NOISE PICKUP)	COMPENSATES FOR PHASE DISTORTION	PROVIDES ADDITIONAL IF AMPLIFICATION (APPROX. 63DB FULL GAIN, GAIN FOR NO FADE APPROX. 40DB)	AUTOMATICALLY REGULATES GAIN TO CONSTANT OUTPUT OF +4 TO +10 DBM DEPENDING UPON MODULATOR REQUIREMENTS				5DB LOSS	QUARTZ CRYSTAL CONTROLLED HARMONIC GENERATOR PRODUCES LOCAL MICROWAVE FREQUENCY. ALSO PROVIDES LOCAL MICROWAVE SIGNAL FOR USE WITH 40 MC SHIFTER.	A 416A VACUUM TUBE MODULATOR COMBINES 70 MC IF FM SIGNAL WITH LOCAL MICROWAVE FREQUENCY TO PRODUCE MICROWAVE TRANSMITTING. SIGNAL, 4 TO 8 DB GAIN.	PASSES ONLY DESIRED FM MICROWAVE SIDEBAND	A THREE STAGE (416A'S) VACUUM TUBE AMPLIFIER AMPLIFIES TRANSMITTED SIGNAL 18 DB.	WAVEGUIDE COUPLING OBTAINS SAMPLING OF OUTPUT POWER AND SAMPLES OUTPUT POWER FOR OVERALL BAY TRANSMISSION TESTS AND CONVERTS IT TO D-C BY MEANS OF A VARISTOR.	VISUALLY INDICATES AMOUNT OF OUTPUT POWER AND ALSO INITIATES ALARM IF POWER DROPS 10 DB OR MORE.	PASSES THIS MICROWAVE SIGNAL TOWARDS ANTENNA AND COMBINES THE SIGNAL WITH SIGNALS FROM OTHER CHANNELS TO BE TRANSMITTED.	TRANSMITS TOTAL MICROWAVE BAND FROM 3700 MC TO 4200 MC. ANTENNA IS DESIGNED TO GIVE 39DB GAIN AND 2° DIRECTIVITY.

LEVEL AND POWER DIAGRAM

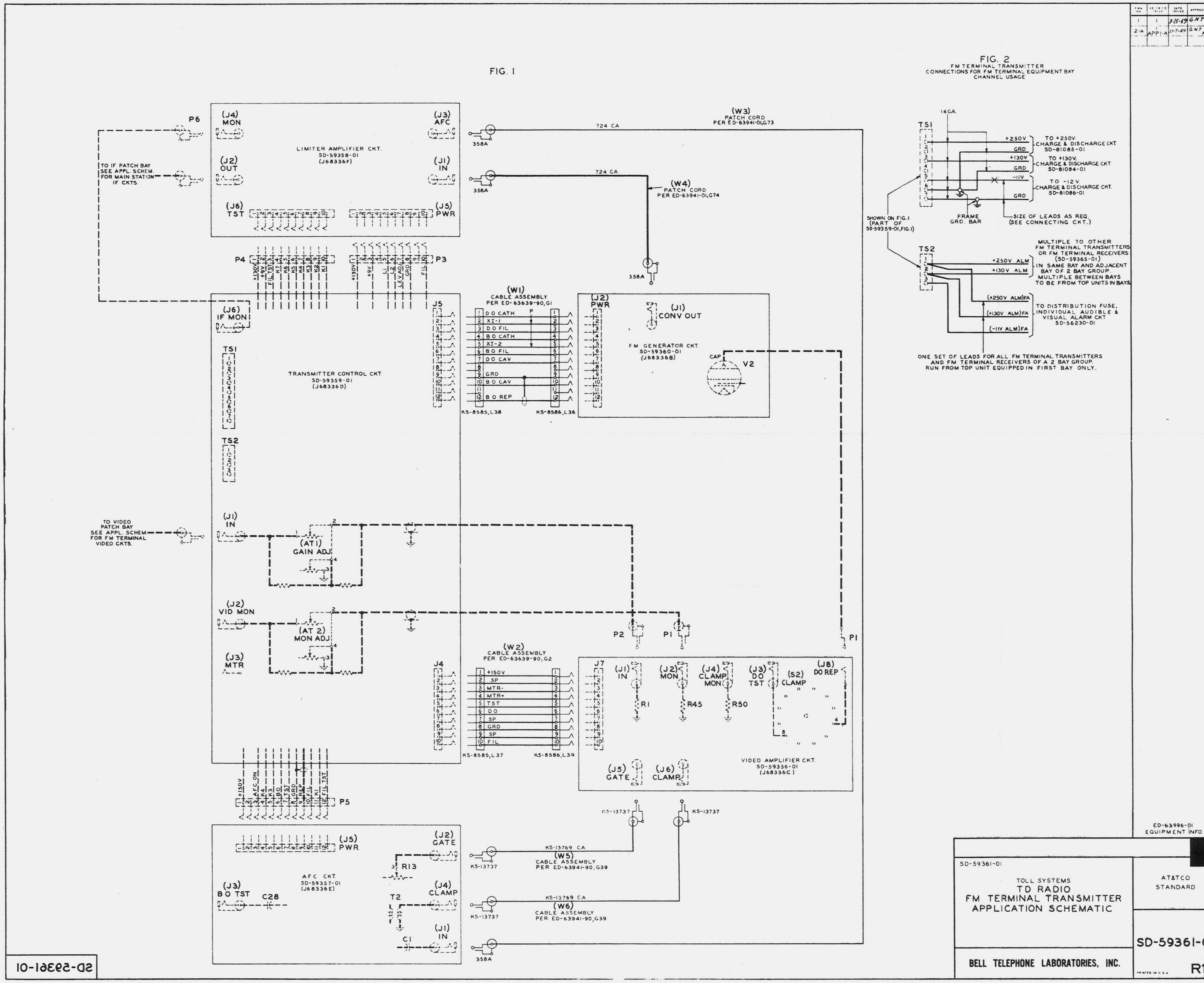
-73* / -96**	-34 / -57	-35 / -58	-35 / -58	-41 / -64	-29 / -52	-30 / -53	+4 TO +10	+10 / +4	+5 / -1	+9	+9	+27	+27	+26	+65

* SIGNAL OVER 30 MILE PATH WITH NO FADING - PATH LOSS ASSUM) TO BE 138DB.
** MIN. SIGNAL WHICH CAN BE FULLY COMPENSATED WITH IF AMPLIFIER OUTPUT OF +10 DBM; ≡ 23DB FADE

LEVEL & POWER DIAGRAM FIGURES IN DBM.

ES-882613

TD-2 RADIO TRANSMITTER-RECEIVER



SD-59361-01

TOLL SYSTEMS
TD RADIO
FM TERMINAL TRANSMITTER
APPLICATION SCHEMATIC

AT&TCO STANDARD

SD-59361-01
R1

BELL TELEPHONE LABORATORIES, INC.

