Section 7

REMOTE-PICKUP FACILITIES

Part 1

A PRACTICAL 26-MC REMOTE-PICKUP BROADCAST SYSTEM

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INTRODUCTION

General Information

The equipment described in this part consists basically of a one-way program shortwave system, operating in the 26-Mc band, groups D through J, Part 4.401 of the FCC Rules, paragraph 2. The transmitter is intended for mobile use, operating from a standard 6-volt car battery. The major units, except the dynamotor, are component parts of SCR 508 (SCR 528 and SCR 538 also contain the same components). These are the BC 604 transmitter and the BC 603 receiver. The transmitter costs $3, and the receiver costs $5.95. The incidental components, such as plugs and receptacles, are also mostly available as war surplus. Such items as the transformers for the receiver power supply, microphone sockets, and VU meter will probably be new materials. Spray painting of the components is recommended. Masking of the front panel and name plates will be found quite simple. Duco Feather Grey No. 246-54909 or equivalent is recommended. Circuit drawings and diagrams are furnished only for the changes and additions, it being assumed the user will procure a copy of War Department Technical Manual TM 11-600 which contains complete circuit and adjustment information of the equipment as originally furnished for the armed services. TM 11-600 does not cover the dynamotor PE 103. However, the circuit diagram of this unit, as well as changes, is included as Fig. 1-6.

There is one disadvantage to the 26-Mc band,[1] and that is potential diathermy interference. The equipment has one very handy feature to cope with this. The transmitter and receiver both are arranged from 10 preset channels, inasmuch as the original design covered the band from 20 to 27.9 Mc. Actually, it is customary to apply to the FCC for use of only a single group of frequencies, groups D, E, F, G, and H, consisting of three specific frequencies, and groups I and J, consisting of two frequencies. There are thus 19 specific frequencies available for this use in the range from 26.11 to 26.47 Mc. Most stations equip their transmitters with either two or three crystals, as the case may be, and preset their receiver push buttons correspondingly. If, during a transmission, diathermy interference occurs, a quick change to an alternate frequency usually eliminates the interference.

[1] As well as long-range interference during the "high" of the 11-year sunspot cycle.

Crystals

Crystals in mounting FT 241 are readily available on the surplus market and carry the channel number and carrier frequency. The crystal frequency is multiplied 54 times to generate the carrier frequency. Crystals are readily available to produce carrier frequencies jnst under several of those specified by the FCC for remote pickup service. They are as follows:

Channel No.	*Crystal frequency, kc*	*Carrier frequency, Mc*	*FCC channel, Mc*
61	483.333	26.1	26.11
62	485.185	26.2	26.21
63	487.037	26.3	26.31
64	488.889	26.4	26.41

These crystals are wire-mounted and silver-plated. They vibrate in such a mode that the frequency is determined for a given crystal and within limits by the large dimensions. Grinding one edge a very small amount will raise the frequency of the crystals listed above to fit the corresponding FCC channel exactly. It is also entirely feasible to grind somewhat more from the edge of the crystal, raising the frequency to one of the higher channels. The crystal mounting base is clamped in a vise, and the crystal itself held by its edges by means of a pair of long-nose pliers the prongs of which have been covered with thin rubber tubing, rubber tape, or masking tape. A few light strokes of very fine sandpaper will take off sufficient material to raise the frequency measurably. Results are better if the sandpaper is wet. It is necessary in this case to wash and dry the crystal each time it is tested as to frequency.

Transmitter

The frequency of 26 Mc lends itself to the use of a quarter-wave whip-type antenna suitable for mounting on a vehicle. The equipment described consists of a battery-operated transmitter and a 110-volt ac-operated receiver. The transmitter was originally designed as a plug-in unit, and this feature has been preserved. As used by the armed services, the standard installation was one transmitter and two receivers, plug-in mounted upon a sturdy shock-mounted base, known as the FT 237 mount. As modified, the mount is shortened and rewired.

The transmitter is frequency-modulated, using a novel modulator known as a Peterson coil. This is a small toroid, using a permalloy ribbon core. The coil, which bears the circuit designation L104 in the schematic, carries RF current at crystal frequency, which is approximately 450 kc, from the crystal amplifier stage V101. Also through the coil passes the audio-modulating frequency from the second audio stage V106. The current magnitudes are so arranged that, superimposed, they saturate the core of the modulator coil. Relatively large inductive kicks or spikes are caused by the saturation, and the phase relation of these inductive kicks produces the phase or frequency modulation. (See Fig. 1-9.) The sharp spikes thus caused also make it entirely practical to pick off the ninth harmonic and amplify it in the following stage. A doubler and a tripler follow, then a power amplifier, and thus, with a minimum number of tubes and consequently low total battery drain, a carrier frequency which is 54 times crystal frequency, is reached. The principal advantage of this system of modulation is that there are no heavy audio transformers. Modulation occurs at a low audio level, there being only two tubes used from microphone level to modulating level. There are only eight tubes used in the entire transmitter, six 6V6GT, one 6L6, one 807. These replace the original complement of seven type 1619 and one type 1626, which are a 2-volt direct-filament type, used for quick heating, making a complete push-to-talk operation feasible, with no idling current drawn from the battery as far as the transmitter is concerned. It was found that the original tubes were unsuitable, since car generator and other noises came through into the audio, hence the change to heater-type tubes. A disadvantage of this type of modulator, and a very serious one, is the fact that the amount of phase shift, hence percentage of modulation, is proportional to audio frequency.

Receiver

While for the original purpose of voice communication it proved quite satisfactory, the lack of bass response is objectionable in many applications for broadcast station use. The over-all frequency response can be greatly improved by the addition of a simple circuit for base frequency reemphasis in the receiver. The network consists of the addition of two 0.01 condensers and one 12,000-ohm resistor and is illustrated in Fig. 1-1. A slight addition to the bass response in the audio circuits of the transmitter [2] will bring the over-all audio response, transmitter microphone terminals through receiver audio output, to within ±3 db from 75 to 15,000 cycles. The circuit accomplishes negative feedback in the receiver at frequencies above 500 cycles, and, owing to an unexpected assistance from a very poor audio system (poor from the standpoint of the broadcast engineer), there is a phase reversal or near reversal at the low end with the combination over all, and at 60 cycles there results actually a *gain* in the audio system from the addition of this negative feedback. The figure shows the basic audio system of the receiver, and the heavy lines indicate the additions.

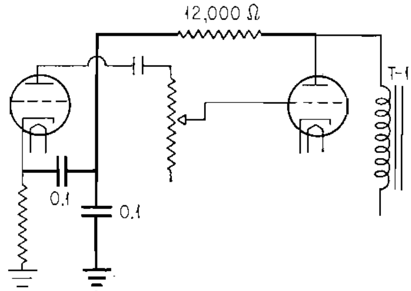

FIG. 1-1. Bass frequency reemphasis circuit to be added to receiver.

The volume control on the front of the receiver now becomes more of a tone control and should, under conditions for best audio response, be left full clockwise. Since it is now within a heavy feedback loop, rotation counterclockwise for the first approximately 200° of rotation serves only to drop the audio response at both the high and low ends of the range, mostly at the low end, and reduces audio volume very little. In extreme cases of noise, when too great a range of transmission is being tried and the received signal is filled with ignition and other noise, this can be of some use. However, over-all circuit noise out of the receiver will be at least 45 db down and sometimes 50 db down. This does not take into account atmospheric noise, which is mainly a matter of propagation path and receiving-antenna efficiency. Audio distortion will be less than 3 per cent over the range 75 to 7,500 cycles. It was discovered that a poor commutator in the dynamotor, especially in the low-voltage side, will at times contribute a surprising amount of low-frequency noise.

The receiver, the BC 603, will almost always be used at a fixed location, such as the main studio. When the receiving location is also the location of the broadcast transmitter, additional problems are frequently encountered. These are not insurmountable. The first thing to take into consideration is to select a group of frequencies that are not harmonically related to the broadcast frequency. This is examined before the remote-pickup CP is applied for. Next, watch out for harmonics at the IF frequency, which is 2.65 Mc. Stations on frequencies around 880 and 1,320 kc, might expect trouble from this score with the receiver located at the main transmitter. At KSID in Sidney, Neb., much difficulty was experienced when the receiver was located within 18 in. of the 250-watt broadcast transmitter. However, when it was moved to the basement, everything was fine. KSID operates on 1,340 kc the second harmonic being 2,680 kc. The IF must be broad in order to prevent am-

[2] For further information regarding this modification, see Fig. 1-10*a*, *b*, *c*.

plitude distortion of the frequency-modulated signal. The original dynamotor is replaced by a 110-volt rectifier which is built on the dynamotor base and plugs in just as the dynamotor did. No tube changes in the receiver are involved. The receiver is of moderate sensitivity and is reasonably stable if warmed up a half hour or so. It has an effective squelch, which will cause audio distortion and also some noise if left on during a program. A sensitive relay could easily be added so that a bell will ring upon a roving reporter calling in. For special applications, where it is desirable to work the receiver from a 6-volt source, a vibrator supply, constructed on the dynamotor base to preserve the plug-in feature, was found much quieter than the original dynamotor, and the dynamotor is available only in the 12- or 24-volt rating.

Where the propagation path from the desired remote-pickup point is too great for dependable operation, much use has been made in Cheyenne of locating the receiver at a remote point, its power being turnd on and off by remote control, simplexed over the telephone line used to carry the audio from the receiver to the studio. For special events such as fires or disasters in nearby towns, the central telephone office in that town is a logical place, particularly if it is a small town. Actually, a telephone office is a prolific source of local interference, but if the program is only a short distance away, as it would be in a small town, the noise is taken care of by the limiter. It is convenient to have special toll facilities quickly available. Holding a telephone instrument up to the loudspeaker of the receiver is another expedient that has been used in order to "get the show on," taking advantage of the beep-type service.

Microphone

As originally manufactured, the transmitter was designed to work from a carbon microphone or telephone-type microphone, or transmitter, as the telephone people call it. This feature has been preserved. All that is necessary is to plug in the carbon microphone, such as a T-17, which is available on the surplus market. The transmitter can be easily installed in other vehicles than an automobile, such as a train, an airplane, or a boat. Several installations in trains and airplanes have been made in Cheyenne. In a plane, the background noise level is so high that results are practically worthless and unintelligible with the usual dynamic-broadcast-type microphone such as RCA 88. However, with the carbon microphone, the signal comes through loud and clear, the noises being discriminated against by the restricted audio range of the carbon microphone and the fact that anybody just naturally talks much closer to this kind of microphone.