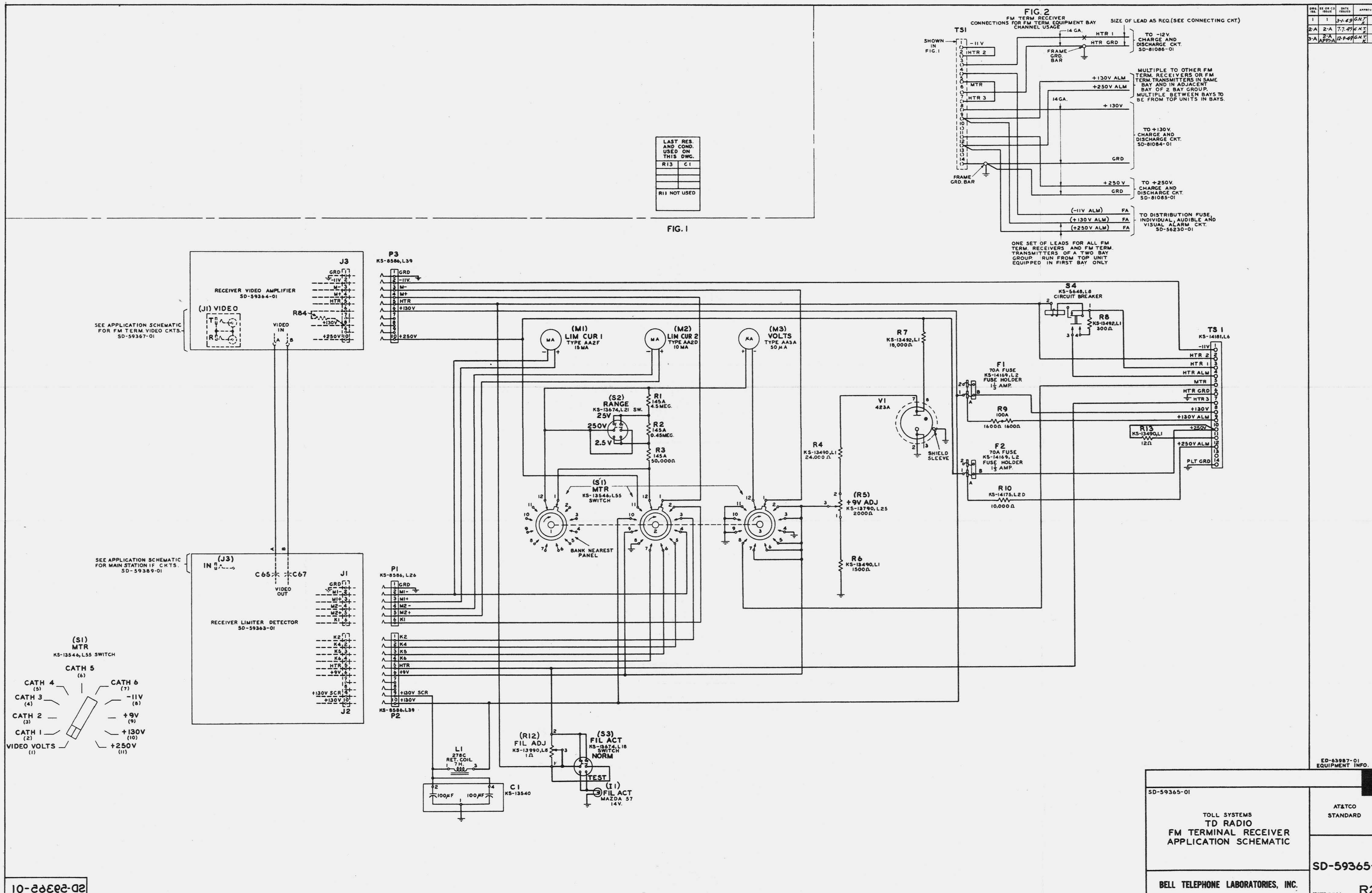


FIG. 2
FM TERM RECEIVER CONNECTIONS FOR FM TERM. EQUIPMENT BAY CHANNEL USAGE
SIZE OF LEAD AS REQ.(SEE CONNECTING CKT)
TO -12V. CHARGE AND DISCHARGE CKT. SD-81086-01
MULTIPLE TO OTHER FM TERM. RECEIVERS OR FM TERM. TRANSMITTERS IN SAME BAY AND IN ADJACENT BAY OF 2 BAY GROUP. MULTIPLE BETWEEN BAYS TO BE FROM TOP UNITS IN BAYS.
TO +130V. CHARGE AND DISCHARGE CKT. SD-81084-01
TO +250V. CHARGE AND DISCHARGE CKT. SD-81085-01
TO DISTRIBUTION FUSE, INDIVIDUAL, AUDIBLE AND VISUAL ALARM CKT. SD-56230-01
ONE SET OF LEADS FOR ALL FM TERM. RECEIVERS AND FM TERM. TRANSMITTERS OF A TWO BAY GROUP RUN FROM TOP UNIT EQUIPPED IN FIRST BAY ONLY
LAST RES. AND COND. USED ON THIS DWG.
R13 C1
R11 NOT USED
FIG. 1
RECEIVER VIDEO AMPLIFIER SD-59364-01
SEE APPLICATION SCHEMATIC FOR FM TERM. VIDEO CKTS. SD-59367-01
RECEIVER LIMITER DETECTOR SD-59363-01
SEE APPLICATION SCHEMATIC FOR MAIN STATION IF CKTS. SD-59389-01
(M1) LIM CUR 1 TYPE AA2F 15 MA
(M2) LIM CUR 2 TYPE AA2D 10 MA
(M3) VOLTS TYPE AA3A 50 μA
(S2) RANGE KS-13674,L21 SW.
(S1) MTR KS-13546,L55 SWITCH
BANK NEAREST PANEL
S4 KS-5648,L6 CIRCUIT BREAKER
V1 423A
SHIELD SLEEVE
F1 70A FUSE KS-14169,L2 FUSE HOLDER 1½ AMP.
F2 70A FUSE KS-14169,L2 FUSE HOLDER 1½ AMP.
(R5) +9V ADJ KS-13790,L25 2000Ω
R6 KS-13490,L1 1500Ω
R4 KS-13490,L1 24,000Ω
R7 KS-13492,L1 18,000Ω
R8 KS-13492,L1 300Ω
R9 100A 1600Ω 1600Ω
R10 KS-14175,L20 10,000Ω
R13 KS-13490,L1 12Ω
TS 1 KS-14181,L6
L1 276C RET. COIL 7H.
C1 KS-13540
(R12) FIL ADJ KS-13990,L6 1Ω
(S3) FIL ACT KS-13674,L18 SWITCH
(I1) FIL ACT MAZDA 57 14V.
(S1) MTR KS-13546,L55 SWITCH
CATH 5 (6)
CATH 4 (5)
CATH 6 (7)
CATH 3 (4)
-11V (8)
CATH 2 (3)
+9V (9)
CATH 1 (2)
+130V (10)
VIDEO VOLTS (1)
+250V (11)
ED-63987-01 EQUIPMENT INFO.
SD-59365-01
TOLL SYSTEMS
TD RADIO
FM TERMINAL RECEIVER
APPLICATION SCHEMATIC
AT&TCO STANDARD
SD-59365-01
BELL TELEPHONE LABORATORIES, INC.
R2

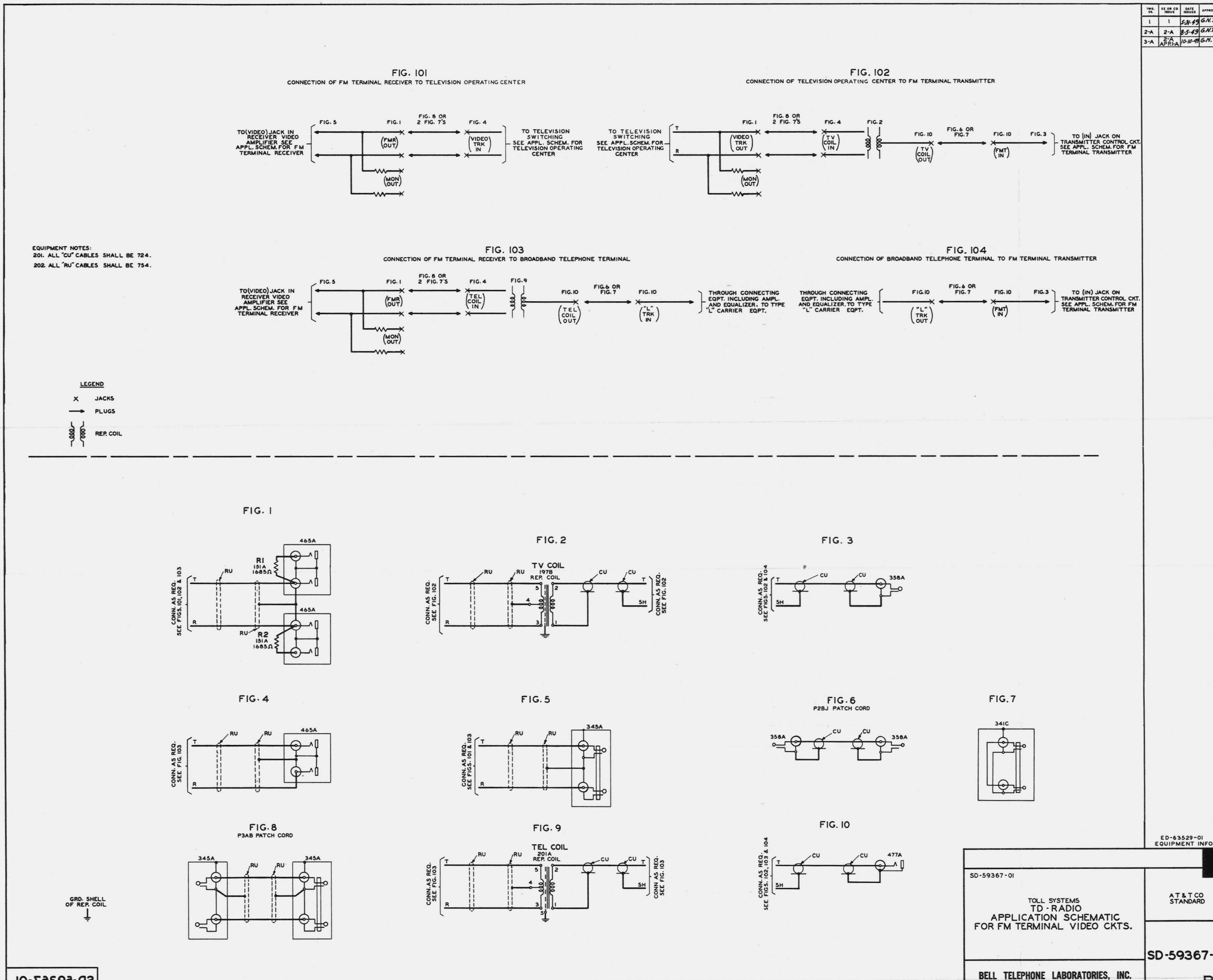


FIG. 101
CONNECTION OF FM TERMINAL RECEIVER TO TELEVISION OPERATING CENTER
TO (VIDEO) JACK IN RECEIVER VIDEO AMPLIFIER SEE APPL. SCHEM. FOR FM TERMINAL RECEIVER
TO TELEVISION SWITCHING SEE APPL. SCHEM. FOR TELEVISION OPERATING CENTER
FIG. 102
CONNECTION OF TELEVISION OPERATING CENTER TO FM TERMINAL TRANSMITTER
TO (IN) JACK ON TRANSMITTER CONTROL CKT. SEE APPL. SCHEM. FOR FM TERMINAL TRANSMITTER
FIG. 103
CONNECTION OF FM TERMINAL RECEIVER TO BROADBAND TELEPHONE TERMINAL
THROUGH CONNECTING EQPT. INCLUDING AMPL. AND EQUALIZER, TO TYPE "L" CARRIER EQPT.
FIG. 104
CONNECTION OF BROADBAND TELEPHONE TERMINAL TO FM TERMINAL TRANSMITTER
EQUIPMENT NOTES:
201. ALL "CU" CABLES SHALL BE 724.
202. ALL "RU" CABLES SHALL BE 754.
LEGEND
JACKS
PLUGS
REP. COIL
FIG. 1
FIG. 2
TV COIL
197B REP. COIL
FIG. 3
FIG. 4
FIG. 5
FIG. 6
P2BJ PATCH CORD
FIG. 7
FIG. 8
P3AB PATCH CORD
FIG. 9
TEL COIL
201A REP. COIL
FIG. 10
GRD. SHELL OF REP. COIL
ED-63529-01 EQUIPMENT INFO.
SD-59367-01
TOLL SYSTEMS
TD-RADIO
APPLICATION SCHEMATIC
FOR FM TERMINAL VIDEO CKTS.
AT&T CO STANDARD
SD-59367-01
BELL TELEPHONE LABORATORIES, INC.
R1

DWG. ISS.	KE OR CD ISSUE	DATE ISSUED	APPROVED
1	1	8-8-49	G.N.T. K

CIRCUIT NOTES:

101. PROVIDE FUSES AS FOLLOWS:

DESIG.	AMP.	POTENTIAL FUSED	ONE PER
SW AMP	0.5	130V. PLT	FIG. 1
SW AMP	3	12V. FIL	FIG. 1
DIST AMP	0.5	130V. PLT	FIG. 3
DIST AMP	3	12V. FIL	FIG. 3

102. PROVIDE SEPARATE FILAMENT AND PLATE BATTERY DISCHARGE LEADS, ONE PER EACH FIG. 106, 107, 108, 109, 110, 111 OR 112. WHEN A FIG. 106 AND A FIG. 107 ARE ASSOCIATED IN THE SAME FIG. 117, THEN A COMMON FILAMENT AND A COMMON PLATE DISCHARGE LEAD SHALL BE USED FOR BOTH AMPLIFIERS.

103. LENGTHS OF NO. 724 CABLE SHALL NOT EXCEED THE FOLLOWING:

FIG.	FROM	TO	MAX. LENGTH
101	RADIO REC.	(REC OUT) JACK	30 FT.
102	RADIO TRS.	(TRS IN) JACK	30 FT.
103	FMT TRS.	(FMT OUT) JACK	45 FT.
104	FMT REC.	(FMR IN) JACK	45 FT.
105	(TRK IN) JACK	(TRK OUT) JACK	15 FT.

104. WHEN EITHER FIG. 7 OR FIG. 8 IS SPECIFIED, FIG. 8 (PATCH PLUG) SHALL BE PROVIDED, UNLESS THE EQUIPMENT ARRANGEMENT MAKES A CORD NECESSARY, IN WHICH CASE FIG. 7 SHALL BE USED.

105. IN FIG. 3 (DIST AMP), THE (A OUT), (B OUT) AND (C OUT) CONNECTIONS ARE IDENTICAL AND MAY BE USED INTERCHANGEABLY.

106. IN FIG. 1 (SW AMP), THE (A IN) AND (B IN) INPUTS ARE INTERCHANGEABLE, PROVIDED THAT EACH CONTROL KEY POSITION IS PROPERLY CORRELATED WITH THE CIRCUIT PATCHED TO THE CORRESPONDING INPUT.

FIG. 51
(FOR FIGS. 1 & 4)

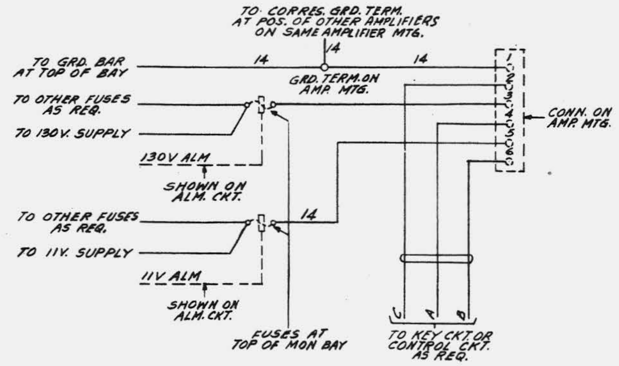


FIG. 52
(FOR FIGS. 3 & 4)