Remote Use

The FCC has assigned exclusively to the remote-pickup broadcast service the following 19 channels between 26.11 and 26.47 Mc: 26.11, 26.13, 26.15, 26.17, 26.19, 26.21, 26.23, 26.25, 26.27, 26.29, 26.31, 26.33, 26.35, 26.37, 26,39, 26.41, 26.43, 26.45, and 26.47 Mc. Further conditions of use are set forth in pages 1-18 and 1-19 of this handbook.

The equipment described has been in use for over 10 years, and hundreds of transmissions have been successfully relayed over KFBC. Many other stations have used identical equipment successfully. The range of reasonably quiet transmission is determined largely by the height and efficiency of the receiving antenna. Several stations report ranges of 10 to 25 miles. A good average figure is about 4 or 5 miles. In large metropolitan cities when working from locations surrounded by extremely tall steel buildings, particularly when the receiver is at some distance from the transmitter, deep fading effects may be experienced, and it is likely that in these locations somewhat better results might be experienced with equipment operating on the higher frequency bands. Little difficulty has been experienced in towns of less than 100,000 population from these effects.

FCC Authorization

Under Part 4, Subpart D, of the FCC Rules and Regulations the above and other frequencies are authorized for remote-pickup broadcast stations. The use of these frequencies is permissible regardless as to the availability of telephone lines. A license will be issued by FCC to an established broadcasting station, and renewals can be made concurrently with the application for renewal of the regular station license. Application for construction permit is made using FCC Form 313, which is a short form and requires only a minimum of information. Application for construction permit and license can be submitted simultaneously following instructions on FCC Form 313.

1. Type of station (remote pickup)
   Station with which proposed station is to be used (your call letters)
2. Frequency (one of those listed above)
   Power (40 watts)
   Type of emission (FM)
   Communication bandwidth, kc [2(8.5 + 0.005 per cent of carrier frequency in kilocycles)]
   Example: $2(8.5 + 0.00005 \times 26{,}410)$
   $= 2(8.5 + 1.3205)$
   $= 2(9.8205)$
   $= 19.641$ kc
3. Location of transmitter (vicinity of city in which standard station is located)
4. Antenna system (vehicle-mounted whip 114 in. high)
5. (Not required)
6. (Not required)
7. Transmitter manufacturer (various)
   Type No. (BC 604 modified)
   Maximum rated power output (40 watts)
   Oscillator, type of circuit (crystal)
   Oscillator frequency (carrier frequency divided by 54)
   Oscillator tube type (6V6 GT), make (various), number (one)
   Last radio stage:
   Tubes, make (various), type (807), number (one)
   Normal plate current (120 ma), plate voltage (500), modulation (not modulated)
8. Percentage of modulation or swing (8.5 kc)
   Frequency tolerance per cent (0.005 per cent)
   Means for maintaining frequency tolerance (temperature-controlled CT cut crystal)
   External means employed to ensure maintenance of assigned frequency within tolerance specified by FCC Rules (BC-221 frequency meter or crystal-controlled multivibrator, checked against WWV)

Rule 4.481 requires that a simple log be kept of each transmission. An operator holding a commercial license or permit is necessary at the remote-pickup transmitter.

CONVERSION

Materials Needed

Transmitter:

One BC 604 transmitter
Six 6V6GT tubes
One 6L6 tube
One 807 tube
One RCA K900849-501 microphone input transformer or equivalent
Three 0.001 300-volt mica condensers
One 10-$\mu\mu$f 300-volt mica condenser

One 2,200-ohm ½-watt carbon resistor
One 510-ohm ½-watt carbon resistor
One 16- to 20-μf 450-volt tubular electrolytic condenser
One 10- to 10-μf 25-volt tubnlar electrolytic condenser
One 40-μf 25-volt tubular electrolytic condenser insulated tie points
Two 75-ohm ½-watt wire-wound or carbon resistors
7-ft shielded, insulated, stranded, single-conductor hookup wire
5-ft insulated, stranded, single-conductor hookup wire
18-in. varnished-cambric tubing
20-ft lacing cord
One 3-ohm 2-watt wire-wound resistor
One crystal, in FT 241 mounting
One 100,000-ohm ½-watt carbon resistor

Receiver:
One BC 603 receiver
One ½-watt 2,500-ohm resistor
One small banana pin and socket
One miniature bayonet-base lamp socket
Two 20-μf 250-volt tubular electrolytic condensers
One 0.1-μf 300-volt paper condenser

BC 603 receiver power supply:
One base from dynamotor DM 34 or DM 36
One Stancor plate transformer P-6134 or equivalent
One Stancor filament transformer P-6010 or equivalent
Two 500-ohm 10-watt resistors, wire wound
One octal tube socket
One 110-volt power cord and convenience plug
One 5Y3GT tube
One 20-μf 250-volt condenser
One 75-μf 250-volt condenser

Transmitter mounting:
One transmitter mounting FT 237D
One socket SO-45
One Cannon receptacle, male P8-42
One SPST toggle switch

Dynamotor:
One PE 103 dynamotor
One 20-ohm ½-watt wire-wound resistor
One 16-μf electrolytic tubular condenser, 600 volts

Remote-control unit:
One box, removed from dynamotor BD 77c or similar, or plain steel box, 9 in. long by 5½ in. wide by 3 in. deep
One no-insertion loss, T wire wound or carbon 250-ohm volume control (1,800-ohm simple rheostat in shunt with microphone will work quite well)
Two miniature bayonet-base pilot-lamp mountings and 6-volt lamps
One VU meter, Weston model 301, type 23, 5,000-ohm resistance or equivalent
One open-circuit headphone jack (two in parallel if desired)
One hinged jack dust cover
One six contact banana plugs, male, receptacle, SO-45
Two microphone sockets, to match the mike plugs of the station
One DPST toggle switch
One DPDT toggle switch
One 5,000-ohm ¼-watt carbon resistor

Transmitting antenna:
One commercial police-type mobile antenna-mounting swivel, spring, and insulator
One mast section MS 49
One mast section MS 50
One mast section MS 51

Cables:

One dynamotor cable shielded, CD 501A, with male plug, P8-24 on one end, and female connector P8-23 on the other end, eight contact (seven contacts only used). This fits the socket P8-41 on the PE 103 dynamotor and connects the dynamotor to the transmitter mounting.

One 15-ft length cordage CO 213. This is a seven-conductor rubber-covered, shielded cable, with two of the conductors separately shielded within the over-all shield. CO 213 is a component part of SCR 508.

Two plugs PL 106. These are six-contact female cord connectors and are attached to the ends of CO 213 and the cord thus constructed is used to connect the remote-control box with the transmitter mounting, plugging into socket SO 45 on each end.

BC 604 Transmitter

Following is a step-by-step procedure for modifying the BC 604 transmitter. The essential modifications are as follows: Change the microphone input transformer to improve frequency response and reduce noise; change the direct-heated filament tubes to cathode type to adapt the filament supply to 6 volts and to reduce noise; change certain circuit elements to retain proper voltages on tube elements when plate supply is reduced to 500 volts; secure the bias of audio stages from cathode resistors instead of filament drop. Figures 1-2, 1-3, and 1-4 pertain to these notes, and the numbers circled in Figs. 1-2 and 1-3 refer to paragraphs 1 and 2 of these notes.

1. Unsolder heavy wires and the smaller wire from the contacts of dynamotor relay S102. Clip the leads to the coil of S102, at S102. Remove four screws holding relay S102, and remove the relay. Remove two screws holding condenser C162. Clip the strap connecting the + end of C162 to the tie point. Cut the wire connecting the − end of C162 to R133, at R133. Remove C162. Unsolder the heavy wire that connected relay S102 at #1 and #3, PG104, and discard. Splice the heavy wire that formerly connected #1, PG101 to the contact of S102 to the smaller wire that formerly connected to the same contact of S102, and slip a piece of spaghetti over the splice. This wire feeds the battery to the filaments. This operation removes the dynamotor relay and associated condenser, since they are no longer needed, but preserves the filament feed.

2. Mount a 16-μf 450-volt electrolytic lengthwise of the transmitter in the space formerly used in part by the dynamotor relay S102. Connect the positive end of this condenser to the hot terminal of C145 (or R147) with a wire about 6 in. long and the negative end to that end of R130 that is connected to #4, PG103 (−B), or using a longer wire run direct to #4, PG103, if preferred.

3. Install RCA mike transformer K900849-501 in the space formerly occupied by relay S101 and condenser C162.

4. Disconnect the WH lead that connects D126 (tank-other use) switch to #2 VS107 at #2 VS107, and ground D126 using the same WH wire, shortened, connecting at the solder lug close to D126. (This is necessitated by other changes in filament circuits.) Clip the wire at #2, VS107. Don't try to unsolder it here.

5. Change the lead connected to #2, VS101, from #7, VS106, to #2, VS106. Filament.

6. Ground #7, S106, to ground lug, not to #8, VS106, because #8, VS106, will be lifted from ground later. Filament.

7. Disconnect the lead connecting #2, VS106, from C139 at C139 end. Connect #2, VS106, to #2, VS105, using this wire that formerly connected to C139. Filament.

8. Disconnect the lead from #7, VS105, which runs to R127, and pull from the cable and discard. Also, discard R127, unsoldering the other lead to R127 at R127. Filament.