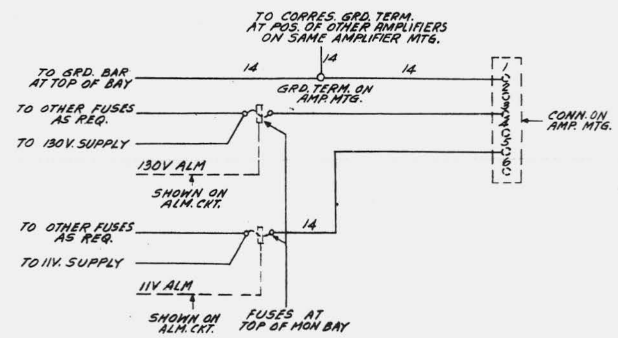


FIG. 1

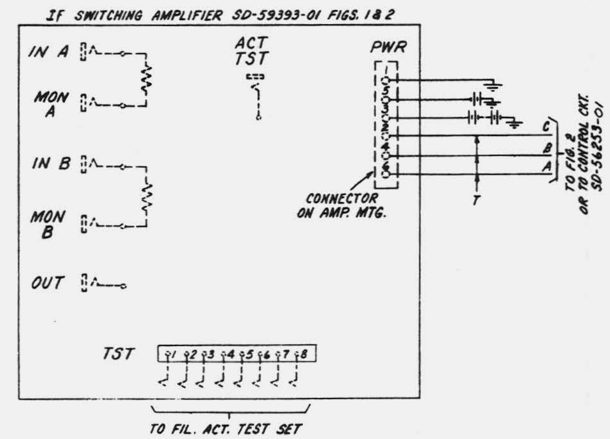


FIG. 2

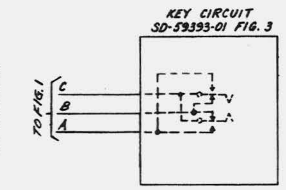


FIG. 3

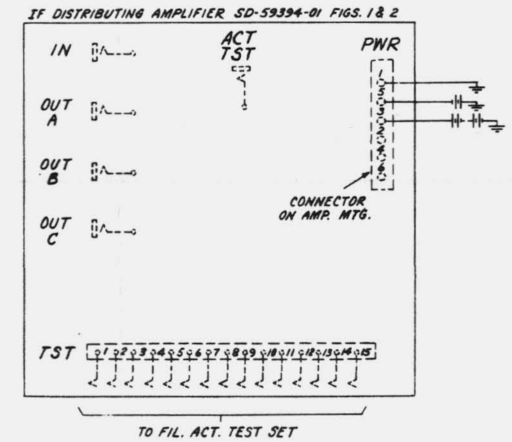


FIG. 6

FIG. 7
SEE NOTE 104

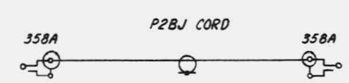


FIG. 8
SEE NOTE 104

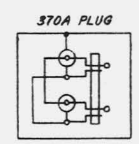


FIG. 4
SEE NOTE 201

FIG. 9

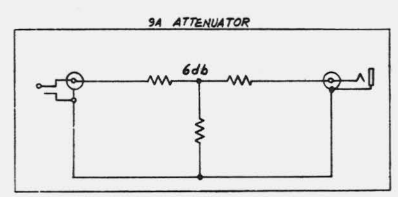
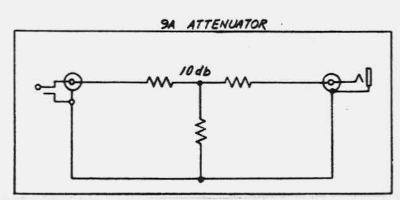
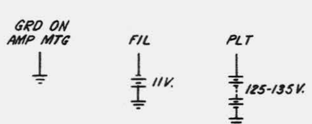


FIG. 5

FIG. 10





OPTIONS USED			
FIGS.		APP. OR WIRING	
1	101		
2	102		
3	103		
4	104		
5	105		
6	106		
7	107		
8	108		
9	109		
10	110		
	111		
	112		
	113		
	114		
	115		
	116		
	117		
	118		
	119		

ED-63528-01 EQUIPMENT INFO.

SD-59389-01 4 SHEETS

TOLL SYSTEMS
TD RADIO
APPLICATION SCHEMATIC
IF PATCHING CIRCUITS
AT MAIN REPEATERS AND TERMINALS

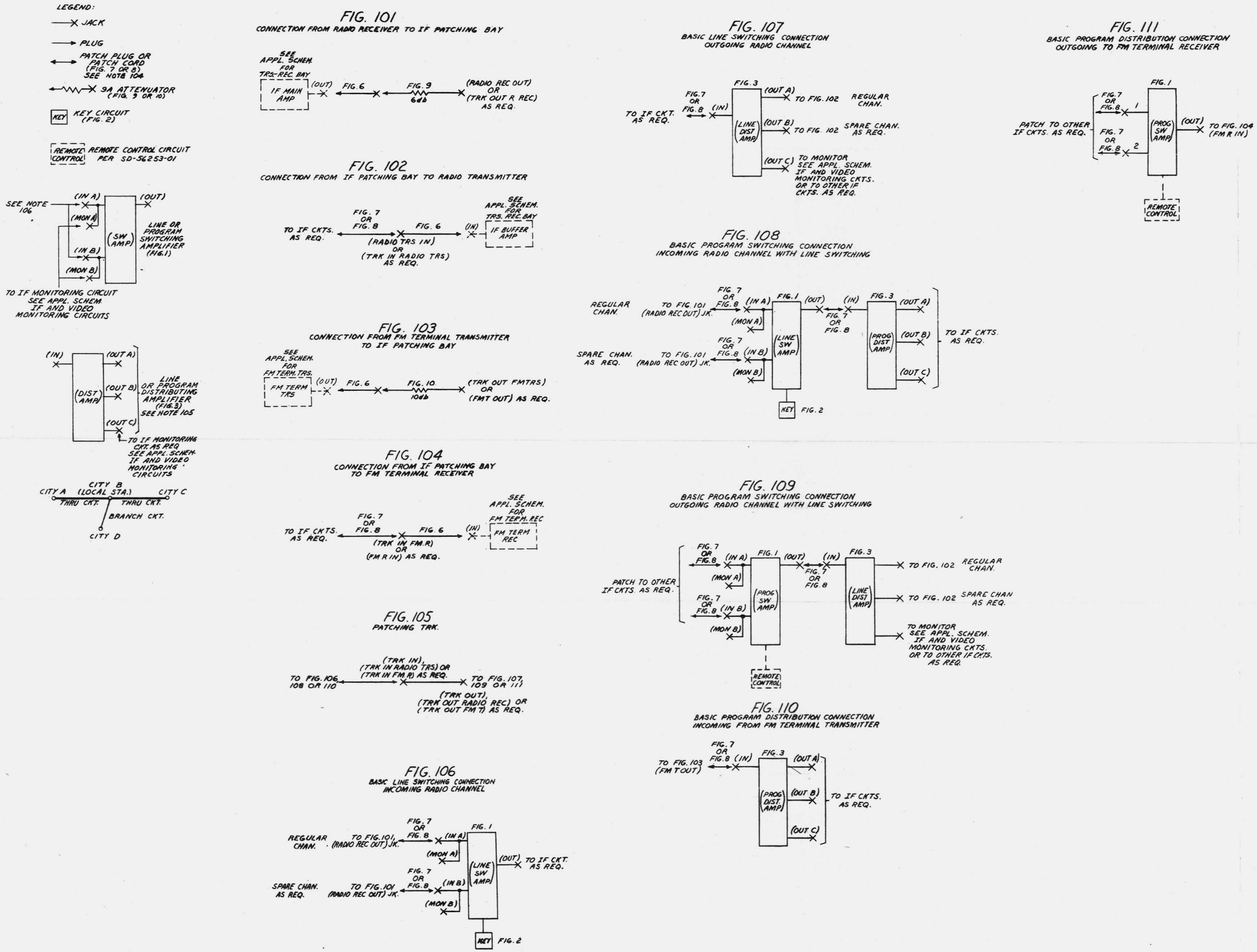
AT&TCO STANDARD

R2
SD-59389-01

BELL TELEPHONE LABORATORIES, INC.

PRINTED IN U.S.A.

SD-59389-01



TD RADIO
APPLICATION SCHEMATIC
IF PATCHING CIRCUITS

BELL TELEPHONE LABORATORIES, INC.

4 SHEETS, SHEET 2

SD-59389-012

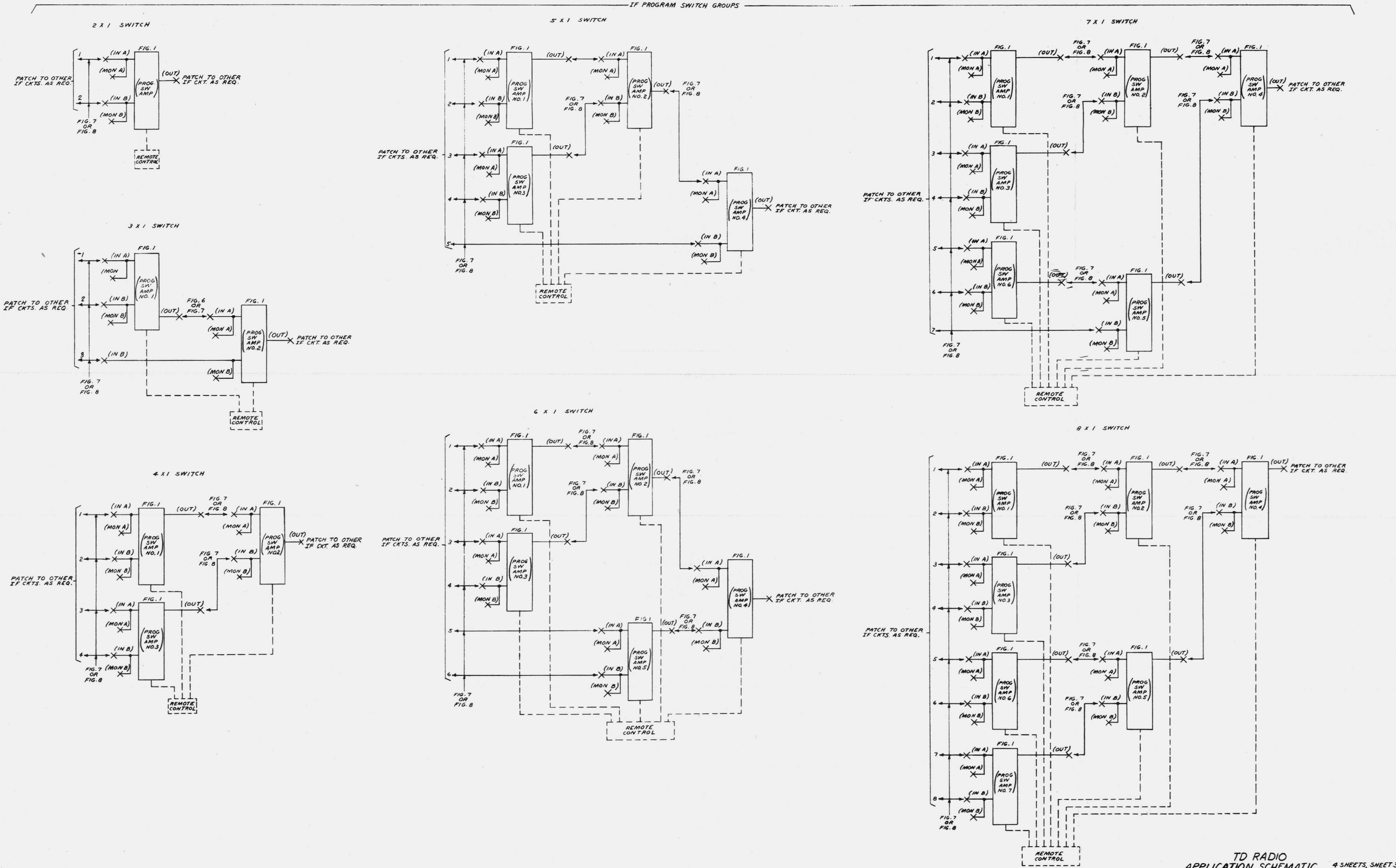
R2

PRINTED IN U.S.A.

SD-59389-012

FIG. 112

IF PROGRAM SWITCH GROUPS



DWG ISS.
1

TD RADIO
APPLICATION SCHEMATIC
IF PATCHING CIRCUITS

4 SHEETS, SHEET 3

SD-59389-013
R2

BELL TELEPHONE LABORATORIES, INC.

PRINTED IN U.S.A.

SD-59389-013

FIG. 113

RADIO CHANNEL WITH NO LINE SWITCHING ORIGINATING FROM FM TERMINAL TRANSMITTER

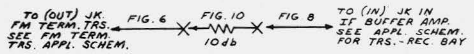


FIG. 114

RADIO CHANNEL WITH NO LINE SWITCHING TERMINATING IN FM TERMINAL RECEIVER

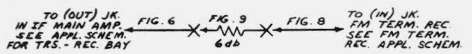


FIG 115

RADIO CHANNEL WITH LINE SWITCHING ORIGINATING FROM FM TERMINAL TRANSMITTER

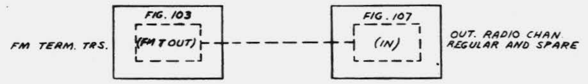


FIG. 116

RADIO CHANNEL WITH LINE SWITCHING TERMINATING IN FM TERMINAL RECEIVER

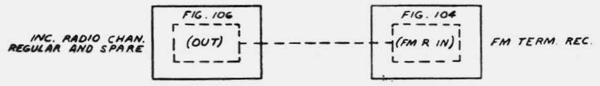


FIG. 117

THRU RADIO CHANNEL WITH LINE SWITCHING

FIG. 118

TYPICAL CHANNEL ARRANGEMENT WITH LINE AND PROGRAM SWITCHING AND BRANCH RADIO CIRCUIT OR FM TERMINAL

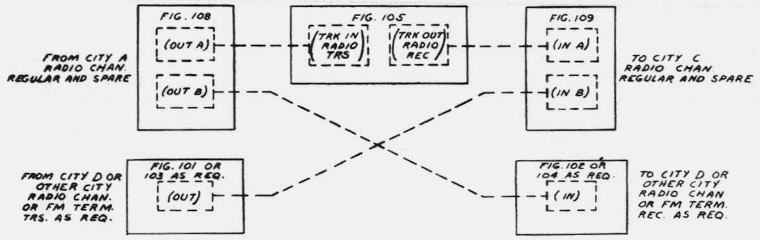
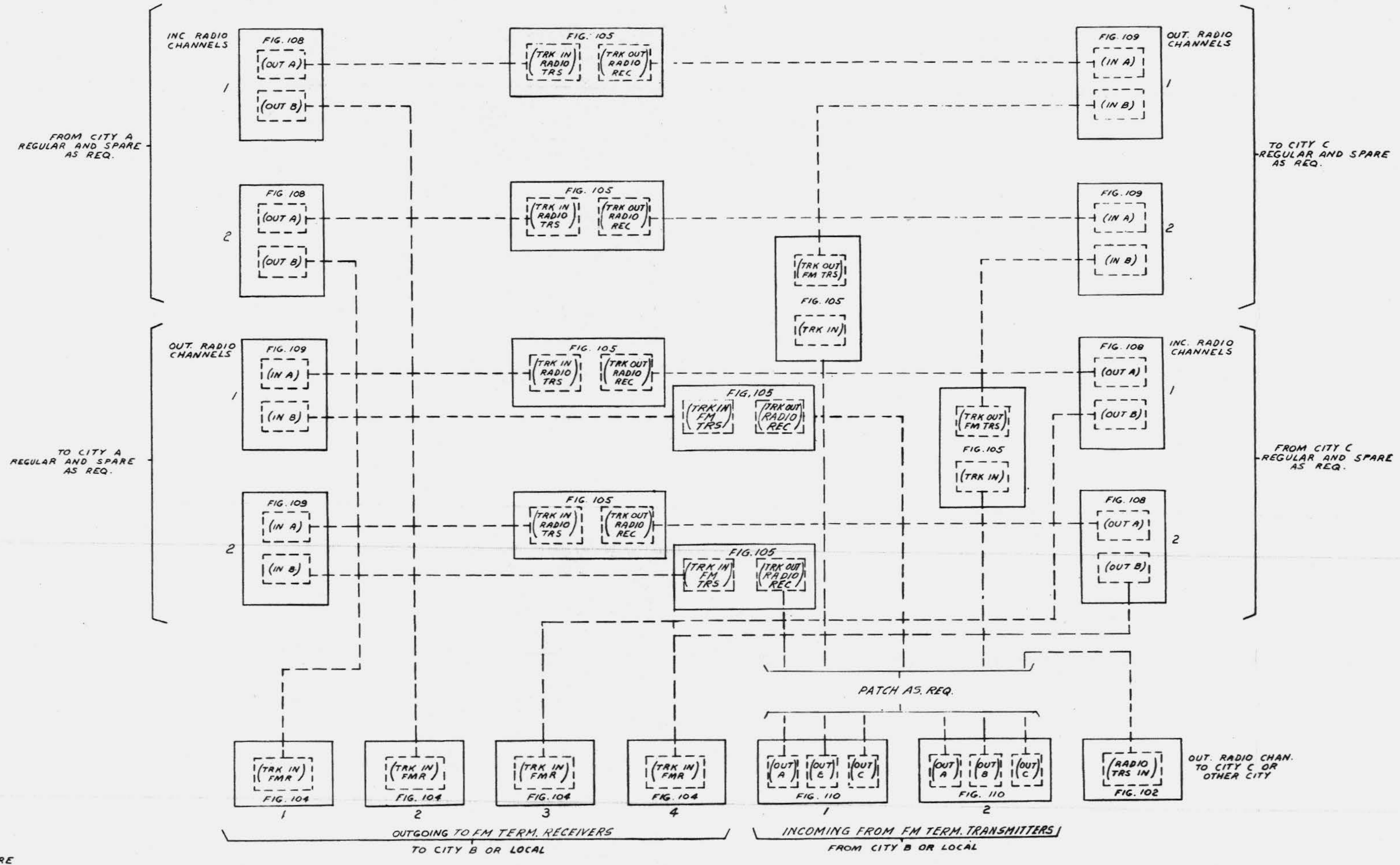


FIG. 119

TYPICAL CHANNEL ARRANGEMENT WITH LINE AND PROGRAM SWITCHING FOR
4 THRU RADIO CHANNELS WITH SPARE RADIO CIRCUITS IF REQ.
4 OUTGOING CIRCUITS THRU FM TERMINAL RECEIVERS
2 INCOMING CIRCUITS FROM FM TERMINAL TRANSMITTERS
1 OUTGOING RADIO BRANCH CIRCUIT.



DWG ISS. 1

TD RADIO
APPLICATION SCHEMATIC
IF PATCHING CIRCUITS

BELL TELEPHONE LABORATORIES, INC

4 SHEETS, SHEET 4

SD-59389-014
R2

PRINTED IN U.S.A.