9. Ground #7, VS105.

10. Ground #7, VS101, using the wire that formerly connected #7, VS101, to R127.

11. Cut the strap connecting R113 to R140 and R141 at R140 and R141. Remove

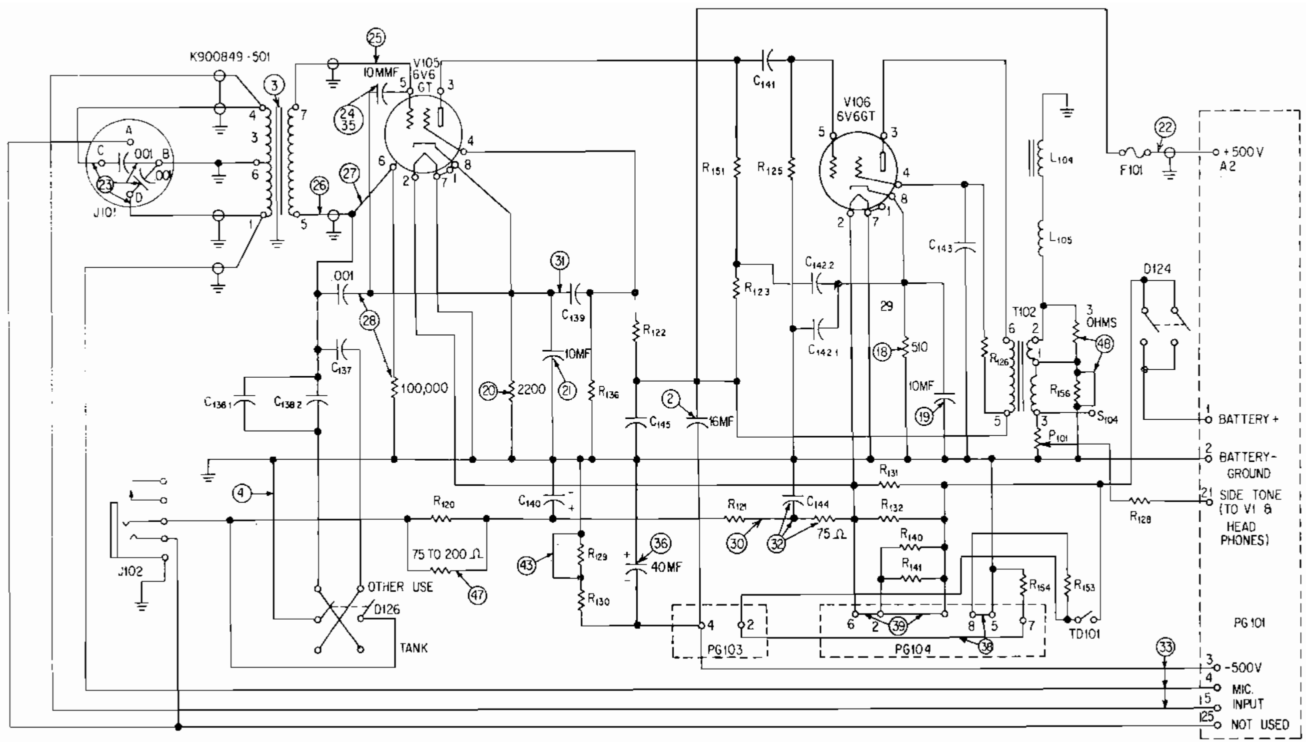

FIG. 1-2. BC-604 transmitter, audio circuits, converted. 31 indicates reference to paragraph 31, p. 7-12.

the screw holding R113 and disconnect R113 from #7, VS102, at R113, and use the wire formerly connected to R113 to connect #7, VS102, to R140 and R141 at the former junction with R113. Cut the yellow wire that connects to lamp ES101 from R113 and reconnect to R140 and R141 at the former junction of R140 and R141 with R113. (Cut the wire from R113. Don't try to unsolder.) This connection is made to the accessible end of R141. Discard R113. Filament.

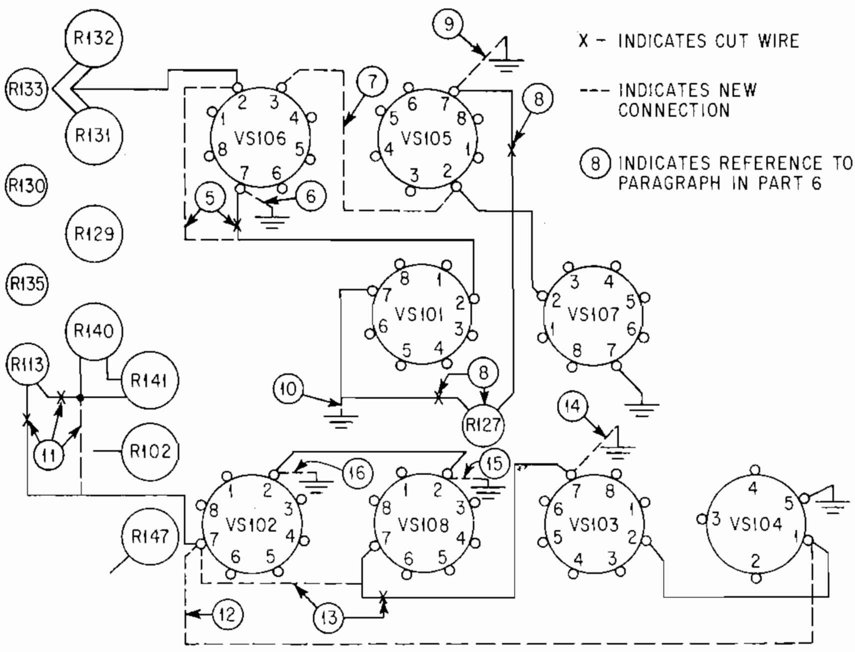

FIG. 1-3. BC-604 transmitter, filament circuit wiring diagram, showing changes made under BC-604 transmitter.

12. Connect #7, VS102, to #1, VS104, with a wire 13 in. long. Filament.
13. Change #7, VS108, from #7, VS103, to #7, VS102. Filament.
14. Ground #7, VS103. Filament.
15. Ground #2, VS108. Filament.
16. Ground #2, VS102. Filament.
17. Disconnect C110 from #2, VS102, and discard. There is no C110 in later units.
18. Install a 510-ohm ½-watt resistor between #8, VS106, and ground, removing ground from #8, VS106. Cathode-bias resistor.
19. Install 10-μf 25- or 50-volt electrolytic condenser between #8 and ground, VS106, + to #8 (cathode). Cathode bypass.
20. Install a 2,200-ohm ½-watt resistor between #8 and ground, VS105, removing ground from #8, VS105. Cathode-bias resistor.
21. Install a 10-μf 25- to 50-volt electrolytic condenser between #8 and ground, VS106, + to #8. Cathode bypass.
22. Disconnect the BL-YL wire connecting #8 on PG103 (+HV) to F161 at F161. Tape the end, and tuck it under the cable. Use the concentric line that connects C161 to #A2, PG101, for this +HV lead, making +B come through A2 on PG101 for using the external dynamotor. Disconnect C161 from the end of the coaxial transmission line. Cut the BL and GR wires from the center contact of S101.

Unsolder the bus wire connecting L111 to S101 at L111 and discard the bus. Unsolder the short coaxial cable that connects ANT terminal to S101 at S101. Remove the four mounting screws of S101. Clip the BLK wire and the BL-OR wire connecting to the coil of S101. Cut the BLK-RD and RD wires from S101. Remove relay S101. Mount an insulated tie point in the relay-mounting screw hole near the end of the coaxial cable connecting to A2, PG101. Solder the end of the coaxial cable to the tie point. Connect the tie point to F101 by means of an insulated stranded wire 19 in. long, taking this wire through hole A. Tie this wire to the cable at the top of the transmitter, also at the end, removing the plate at the right end of the transmitter to make the cable accessible. See paragraphs 43, 44, and 45 for disposition of the rest of the wires that formerly connected to S101.

23. Disconnect transformer T101 primary from terminals C and D of J101 at J101, and install condensers from C and D to ground (.001) and connect shielded wires from C and D to #4 and #1 of RCA mike transformer K900849-501. Ground shields at jack J102 (to solder lug installed under mounting screw) and ground shields at the transformer. Prepare and connect to transformer K900849-501 an additional shielded wire to each #1 and #4 and to #5 and #7 to be used later. Ground lug #6 of transformer K900849-501 to 6-32 screw adjacent, using a soldering lug and small 6-32 nut. Run the wire from this soldering lug to ground at C143. Slip spaghetti over ends of wires removed from C and D, J101.

24. Remove the lead connecting #5, VS105, to #5, T101, and discard the lead. If a small mica condenser is connected to #5, VS105, leave it connected to #5 but move the other end from #2, VS105 to #8, VS105.

25. Run the shielded lead from #7 transformer K900849-501 to #5, VS105. Ground the shield at both ends. Audio grid lead.

26. Connect the shielded wire from #5, transformer K900849-501 to #6, VS105 (used as tie point). Ground the shield at both ends.

27. Disconnect the wire that runs from the junction of C137 and C138 to #4, T101 at T101 end, and connect the junction of C137 and C138 to #6, VS105 (actually #5, transformer K900849-501). It may be advisable to replace the existing wire, which is solid, with a new wire about 3 in. long, which is stranded. Do not solder #6, VS105, until after the next step is completed.

28. Connect a ⅓-watt 100,000-ohm resistor from #6, VS105, to #1, VS105, and a 0.001 postage-stamp condenser from #6, VS105, to #8, VS106.

29. Disconnect BL-OR wire connecting C of C142.1 and C142.2 to C138 at C139 and move to #8, VS106 (it formerly went eventually to VS106, #2). Plate and grid isolation filters.

30. Disconnect R121 from C139.

31. Connect C139 (terminal formerly connected to R121) to #8, VS105. Screen grid bypass, V105.

32. Solder the ground lug of an insulated tie point to the terminal of C138 nearest PG101, and connect the end of R121 that formerly connected to C139 to the tie point. Connect a 75-ohm ½-watt resistor from #2, VS106, to the tie point. Remove the dust shield from the trimmer condensers and S104. Disconnect C144 from the radio-interphone relay S104, at S104, also at C144, and discard the wire. Connect a new wire 8 in. long from C144 to the tie point to which R121 is now connected, using hole E. Carbon-mike button current feed and filter.

33. It is necessary to remove four mounting screws holding PG101, also spacers. Be sure the spacers and grounding straps are restored after connections have been made. PG101 must be free to move. Connect #4, PG103, to #3, PG101 (−HV) with a wire 8 in. long. Connect #1, transformer K900849-501, to #4, PG101, using shielded wire and a ground shield at the transformer end. Connect #4, transformer K900849-501, to #5, PG101, using shielded wire and a ground shield at the transformer end. This operation disconnects the mike circuit of T101 and substitutes transformer K900849-501 for T101 and connects −HV of dynamotor to R130. Disconnect the present wires from #4, PG101, and #5, PG101, and slip spaghetti over the ends and tuck under the cable. Slip spaghetti over new wires to be connected to #3, #4, #5 of PG101, and slide it over the terminals after soldering.

34. Disconnect at the socket the shielded wire from #5, VS106, which goes to #2, S104, thus removing R148 from the circuit and raising the gain of the audio amplifier. Some sets do not have R148 and have no connection to Sec. 2, S104, and paragraph 34 can be disregarded in these cases. The purpose of R148 is to reduce the audio gain while transmitting, and, in any event, this gain-reduction circuit is not desired in this application. The easiest way may be to clip also the other shielded wire of this pair at #6, VS106 (used as tie point), also the ground of the

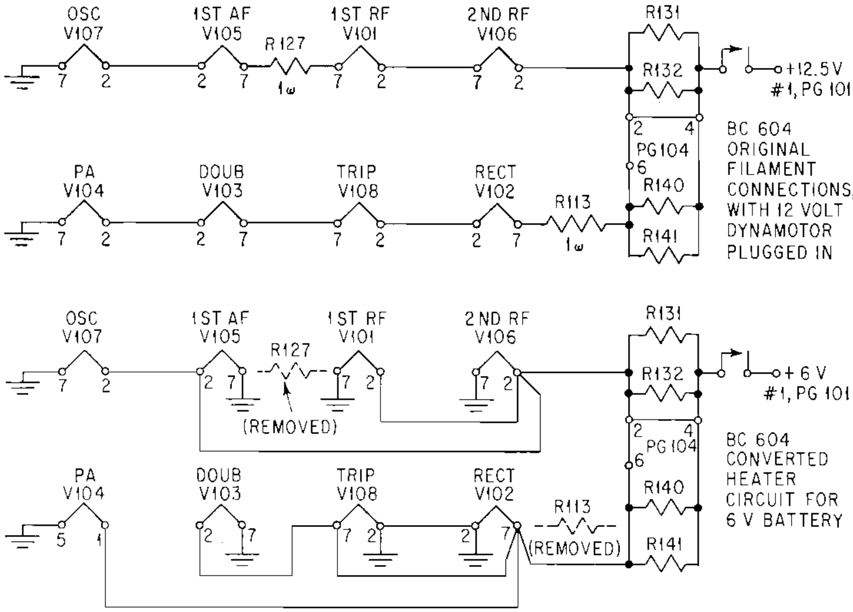

Fig. 1-4. BC-604 transmitter, original filament schematic and converted heater schematic.

shield, so spaghetti can be slipped over the end of the entire cable and the cable tucked away adjacent to the relay S103. R148 can also be disconnected from #6, VS106, also at its other end, and discarded.

35. Connect a 10-$\mu\mu$f condenser from #5, VS105, to #8, VS105, keeping leads not over ⅜ in. long. Some transmitters already have such a condenser connected from #5, VS105 to #2, VS105. If so, this condenser has been reconnected in paragraph 24.

36. Lay a 40-μf 25- or 50-volt tubular electrolytic condenser in the space between the end of the transmitter and PG103 and PG104, and connect the positive end of the condenser to ground, using the ground lug at the corner of PG101, and the negative end to #4, PG103 (−B). Bias filter. If resistor R152 is in the way, disconnect it and remove it. This resistor serves as a load on the interphone output and is not needed. It is connected from #20, PG101, to ground. Cut the wire at #20, PG101, and at the ground lug. The screw can be retained to tie the condenser to.

37. Connect #4, VS104, to ground (#5, VS104), grounding cathode of V104, type 807.

38. Connect #2, PG103 to #7, PG104, and #5, PG104, to #8, PG104. Crystal heaters.

39. Connect #2 to #4 to #6, on PG104, shorting the 24-volt dropping resistors R131 and R132, and R140 and R141.

40. Disconnect R115 from C138 and from T101, and discard R115.

41. Cut the BR wire at D122 that connects to R135. Cover out the end with spaghetti, and tuck it under the cable. This makes it impossible to close the battery circuit through the coils of antenna relay S101 and receiver disabling relay S103, which are not used, thereby saving battery current.

42. Cut the RD-BR wire at the tie point (near R132 and to which tie point +C162 was formerly connected) which connects S104 to D124. This cuts the feed of the d-c filament battery to the coil of S104, radio-interphone relay, which is not used and which thereby saves a drain on the filament battery if the radio-interphone switch should be inadvertently thrown to "interphone."

43. Mount a soldering lug in the hole which formerly held S101, near L110, and ground the GR and BL wires which were removed from the contact of S101 to the lug, thus maintaining a continuous short to ground of R129. R129 was used to block all tubes quickly when the press-to-talk switch is pressed. This feature is not needed, since for this application the carrier is kept continuous.

44. Mount an insulated tie point with insulation suitable for RF near the end of the short RF coaxial cable that connects to ANT post, and solder the free end of this coaxial cable to the tie point. Connect the end of L111 formerly connected to S101 to the tie point by means of a piece of heavy tinned bus wire, taking care to form the bus so it will not short to ground.

45. Mount a three-point, vertical, insulated tie point strip in the remaining hole formerly used for mounting S101. To the lower tie point, connect BLK wire that formerly connected to coil S101. To the second point, connect BL-OR wire that formerly connected to the coil, S101. To the top point connect the RD and BLK-RD wires that are in series with the HV to V4. The antenna relay S101 is not used.

46. Remove the lamp E101, which is a 24-volt lamp, and replace with a 6- to 8- or a 12-volt lamp. The 24-volt lamp removed is used in the receiver.

47. Shunt R120 (200 ohms) with a 75-ohm ½-watt resistor. The carbon-mike current feed was designed to work from 12 volts and having added 75 ohms in series with R121 already in paragraph 32, it is now necessary to reduce the total resistance in the carbon button circuit so that the 6-volt source will cause sufficient button current to flow. However, if the particular carbon mike used does not give sufficient output, this 75-ohm resistor should be replaced with one of 200 ohms. If mike level is too high, substitute a 25-ohm resistor, which, while increasing the current flow, will act as a voice frequency load, reducing the signal level.

48. Clip the BL shielded wire from terminal #0 of L105, and clip the RD-BL shielded wire from #2, T102. Clip the ground wire of this shielded twisted pair, slip spaghetti over the bared end of the cable, and tuck it away in the space around the relay S103. Unsolder the bus wires from #1, L105, and temporarily remove L105. Short R156 by connecting #1, T102, to ground with a short bare tinned wire. Connect an insulated stranded wire 3 in. long to #2, T102, skin and tin the other end of the wire. Connect a 3-ohm 2-watt wire-wound resistor between #2, T102, and ground. Restore L105 to its original mounting. Connect #0, L105, to #2, T102, by means of wire already connected to #2, T102. Reconnect bare bus wires to #1, L105.

49. Rearrange screen grid dropping resistors R114 and R116, for V104, from series to parallel. Clip the strap at #2, VS104 (screen grid), and solder the clipped end to the adjacent terminal of R114, thus connecting R114 and R116 in parallel. By means of an insulated wire 4 in. long, connect the original junction of R114 and R116 to #2, VS104.

50. Install tubes in the transmitter as follows:

V101	6V6GT	V104	807
V102	6V6GT	V106	6L6
V103	6V6GT		
V105	6V6GT		
V107	6V6GT		
V108	6V6GT		

Transmitter Mounting

Mounting FT 237D is a component of SCR 508, SCR 528, and SCR 538. FT 237D is designed to accommodate one BC 604 transmitter and two BC 603 receivers. The mounting is cut by means of a hack saw, so as to accommodate only a transmitter BC 604. It is necessary to dismount the right-hand shock mount from the discarded part and remount the shock mount under the right-hand end of the receiver. All existing wiring of the FT 237D is discarded. Socket S045 and receptacle P8-42 are mounted on the left end of FT 238D, as is the SPST toggle switch. J 403 is retained. The mounting is wired in accordance with the diagram in Fig. 1-5. The mounting provides a plug-in shock mounting for the transmitter. No tools are needed to remove the transmitter for test or storage.

PE 103 Dynamotor

Most cars use a grounded negative battery. The PE 103 dynamotor is originally designed for use with a positive battery ground. The BC 604 transmitter is designed for a negative battery ground. (The electrolytic condensers of the carbon-mike circuit dictate a negative battery ground.) The changes of the PE 103 dynamotor consist mainly of the following: Reverse the input polarity (this amounts to reversing the polarity of the high-voltage brushes and interchanging the + and − signs at the ends of battery cables). Raise the operating current value of the HV overload breaker. Bring the negative high voltage out through terminal #2 of the output connector, thus isolating the high-voltage output from the d-c input circuit. A high-voltage filter condenser is also added. Following is a step-by-step procedure to accomplish these modifications. The following paragraphs refer to Fig. 1-6.

If it is desired to use the equipment with a positive ground, replace the carbon-mike filter condensers in the transmitter with insulated tubular type, reversing the polarity of the connections. For positive battery ground, the only changes that will be needed in the original PE 103 are the addition of the HV condenser, raising the operating point of the two breakers, bringing out the negative high voltage through #2, 3K1, shorting 3R2.

1. Remove HV and bell (long brush cover, opposite end from battery cables). Loosen four knurled screws in the top plate, and remove the dynamotor from the base.

2. Remove the terminal bolt from the old −HV brush. Isolate the two heavy wires formerly connected to the old −HV brush, but connect them together by means of the screw and nut just removed. Slip a piece of sleeving over the junction of the tape. Clear the heavy strip connected to the old −HV brush by bending it toward the outside.

3. Reconnect the green wire to the old −HV brush by means of a new bolt and nut, but clip the green wire at the lug and at the condenser. Solder a new insulated wire 8 in. long to the lug just bolted to the old −HV brush, and connect the other end of the wire to the condenser that is connected to the old +HV brush (by means of the green wire) and RF choke.

4. Clip the green wire at the condenser and RF choke to which the old +HV brush was formerly connected; also clip the same wire at the old +HV brush. By means of an insulated wire 8 in. long, connect the old +HV brush to the condenser which formerly connected to the old −HV brush.

5. Disconnect three wires from breaker 3E3 and three wires from breaker 3E5. Remove two screws at the front of breaker 3E5 and one screw from the rear of breaker 3E5 and remove the breaker. Disassemble breaker 3E5, divide the coil into two approximately equal parts, and reconnect the two halves in parallel, with the current flowing around the core in the same direction in each half.