SD-59389-014

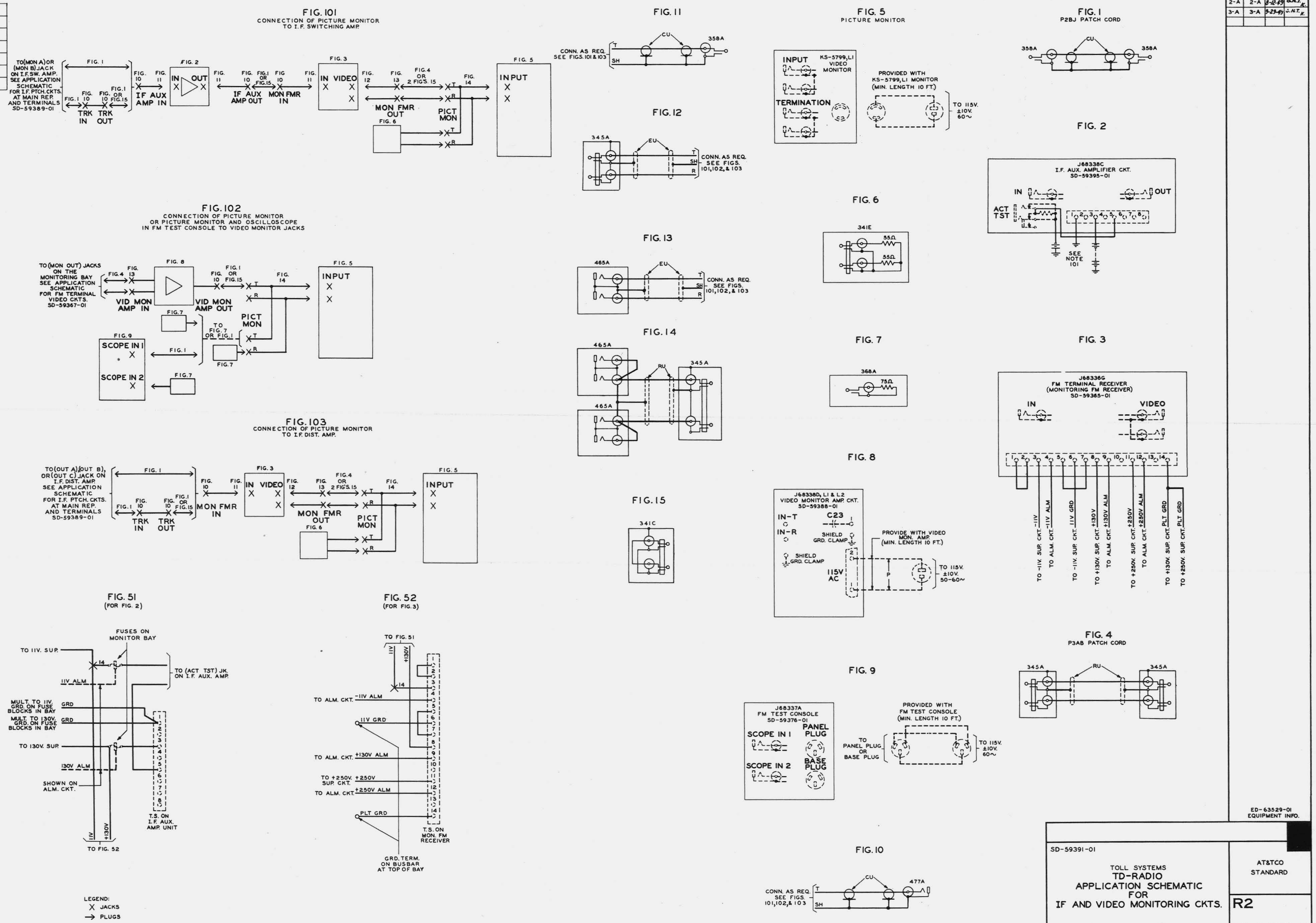
CIRCUIT NOTES:

101.

DESIG.	AMP.	POTENTIAL FUSED	ONE PER
	0.5(70G)	+130V. PLT.	FIG. 2
	3(70C)	-12V. FIL.	FIG. 2

EQUIPMENT NOTES:

201. ALL "CU" CABLES SHALL BE 724.
202. ALL "RU" CABLES SHALL BE 720.
203. ALL "EU" CABLES SHALL BE 754B.



ED-63529-01 EQUIPMENT INFO.

DWG. ISS.	EX OR CD ISSUE	DATE ISSUED	APPROVED
1	1	7-29-49	G.H.F.
2-A	2-A	8-12-49	G.H.F.
3-A	3-A	3-29-49	J.N.T.

SD-59391-01

TOLL SYSTEMS
TD-RADIO
APPLICATION SCHEMATIC
FOR
IF AND VIDEO MONITORING CKTS.

AT&TCO STANDARD

R2

SD-59391-01

BELL TELEPHONE LABORATORIES, INC.

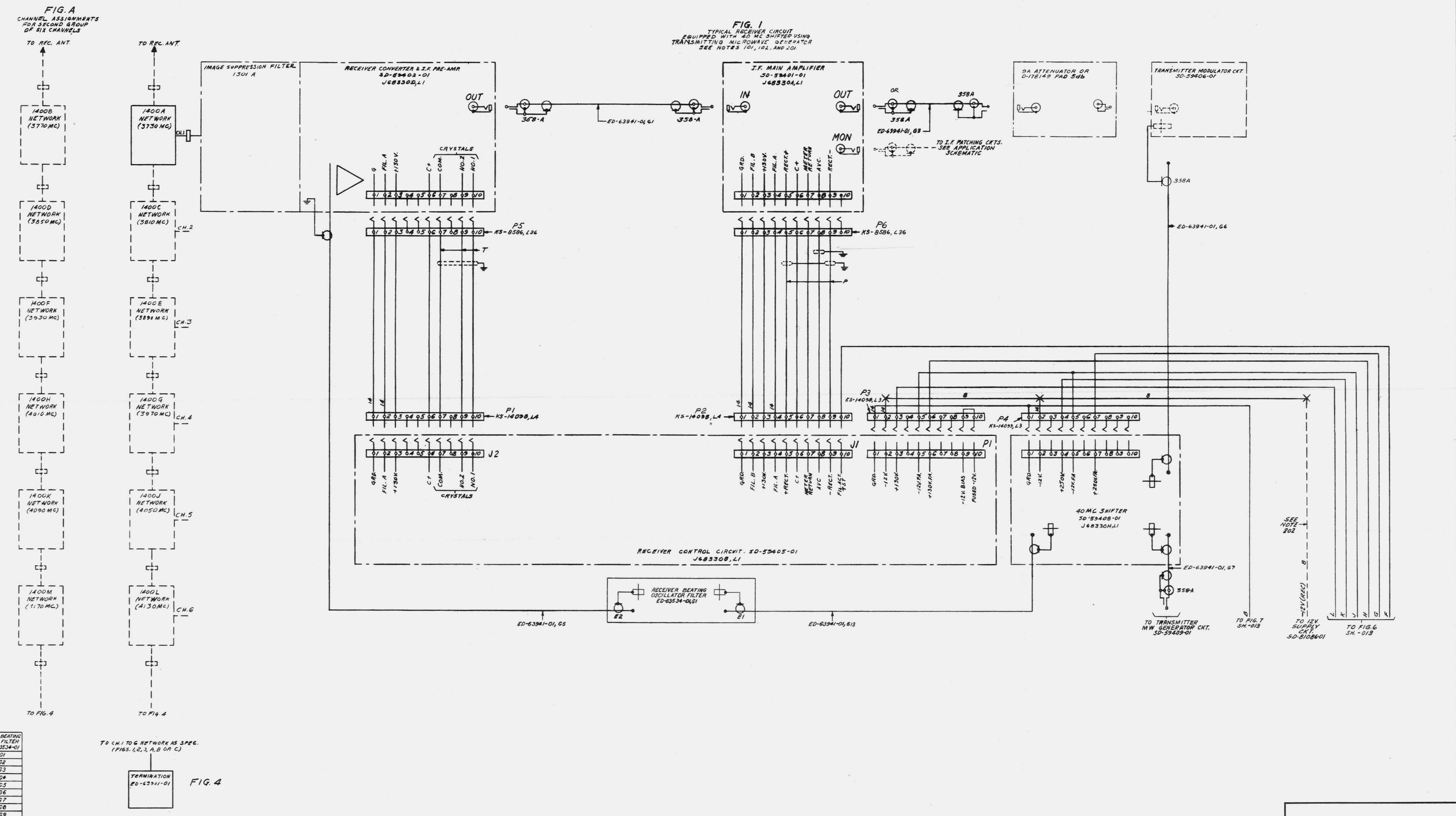
SD-59391-01

DWG. ISS.	EE OR CD ISSUE	DATE ISSUED	APPROVED
1	1	1-18-49	G.N.T. K.
2-A	1 APP.1-A	1-27-49	G.N.T. K.
3-A	1 APP.2-A	2-16-49	G.N.T. K.
4-A	1 APP.3-A	3-22-49	G.N.T. K.
5-A	1 APP.4-A	4-8-49	G.N.T. K.
6-A	2-A	5-20-49	G.N.T. K.