6. Before replacing 3E5 run an insulated wire 14 in. long through the hole in the base. Connect one end of the wire to the old +HV brush and the other end to the tie point that connects to condenser 3C8 and #2, 3K1. Clip the wire at the tie

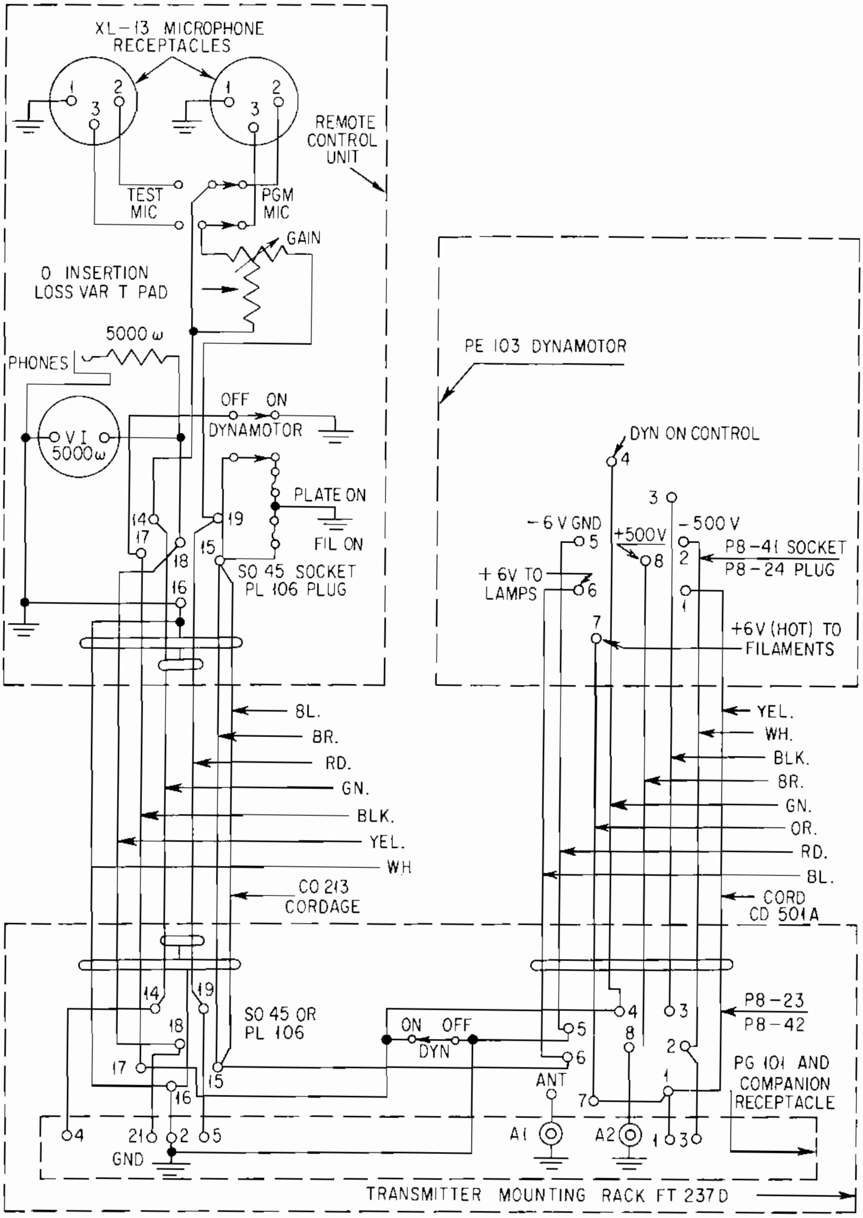

FIG. 1-5. FT 237-D mounting, schematic as modified. Remote-control schematic and connections for interconnecting cords, plugs, and sockets.

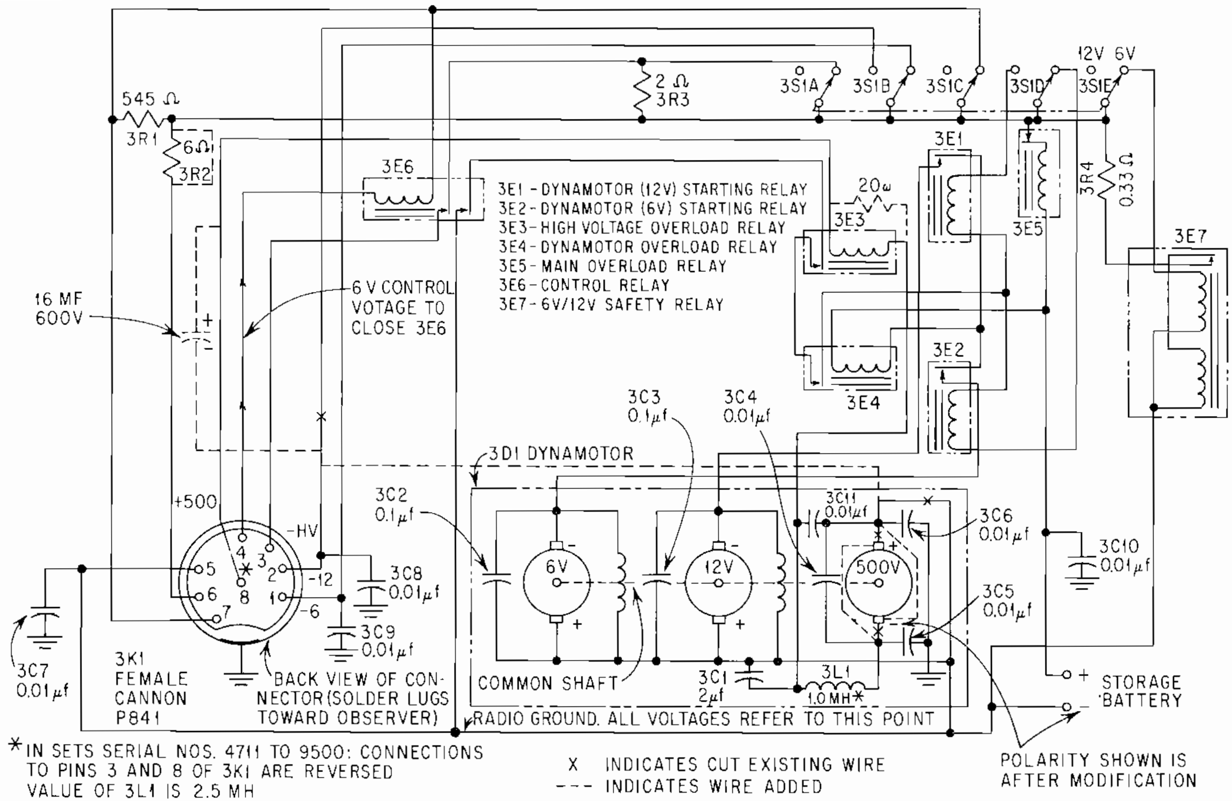

FIG. 1-6. PE-103 dynamotor schematic, showing modifications.

point that connects the tie point to 3S1B, and slip the sleeving over the end of the wire. Connect the other end of the wire to the old +HV brush. This becomes the new −HV brush, and the −500 volts is thus isolated from the 6-volt circuit and is brought out separately through #2, 3K1.

7. Restore breaker 3E5 to the original mounting position. Restore three wires to 3E3 and three wires to 3E5.

8. Connect a 10-ohm 2-watt wire-wound resistor between the two coil terminals of breaker 3E3. These are the terminals to which are connected two black wires leading from inside the breaker. This raises the tripping point of the HV overload from the original 0.220 to about 0.400 amp.

9. Drill a small hole through the bakelite strip mounting the insulated tie point which is connected to 3C8 and to #2, 3K1. Connect an insulated wire 5 in. long to a 16-μf 600-volt tubular electrolytic condenser at the − end. Lay the condenser parallel to breaker 3E3 in the space between 3E3 and the metal bracket supporting the old +6-volt terminal, with the − end of the condenser nearest the panel. Tie the condenser in place with lacing cord. Connect the + end of the condenser to the terminal of 3E3 farthest away from the panel of the dynamotor, the terminal which connects to +500 volts, #8, 3K1.

10. Short resistor 3R2 (6-ohm) which connects to #6, 3K1, by means of a heavy wire.

11. Restore the dynamotor to its case. Restore the HV end bell.

12. Change the − tag to the battery cable now bearing the + tag, and move the + tag to the cable now bearing the − tag.

BC 603 Receiver

Following is a step-by-step procedure for modifying the BC 603 receiver. The modification of the receiver proper consists mainly of adding plate-supply filter condensers, reducing the audio level through the first audio stage, connecting the receiver ON switch into the 110-volt a-c supply to the rectifier, and adding a pilot lamp.

1. Remove the front guard by removing four screws in the corner. Remove the dust cover by releasing the shakeproof screw in the rear.

2. Remove the front panel by removing six 6-32 screws, including that holding the EMERGENCY LOCK if the receiver has this feature, and two 8-32 screws, one above and one below the push buttons. The front panel is plug-in, and by working back and forth the plug at the bottom should readily disengage.

3. BC 604-DM only. [The 604-DM has four contacts on D5 (is a make-one-break-one switch), whereas D5 on BC 604-D is a simple open-and-close switch. BC 604-DM has no R22, R32, R33.] Mount two 4,700-ohm ½-watt resistors in parallel between the two tie points at the end of the bakelite terminal strip, removing the wire connected between these two points. This puts the new 2,350-ohm resistance in series with T1, the output transformer, and D2. Clip at both ends and remove from the cable the wire connecting the center terminal of P1 to D5. This wire is connected through #12, PG-3, then through #7, PG-1, and to the receiver disabling relay of the transmitter. Receiver disabling is not used in this application, and since this wiring is in the grid circuit of the first audio amplifier and is unshielded, it is best disconnected.

4. BC 604-D only connects a ½-watt 2,500-ohm resistor in parallel with R22, R32, R33.

5. Remove the spare fuse mounting.

6. Mount a bayonet miniature lamp socket in the hole formerly used by the spare fuse. It will probably be necessary to enlarge the hole slightly by reaming or filing.

7. Connect a small banana pin socket to the center terminal of the lamp mounting. Such a socket can be obtained by disassembling a plug and socket such as is used in the 247N command sets. Take care that the center pin of the lamp mounting is left free to move, and slip a piece of spaghetti or rubber tubing over the banana socket for insulation.

8. Solder the shell terminal of the lamp socket to the frame of the mounting, grounding one side of the lamp.

9. Replace the front panel on the receiver. Replace the front guard.

10. Place the soldering lug under the 6-32 screw at the lower left-hand corner of the front panel, strip and tin the ends of an insulated wire 3 in. long, solder one end of the wire to the soldering lug, and insert the other end in the G binding post, thus grounding one side of the antenna input at the front panel, in addition to the ground at PG-1.

11. Connect by means of an insulated wire 19 in. long, #8, PG-2, to #1, J-3. If #8, PG-2, is strapped to #11, PG-2, remove the strap. Run a wire along the main cable, and tie to same with a lacing cord. This places REC ON switch, D1 also fuse F1, in series with the 110-volt a-c supply to the rectifier cord.

12. Lift the cable from the fear of the receiver and place the 20-μf 250-volt electrolytic tubular condenser in the corner under PG-2, vertically, and connect the + end to #13, PG-2, and the − end to the − terminal of C25 (lower terminal) or optionally to #7, PG-2. Plate supply filter.

13. Mount a 20-μf 250-volt tubular electrolytic condenser in the space over condenser C20, and connect the − end to the − end of C25 and the + end to the + end of C25. Tie the condenser in place with a lacing cord. Plate supply filter.

14. Connect a 0.1-μf condenser from #1, LCU4 (which is connected to #15, J3), to ground at the lug to which L1 is grounded.

15. Skin and tin the ends of a piece of insulated wire 13 in. long; connect a banana plug, the mate to the banana jack of paragraph 7, to one end of the wire; and connect the other end of the wire to #2, VS4. This connects the hot 12-volt filament to the pilot lamp. Slip a piece of spaghetti or rubber tubing over the banana pin to insulate same. Tie this wire with a lacing cord to the conduit carrying the antenna wires.

16. Remove the 250,000-ohm resistor, R10, which connects #4, V7, to C11 and remove the megohm resistor, R11, which connects between the junction of C11, C13, C26 and #2, V9. Return these resistors to the circuit with their positions interchanged. In other words, change R10 from the original value of 250,000 ohms to 1 megohm and change R11 from the original value of 1 megohm to 250,000 ohms. This reduces the audio level at the grid of the first audio stage to prevent overloading.

17. Cut a piece of sheet metal of such size to cover the plug on the back of the receiver, drill two holes in the cover and two matching holes in the receiver at the ends of the plug, and by means of self-tapping 6-32 screws, mount the cover. This is to protect the live contacts on the plug which now bear 110 volts a-c.

18. Install the negative feedback circuit as outlined by heavy lines in Fig. 1-1.

Power Supply for Receiver

Since the receiver in most cases will be located at a place such as the studios or the main transmitter location, where 110-volt 60-cycle a-c power supply is available, it is modified to operate from such a power source rather than from a d-c source. The receiver requires 12 volts filament supply. If the components are carefully chosen, they can be mounted on the base of the originally furnished dynamotor DM 34 or DM 36. The socket for the rectifier tube is mounted flush with the dynamotor base. Two 500-ohm 10-watt resistors plus a 20- and 75-μf condenser are used as a filtering network and a voltage-dropping device to drop the voltage from that provided by most stock transformers that will fit the base. The base suggested will plug into the receiver, thus making a convenient arrangement. The receiver requires 200 volts at about 60 ma. Figure 1-7 indicates suitable wiring of such a rectifier and strapping of the multiconnector socket on the base to connect the front-panel ON-OFF switch into the primary and to connect the separate filament strings in parallel.

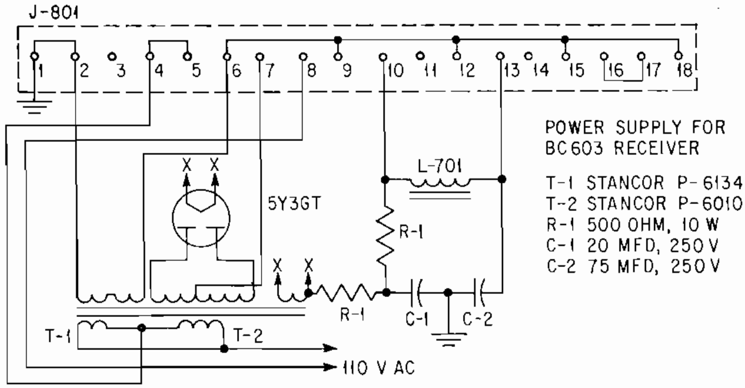

FIG. 1-7. BC-603 receiver, 110-volt a-c supply.

INSTALLATION

Receiver

Results as regarding distance covered without objectionable noise will depend largely on the height and efficiency of the receiving antenna. A ground-plane quarter-wave antenna or coaxial half-wave antenna located on top of the main transmitting tower will probably be the best, provided the main transmitter is not too far removed from the area in which most of the relayed programs will originate. Next best is a similar antenna on top of a tall building in the center of the area in which programs will originate. Good results can be had over shorter distances with an antenna located in an open and quiet location on a 40-ft telephone pole. The receiving antenna is matched to a concentric transmission line such as RG 8U, and the line connected to the receiver. The squelch control of the receiver should be OFF during program reception. The audio output is taken from the receiver at the phone jack. VOLUME is adjusted for +4 VU into 500 ohms. One side of output is grounded. The receiver should be peaked at carrier frequency by means of the RF trimmers. It is vital that the antenna trimmer be so peaked.

Transmitter

If a pleasure car is used, the transmitter is installed in the luggage compartment on the left side. The mounting is screwed to the floor by means of heavy sheet-metal screws or bolted down. It must be carefully grounded to the chassis of the car.

Transmitting Antenna

The transmitting antenna is mounted on the left side of the body of the car at the rear, keeping the antenna lead as short as possible. Use three mast sections, a total of 114 in. A commercial police-type antenna mounting and insulator, which includes a spring to protect in case of driving under an obstacle, should be selected.

Dynamotor

Mount the dynamotor permanently in the rear luggage compartment next to the transmitter on the right side of the car. Clamp the low-voltage lead to the frame of the car. Cut a hole 1¼ in. in diameter through the floor. Pass the + low-voltage lead through the hole and forward to the car battery. Clamp the lead directly to the hot terminal of the battery, splicing with similar cable if necessary. Clamp by means of pipe straps and tie snugly to the underside of the floor of the car to prevent chafing and shorting. By means of cable CD 501A connect the dynamotor to the transmitter mounting.

Remote Control

The function of the remote control is to provide a convenient means of controlling the audio level and indicating when the filament is on, also of switching the plate supply dynamotor on and off. By frequent use of the DYN ON switch, much battery current is saved during test transmissions and cueing transmissions. Means is also provided for switching in a test microphone in place of the regular program mike. The remote control is usually placed on the seat beside the driver of the car. When not in use, it is removed from the connecting cord and put in an out-of-the-way place.

If more than one mike at a time is needed, a regular four-channel remote amplifier is connected in place of the pro-mike by means of suitable level-reducing pads and isolation coils. Since the volume indicator is fed from the ouput of the audio amplifier at about zero level through the same cable that the low-level microphone is fed to the audio amplifier, it is absolutely necessary that the two microphone conductors be separately shielded, preferably within the over-all shield of the cable. Such a cable is CORDAGE 213, a component of SCR 508. Figure 1-5 is a circuit diagram of the internal wiring of the remote control, also the manner in which the remote control is connected to the transmitter through the transmitter mounting and to the dynamotor. The lettering of the remote control shown in the photograph is engraved. An excellent job of lettering can be done with decals.

OPERATION

Leave the filament switch of the transmitter on. Leave the high-voltage and main overload switches of the dynamotor on. Turn the filaments on by means of turning on the filament overload of the dynamotor (the switch nearest to the hinge of the door covering the overload control). If left on continuously, this switch causes a small drain of about 15 ma on the battery. Allowing the normal time for the filaments to warm, turn the DYNAMOTOR switch of the remote control to ON position. This applies high voltage to the transmitter and places the carrier on the air. Microphones of an output level as great as that of the RCA 88 type must be used. Those of a low output level such as the RCA 44 type will not fully modulate the transmitter. Such microphones can be used, however, using a regular remote amplifier, the output of which is fed through the microphone terminal of the remote control or directly into the transmitter through the MAGNETIC MIC socket. Once properly tuned up, the transmitter and transmitting antenna circuits will need little readjustment. These circuits will keep their adjustment even though the car is driven over hundreds of miles of rough roads. The equipment has been used for many years without any readjustment of any kind. Since the equipment draws approximately 32 amp from the 6-volt battery, it is well to run the car engine if transmissions are longer than 15 min.

For transmission from airplanes, where the acoustic noise level is high, provision in the modification instructions is made for use of a carbon microphone. In such conditions, the carbon microphone will give better over-all results than a high-quality broadcast-type microphone. The close-talking variety such as T-17 is most suited. The carbon microphone is plugged into the CARB MIC jack. The volume control on the remote control is turned off during use of the carbon microphone. No variable volume control for the carbon microphone is provided. However, the TANK OTHER USE switch is a high-low carbon-microphone volume control. The gain for a given carbon microphone can be adjusted by the shunting resistor R120 within the transmitter. The volume will be indicated on the VU meter. It should be anticipated that the announcer will use a high voice level under high noise conditions.

Transmitter Notes

Since the type 1619 tubes have been replaced in the RF line-up with type 6V6GT, and since the 6V6GT has a different internal capacitance between the elements from the 1619, the trimmer condensers across the tuning coils will have to be changed to compensate. While this effect is very substantial, nevertheless, the condensers do not need to be rotated more than about 15° in order to bring the circuits into resonance. Some will be increased; some decreased. The tune-up procedure is to set the meter switch at position #3, rectifier grid current, and rotate the main tuning shaft until a reading of 20 or 21 or maximum on the meter is had. Then set the meter switch to position #4, doubler grid current, and adjust C153 and C157 for maximum meter indication. Next, set the meter switch to #1, tripler grid current, and adjust C114 and C116 for maximum meter deflection. Next, set the meter switch to #5, power-amplifier grid current, and adjust C120 for maximum deflection on the meter. Great care must be used to see that the ninth harmonic of the crystal frequency is selected in the plate circuit of the rectifier tube and not some other harmonic. One method, before modifying, is to connect the transmitter by means of using dynamotor DM-35 and a 12-volt source and a dummy antenna A162, and rotate the main tuning shaft with a tuning lock loosened until maximum output into the dummy antenna is had, all in accordance with instructions contained in the technical manual.

With the use of an absorption-type wavemeter, the proper harmonic can easily be selected, and with such an instrument at hand, it should be not necessary to tune up the transmitter initially before making the modifications. There is the advantage, however, since surplus and not new equipment is being used, that if there may be any defect in the transmitter, it can more easily be located and remedied if the transmitter is tested before modifications are undertaken.

Typical meter indications, after conversion outlined herein, are:

Meter position	*Circuit metered*	*Meter reading*
2	RF amplifier grid	19
3	Rectifier grid	21
4	Doubler grid	20
1	Tripler grid	23
5	Power-amplifier grid	20
6	Total B-supply current	60

The only value that is critical is the rectifier grid current, meter position #3. The only requirement in the other grids is that sufficient grid excitation be had in each stage to drive the stage following and to secure stability of operation.

The SIDETONE control adjusts the voltage fed to the VU meter. With a meter as specified, the proper setting of this control will be about 15° less than maximum clockwise position. Apply 1,000 cycles of audio frequency to the microphone input, at such level as to cause 11.5 volts to appear at terminal 21 of PG 101 of the BC 604 transmitter, with the VU meter and headphones of the remote control disconnected, measured with a vacuum-tube voltmeter, with the SIDETONE at maximum clockwise. This will produce a frequency swing of about 5 kc. Modulation peaks will achieve the level limit of 8.5-kc swing. Connect the VU meter, insert high-impedance headphones, and adjust the SIDETONE control to indicate +4 on the VU meter.

If the transmitter is adjusted so that a reading of other than 20 or 21 with meter selector on position 3 in obtained, the carrier swing (modulation percentage) and distortion will not be optimum. This reading can be controlled by changing the screen grid voltage of the first RF amplifier, V101, by changing the value of R103.

The antenna-current meter reads not only the antenna current but the capacitance current of the small section of concentric line in the antenna circuit.