CIRCUIT NOTES:

101. THE 1400 AND 1401 TYPE NETWORKS SHALL BE CONNECTED TOGETHER IN TANDEM IN NUMERICAL ORDER (WITH RESPECT TO FREQUENCY) WITH THE NETWORK OF LOWEST FREQUENCY NEAREST TO THE ANTENNA. NETWORKS OF ANY OF THE INDICATED FREQUENCIES MAY BE USED FOR ANY CHANNEL PROVIDED THEY ARE CONNECTED AS STATED ABOVE.

102. THE TERMINATION PER ED-63901-01 SHALL BE CONNECTED TO THE LAST NETWORK IN THE LINE.



EQUIPMENT NOTES:

201. WIRING AND EQUIPMENT SHALL BE PROVIDED IN ACCORDANCE WITH TABLES "A", "B", AND "C" AS SPECIFIED FOR EACH FIG. 1, 2 OR 3.

202 (a) ONE POWER FEEDER FOR EACH VOLTAGE REQUIRED SHALL BE PROVIDED FOR BOTH THE RECEIVER (FIG. 1) AND TRANSMITTER (FIG. 3) OF A BAY (J68331A) AT AUXILIARY STATIONS, IN WHICH CASE FURNISH "X" AND OMIT "Y" WIRING.

(b) ONE POWER FEEDER FOR EACH VOLTAGE REQUIRED SHALL BE PROVIDED FOR EACH RECEIVER (FIG. 1) AND FOR EACH TRANSMITTER (FIG. 3) OF A BAY AT TERMINAL AND MAIN STATIONS, IN WHICH CASE FURNISH "Y" AND OMIT "X" WIRING.

(c) THE +130V. POWER FEEDER FOR THE BUFFER AMPLIFIER (FIG. 3) IS NOT REQUIRED AT AUXILIARY STATIONS.

203. FURNISH "Z" OPTION ONLY WHEN FIG. 1 OR 2 IS FURNISHED.

TABLE A

RECEIVER EQUIPPED WITH 40 MC SHIFTER AND USING TRANSMITTING MICROWAVE GENERATOR (FIG. 1).

REC. FREQ.	NETWORK	IMAGE SUPP. FILTER	CONV. & I.F. PRE-AMP. J68330D	I.F. MAIN AMP. J68330A	40MC SHIFTER J68330H	REC CONT. UNIT J68330B	REC. BEATING OSC. FILTER ED-63534-01
3730	1400A	1301A	L1	L1	L1	L1	G1
3770	1400B	1301B	L2	L1	L1	L1	G2
3810	1400C	1301C	L3	L1	L1	L1	G3
3850	1400D	1301D	L4	L1	L1	L1	G4
3890	1400E	1301E	L5	L1	L1	L1	G5
3930	1400F	1301F	L6	L1	L1	L1	G6
3970	1400G	1301G	L7	L1	L1	L1	G7
4010	1400H	1301H	L8	L1	L1	L1	G8
4050	1400J	1301J	L9	L1	L1	L1	G9
4090	1400K	1301K	L10	L1	L1	L1	G10
4130	1400L	1301L	L11	L1	L1	L1	G11
4170	1400M	1301M	L12	L1	L1	L1	G12

OPTIONS ON THIS DWG.			
FIGS.			
1	6		
2	7		
3		A	
4		B	
5		C	
APP. OR WIRING			
Z			
Y			
X			

SD-59403-01 — 3 SHEETS

TOLL SYSTEMS
TD-2 RADIO
APPLICATION SCHEMATIC
FOR
TRANSMITTER-RECEIVER BAY

AT&TCO STANDARD

BELL TELEPHONE LABORATORIES, INC.