Frequently, large-scale readings of antenna current can be had with the antenna entirely disconnected. Two antenna mast sections will produce a higher antenna current reading than three, but three will give considerably more radiation than two.

There is provision for operation on 10 different frequencies, changed by means of pressing a single push button. For this application, the trimmers should be peaked at the single frequency, disregarding tracking over the whole band. Follow the tuning instructions of Technical Manual TM 11-600 in every other respect.

The modifications make inoperative the RECEIVER-TUNE and RADIO-INTERPHONE switches. Tune the output stage and antenna coupling circuits for maximum antenna current, with three masts connected.

Difficulties Which May Be Encountered

Of the hundreds of installations that have been made, the most frequent causes of difficulty that have been encountered are discussed below:

1. *Connection and matching of transmitter to antenna.* There is about 18 in. of low-impedance coaxial cable *internally* in the transmitter. If the output is taken from the antenna terminal on the front of the transmitter, this cable is still shunted

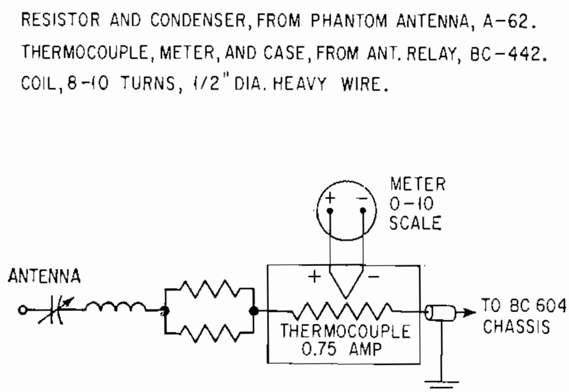

FIG. 1-8. Antenna output-tuning indicator.

across the antenna output. If the antenna output current is taken, as it will generally be if a plug-in mounting is used, through the coaxial connector at the end of the transmitter, then this internal coaxial cable is in series with the antenna. It has been found that only an open wire, not to exceed 18 in. in length, can be used to connect from the cannon plug to the base of the whip. A coaxial cable *can* be used—preferably RG 8U—for the connection to the whip, but this coaxial cable *must* be exactly one or more half waves long electrically.[3] When installed in a standard pullman car, a coaxial cable of three half waves in length was used. When an odd length of coaxial cable is used for this connection, the output tuning elements of the transmitter apparently cannot achieve resonance and a match. An antenna-current meter is provided, but it is coupled to the antenna circuit in a rather unusual way, and when everything is right, it makes a very reliable antenna resonant indicator. It should be noted that under extreme conditions of nonresonance or mismatch, a large showing can still be obtained from this meter, with practically no radiation.

2. *Receiver installation.* Generally speaking, results will be governed very largely by the efficiency of the receiving antenna. The higher the receiving antenna, the better the results, assuming, of course, that there is an impedance match. The receiver apparently presents a fairly good match to RG-8U cable. A ground plane quarter-wave antenna, omnidirectional, matched to RG-8U cable, the antenna being mounted about 45 ft above in the clear, will give good results. Actually satisfactory

[3] Obviously, a matching network could be provided to feed any length of coaxial line with a low VSWR, but this assumes no additional circuits.

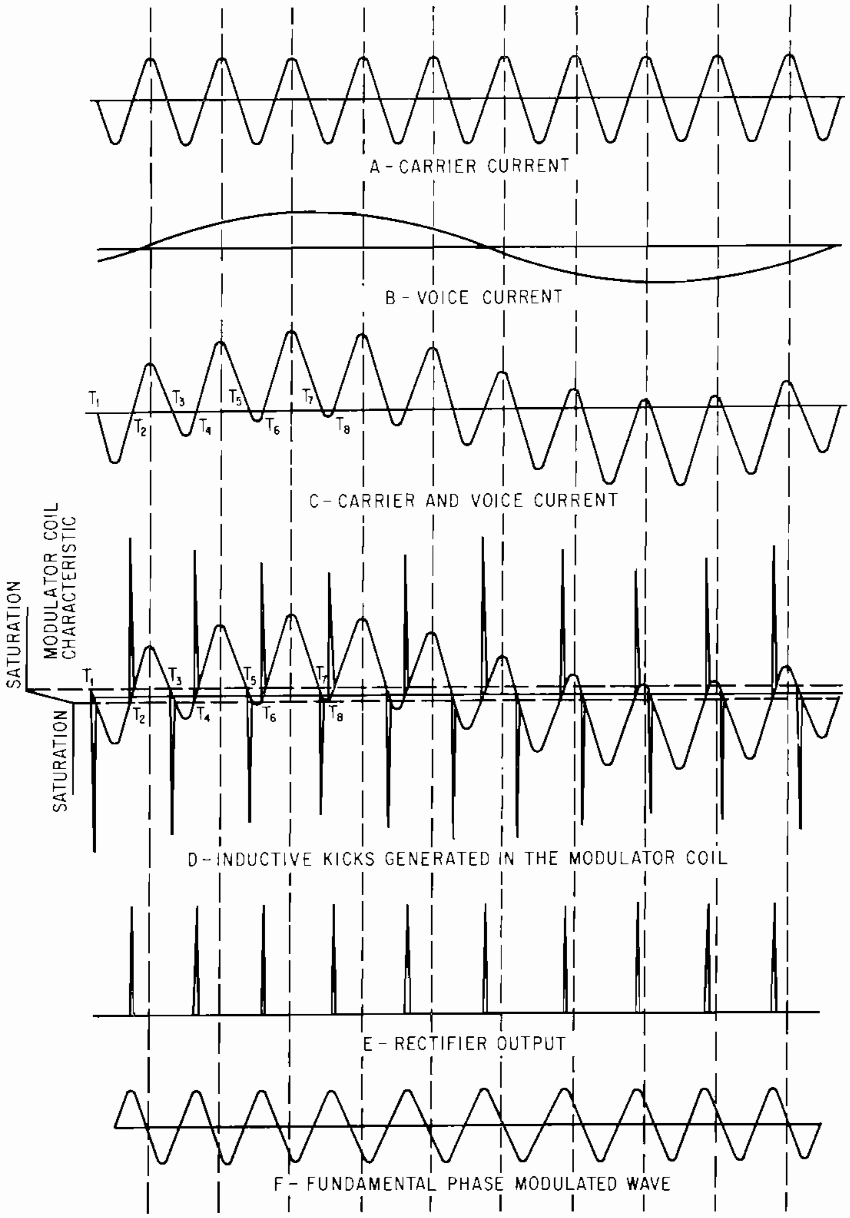

FIG. 1-9. Radio transmitter BC-604, method of modulation.

reception has been had over a distance of 2 or 3 miles with a 15-ft piece of wire hung out of a second-story hotel window, provided the input of the receiver is carefully tuned.

3. *Receiver antenna tuning.* On the left side of the receiver is the antenna trimmer, C1.1 on the schematic diagram. This adjustment has the same effect that most antenna trimmers do, and its purpose is to bring the first tuned circuit in the receiver to resonance, regardless of the nature of the impedance that is connected across the antenna input terminals. Thus, for each particular antenna, there will probably be a certain best adjustment of this trimmer. It need not be adjusted when different channels are selected within the allocated 26-Mc band for this service, but it should be checked from time to time to make up for any change in the antenna or if the first tube is changed. This adjustment is best made with no transmitter carrier on, tuning for maximum noise, with the main tuning set to between 26 and 27 Mc. A good technique can be developed for this adjustment by using the "sensitivity" control in connection with the "squelch feeling" for the antenna trimmer adjustment that causes the noise to just operate the squelch, with the "sensitivity" the farthest counterclockwise that will still cause the squelch to operate as the trimmer is rocked.

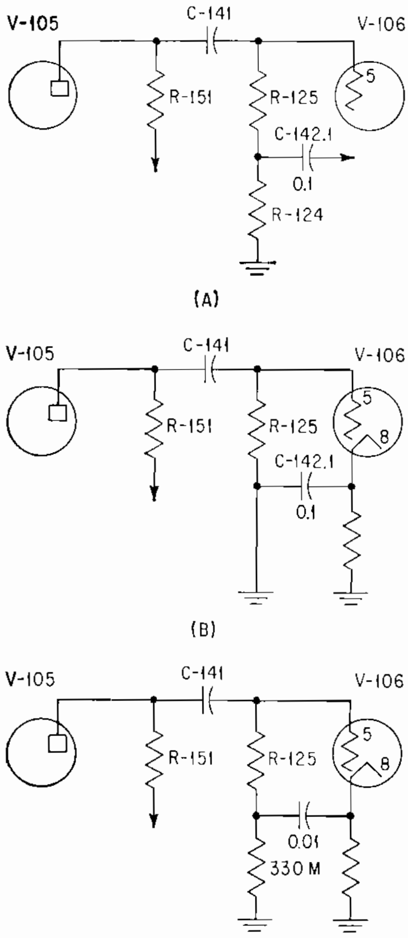

FIG. 1-10. (*A*) Partial diagram of BC-604 transmitter audio circuit as it appears in original diagram in Technical Manual TM 11-600. (*B*) Partial diagram of BC-604 transmitter audio circuit as it appears in Fig. 1-2. (*C*) Partial diagram of BC-604 transmitter audio circuit including modification which should be made to increase frequency response. (This modification is not included in Fig. 1-2.)

Cueing

A logical question which arises at this point relates to cueing. The reader may ask, "Why isn't two-way cueing utilized?" The answer is that there is a better way to do the "talk-back" job. The initial requirements are for a high quality, dependable, noise-free remote-pickup circuit which is mobile and easily portable.