SD-59403-01

R3

SD-59403-011

FIG. B
CHANNEL ASSIGNMENTS
FOR 2ND. GROUP OF SIX CHANNELS

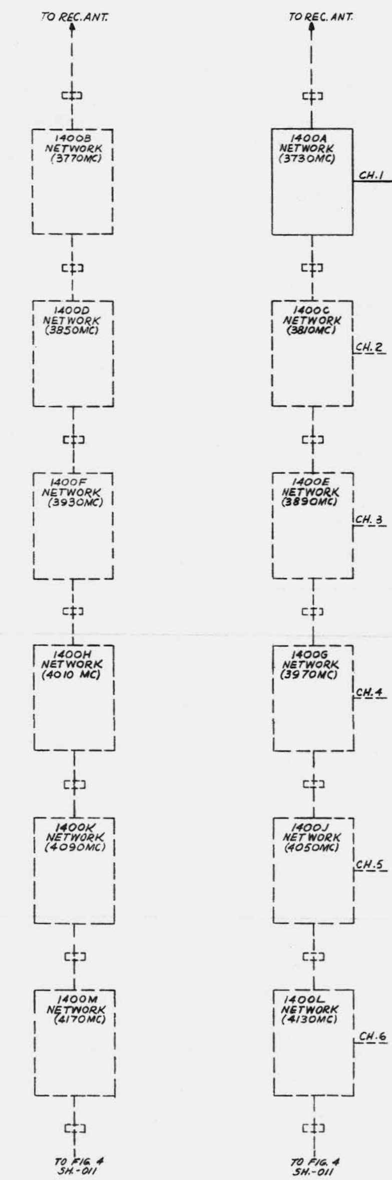


FIG. 2
TYPICAL RECEIVER CKT.
EQUIPPED WITH RECEIVING MICROWAVE GENERATOR
SEE NOTES 101, 102 & 201

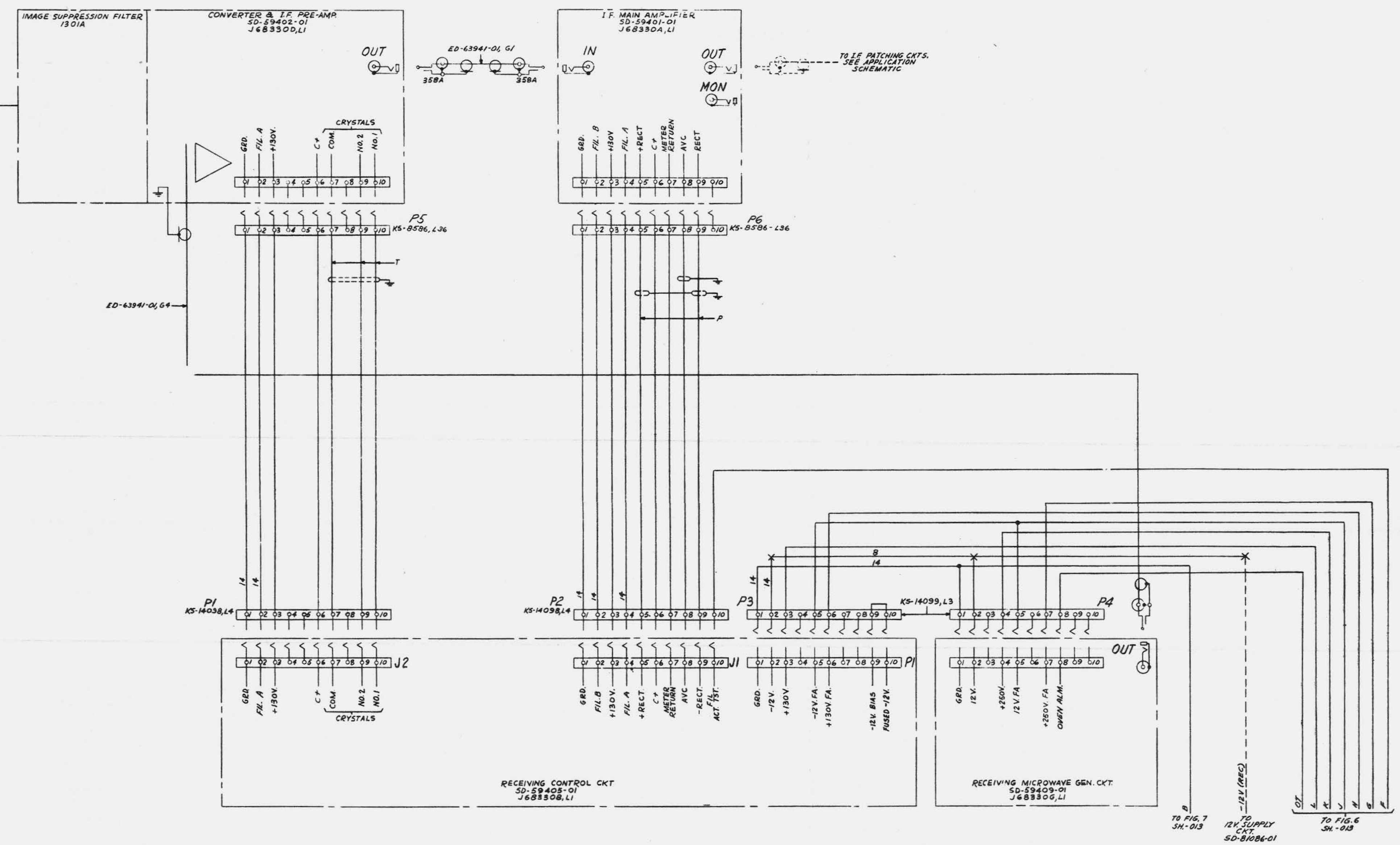


TABLE B
RECEIVER EQUIPPED WITH RECEIVING MICROWAVE GENERATOR (FIG. 2)

REC. FREQ.	NETWORK	IMAGE SUPP. FILTER	CONV. & I.F. PRE-AMP. J68330D	I.F. MAIN AMP. J68330D	REC. MICROWAVE GEN. UNIT J68330G	REC. MICROWAVE GEN. CRYSTAL KS-13978, L1	REC. CONT. UNIT J68330B
3730	1400A	1301A	L1	L1	L1	17.592592	L1
3770	1400B	1301B	L2	L1	L1	17.777777	L1
3810	1400C	1301C	L3	L1	L1	17.962962	L1
3850	1400D	1301D	L4	L1	L1	18.148148	L1
3890	1400E	1301E	L5	L1	L1	17.685185	L1
3930	1400F	1301F	L6	L1	L1	17.870370	L1
3970	1400G	1301G	L7	L1	L1	18.055555	L1
4010	1400H	1301H	L8	L1	L1	18.240740	L1
4050	1400J	1301J	L9	L1	L1	18.425925	L1
4090	1400K	1301K	L10	L1	L1	18.611111	L1
4130	1400L	1301L	L11	L1	L1	18.796296	L1
4170	1400M	1301M	L12	L1	L1	18.981481	L1

DWG. ISS. 1, 2-A, 3-A, 4-A, 5-A, 6-A

TD-2 RADIO
APPLICATION SCHEMATIC
FOR
TRANSMITTER-RECEIVER BAY

BELL TELEPHONE LABORATORIES, INC.

3 SHEETS, SHEET 2
SD-59403-012
PRINTED IN U.S.A.
R3

SD-59403-012

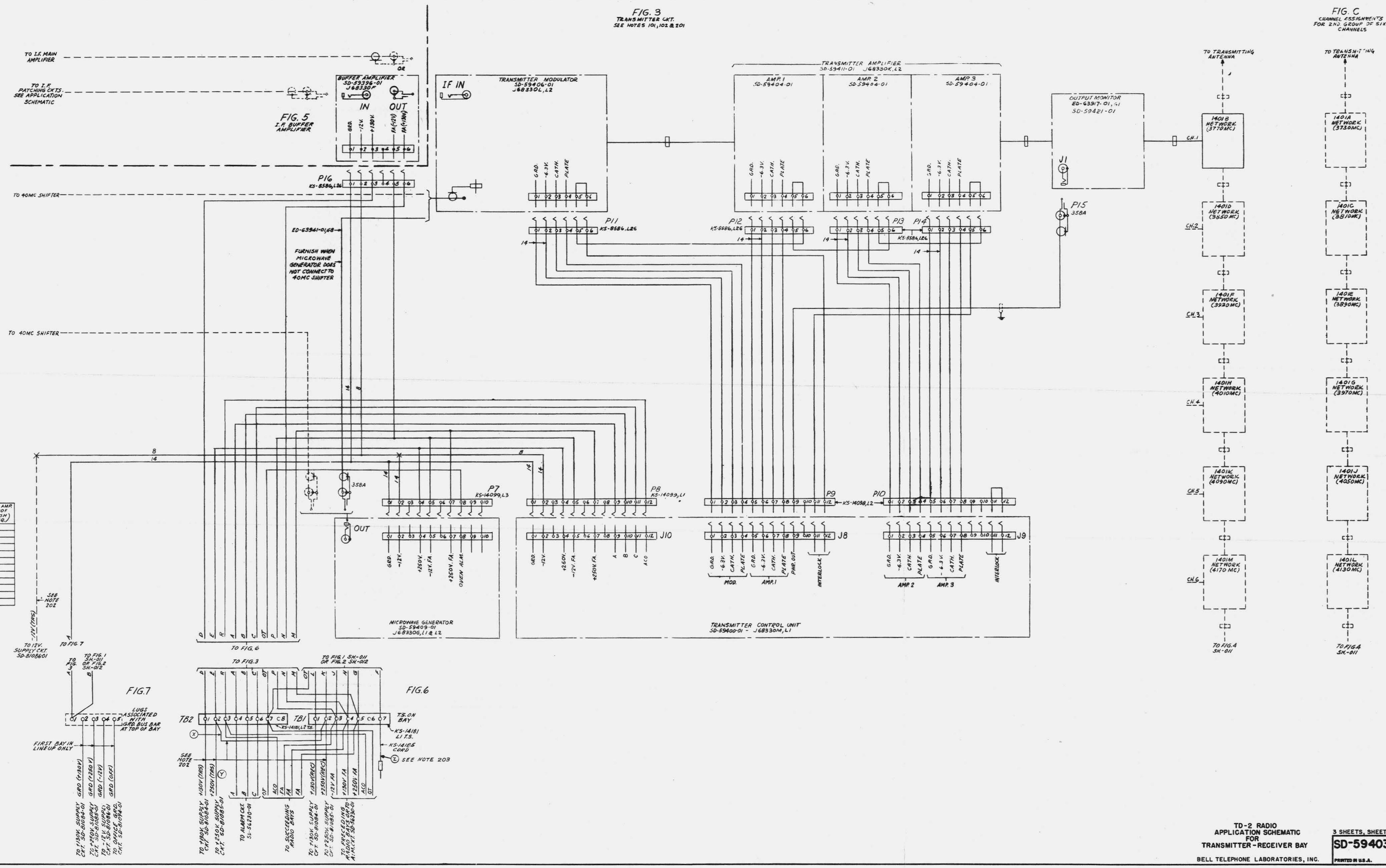


TABLE C
TRANSMITTER (FIG. 3)

TRS. FREQ	NETWORK	TRS. MOD. J68330L	TRS. AMP. J68330K	MICROWAVE GEN. UNIT J68330G	MICROWAVE GEN. CRYSTAL KS-13978, L1	TRS. CONT. UNIT J68330M	BUFFER AMP. J68330F (FURNISH AS REQ.)
3730	1401A	L1	L1	L1, L2	17.592592	L1	L1
3770	1401B	L2	L2	L1, L2	17.777777	L1	L1
3810	1401C	L3	L3	L1, L2	17.962962	L1	L1
3850	1401D	L4	L4	L1, L2	18.148148	L1	L1
3890	1401E	L5	L5	L1, L2	17.685185	L1	L1
3930	1401F	L6	L6	L1, L2	17.870370	L1	L1
3970	1401G	L7	L7	L1, L2	18.055555	L1	L1
4010	1401H	L8	L8	L1, L2	18.240740	L1	L1
4050	1401J	L9	L9	L1, L2	18.425925	L1	L1
4090	1401K	L10	L10	L1, L2	18.611111	L1	L1
4130	1401L	L11	L11	L1, L2	18.796296	L1	L1
4170	1401M	L12	L12	L1, L2	18.981481	L1	L1

TD-2 RADIO
APPLICATION SCHEMATIC
FOR
TRANSMITTER-RECEIVER BAY

BELL TELEPHONE LABORATORIES, INC.

3 SHEETS, SHEET 3

SD-59403-013

PRINTED IN U.S.A.

R3

SD-59403-013