The transmitting equipment described draws about 32 amp from the 6-volt battery. A new fully charged standard equipment car battery, with no other load on it, will operate this transmitter for over an hour. With the car engine running, it will operate for considerably longer. As other loads are added, first a receiver, then lights, perhaps a heater, etc., the margin grows narrower. As a matter of fact, for complete freedom of worry from this source, many stations install the Leece-Neville alternator-rectifier type of generator in their mobile unit. This will put out up to 100 amp continuously, with engine barely above idling speed. A condenser and coil filter are usually necessary to suppress ripple. The 32 amp is about the feasible limit, and this transmitter uses about 40 watts input to the plate of the final stage. Input to the last tube of, say, 250 [4] watts or more would surely indicate some kind of gasoline generator, with all its cumbersome complications. Next, a mobile transmitting antenna is indicated. This means that to get any efficiency, the antenna should be about a quarter wave long. At 26 Mc, the car body, with its large capacity to ground, serves as a pretty good substitute for a ground, and a quarter-wave whip is of a very convenient size. Thus, a good transmitting efficiency is achieved. And so we find that for *mobile* use, this power range and this frequency are naturals. Now examine the requirements for the circuit in the reverse direction,

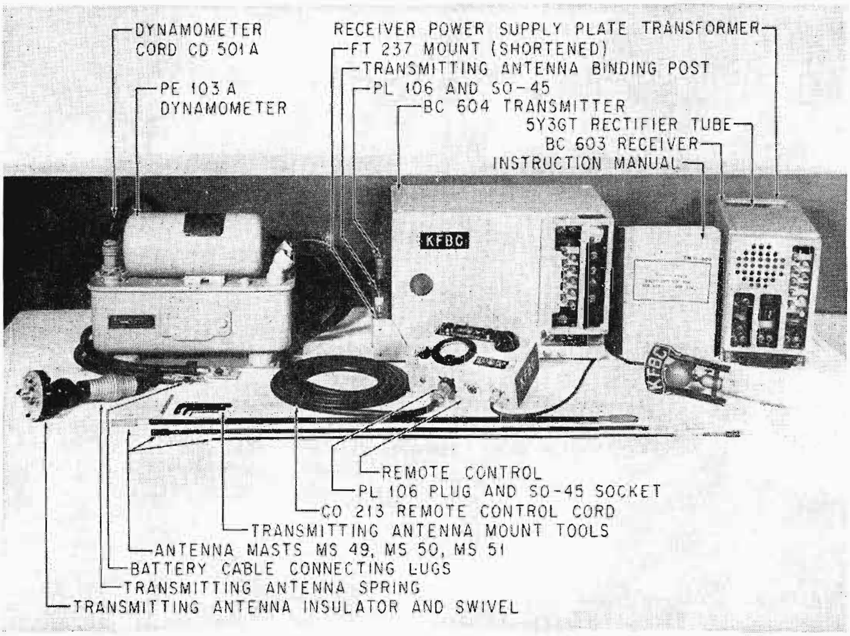

FIG. 1-11. View of the various components of the system.

or the "talk-back." To begin with, the location of the talk-back transmitter, in the general case, will be fixed, and, in addition, it will mostly be at the same location as the main broadcast transmitter, which means that a near-perfect transmitting ground is available. There is nearly always a tall structure (the main transmitting tower) close at hand. Furthermore, the transmitter can and surely will be operated on an a-c source, not a car battery. Thus, there is no rigid limitation on the number of watts available from the primary power source. And, probably the most important difference in the requirements between the talk-back and the mobile pickup equipment is the fact that the talk-back needs only to transmit intelligence. Finally, and very compelling, is the question of the receiver for the talk-back, which is, of course, located in the vehicle which carries the pickup transmitter. This vehicle will inevitably have a standard broadcast receiver as part of its original equipment. Group B of the FCC assignment specifies 1,606 kc, in addition to other frequencies. Many standard BC car receivers will tune to 1,606 as they come from the factory. Those that do not can be made to do so with a very slight adjustment of the oscil-

[4] Not recommended for a single 807 tube.

lator trimmer, with no serious impairment to their operation across the broadcast band. Thus, the receiver part of the talk-back circuit is already provided in a most satisfactory manner. The talk-back transmitting antenna, using the regular ground, and a wire supported to prevent any detuning of the main radiator will prove highly efficient. Experiment has shown that this is quite feasible, using about one-third to one-half the available height, if the tower is located away from the building. In any event, a good ground is available. Since voice-only transmission is required, any of the many war-surplus communication transmitters are adequate from this standpoint. A good example is the BC 191, which is available on the surplus market at approximately $29.90 complete with tuning unit TU 5. This is rated at 100 watts input to the last stage. It will have to be modified to crystal control. This is a very simple modification. The present oscillator is changed to an RF amplifier, and

Fig. 1-12. View of the remote-control unit.

a 6L6 tri-tet crystal oscillator is constructed on a separate chassis and fed by coaxial cable to the BC 191. In addition, a 1,000-volt 350-ma power supply will be needed. Parts for this will cost no more than the transmitter. A push-to-talk relay is built into the transmitter, and a small d-c rectifier will be needed for this. Thus, for less than about $100 worth of materials, plus our labor, we are in business with a talk-back that will surely communicate out as far as the remote pickup will transmit in. It will immediately be apparent that the first station in any community to apply for group B assignment for its talk-back is the lucky one. Actually, however, it is fairly simple to make a converter so that almost any of the lower authorized frequencies in groups A, B, or C, will serve very nicely. The BC 375 transmitter is more readily located on the war-surplus market and will do about as well as the BC 191 but will require somewhat more extensive changes to operate from alternating current instead of the intended 28 volts direct current.

Note: Equipment discussed in this part can be obtained from the following sources:

R. W. Electronics, 2430 S. Michigan Ave., Chicago 16, Ill.
Fair Radio Sales Co., 132 S. Main St., Lima, Ohio.
Columbia Electronics, 2251 W. Washington Blvd., Los Angeles 18, Calif.
C & H Sales Co., 2176 E. Colorado St., Pasadena 8, Calif.
Texas Crystals, 8538 W. Grand Ave., River Grove, Ill.
G & G Radio Supply Co., 51 Vesey St., New York 7, N.Y.
Edison Electronic Company, 1902 N. Third St., Temple, Tex.

Part 2

A PRACTICAL 160-MC REMOTE-PICKUP BROADCAST SYSTEM

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CONVERSION OF THE MOTOROLA FMTRU 30 EQUIPMENT FOR USE IN THE 160-MC REMOTE-PICKUP BAND

Introduction

The equipment described in this part consists basically of the Motorola FMTRU 30 which is designed to operate in the 152- to 162-Mc band with an output power of 30 watts. This is a crystal-controlled unit and maintains its operating frequency within a tolerance of 0.0025 per cent (minus 20 to plus 60°C). The unit is frequency modulated utilizing an angular balanced modulator with a required 20-kc deviation for 100 per cent modulation. It is primarily intended for 6-volt operation but with slight modifications can be adapted for 12-volt systems. After modification the frequency response will be found to be substantially flat from 50 to 5,000 cycles with extremely low distortion and noise. Dependable transmission in excess of 25 miles can be expected from such a unit, depending, of course, on the height of the receiving antenna and the local terrain and noise level. *Before conversion is attempted, a complete original instruction manual should be obtained from the manufacturer.*

Frequency Allocation

The FCC has allocated nine remote-pickup channels between the frequencies of 152.87 to 153.35 Mc. These are shared with the Industrial Service, and in fact, the Industrial Service has priority of use. It should be pointed out here that band loading by the Industrial Service will increase because of the recent channel-splitting decision of the FCC, with consequently less opportunity for broadcast shared use of this band. Since Industrial interference posed such a problem in the 152.87- to 153.35-Mc band, no attempt was made to convert this unit for these frequencies but to utilize a band which had fewer disadvantages to the remote-pickup service.

The frequency of 166.25 Mc was decided upon even though the Commission has imposed certain limitations upon its use. This frequency under present rules may not be utilized within the area bounded on the West by the Mississippi River, on the North by the parallel of latitude 37°30′ N and on the East and South by that arc of the circle with a center at Springfield, Ill., and radius equal to the airline distance between Springfield, Ill., and Montgomery, Ala., subtended between the foregoing West and North boundary and also within a 150-mile radius of New York. Another limitation to the use of this frequency is that no interference shall be caused to government radio stations. To date, operation of this equipment has produced no known interference complants.

It should be pointed out that the Commission in its Notice of Proposed Rule Making, Docket 11959,[1] proposed to delete this frequency and substitute in lieu thereof six exclusive remote-pickup channels each 30 kc wide between 161.646 and 161.825 Mc. These will be exclusive to the broadcast industry, and, *if they are allocated,* this equipment could be easily converted to this band.

Where the propagation path from the desired remote-pickup point is too great for dependable operation, the receiver can be used at a remote point, and its power turned on and off by remote control merely by simplexing the telephone line used to carry the audio from the receiver to the studio. For special events such as fires or disasters in nearby towns, the central telephone office in that town is a logical place to tie into the telephone facilities, particularly if it is a small town.

Conditions of Use

Remote-pickup broadcast stations will not be granted exclusive frequency assignments, and the same frequency or frequencies may be assigned to other licensees in the same area.

Applicants may request information about the existing remote-pickup assignments in a particular area and apply for unassigned frequencies to the extent permitted by the FCC rules. The Commission is unable to supply information regarding existing assignments to the industrial radio stations in the band shared by remote-pickup stations with the service.

Where a frequency is shared by two or more remote-pickup stations and simultaneous operation is contemplated, the transmission of actual program material has first priority, the transmission of cues and orders including preparatory communications has second priority, and the use of the remote-pickup station for other authorized communication has the lowest priority.

For detailed conditions of use see pages 1-18 and 1-19 of this handbook.

Licensing

Under Part 4, Subpart D, of the FCC rules and regulations, the above and other frequencies are authorized for remote-pickup broadcast stations. *The use of these frequencies is permissible regardless of the availability of telephone lines.* A license will be issued by FCC to an established broadcasting station and renewals may be made concurrently with the application for renewal of the regular station license. Application for construction permit is made using FCC Form 313 which is a short form and requires only a minimum of information (see below). *Application for construction permit and license may be submitted simultaneously,* following instructions on FCC Form 313.

1. Type of station (remote pickup)
   Station with which proposed station is to be used (your call letters)
2. Frequency (166.25 Mc)
   Power (30 watts)
   Type of emission (60 F3)

[1] NAB testimony in this docket requested 10 channels.

Communication bandwidth, kc (60 kc)
3. Location of transmitter (vicinity of city in which standard station is located)
4. Antenna system (vehicle mounted)
7. Transmitter manufacturer (Motorola)
Type No. (FMTRU-30)
Maximum rated power output (30 watts)
Oscillator, type of circuit (crystal)
Oscillator frequency
Oscillator tube type (7C7), make (various), number (one)
Last radio stage:
Tubes, make (various), type (2E26), number (two)
Normal plate current (260 ma), plate voltage (420), modulation (angular balanced)
8. Percentage of modulation or swing (±20 kc)
Frequency tolerance per cent: 0.005 per cent from −30° to +80°C., or 0.0025 per cent from −20° to +60°C.
Means of maintaining frequency tolerance (quartz crystal)
External means employed to ensure maintenance of assigned frequency within tolerance specified by FCC rules (BC-221 frequency meter or crystal-controlled multivibrator, checked against WWV)

Section 4.481 requires that a simple log be kept of each transmission. An operator holding a commercial license or permit is necessary at the remote-pickup transmitter.

Base-station Antenna Location

We constructed a ground plan antenna as shown in Fig. 2-2 and first tried mounting the antenna on a TV mast on top of our studio building. The antenna was about 40 ft

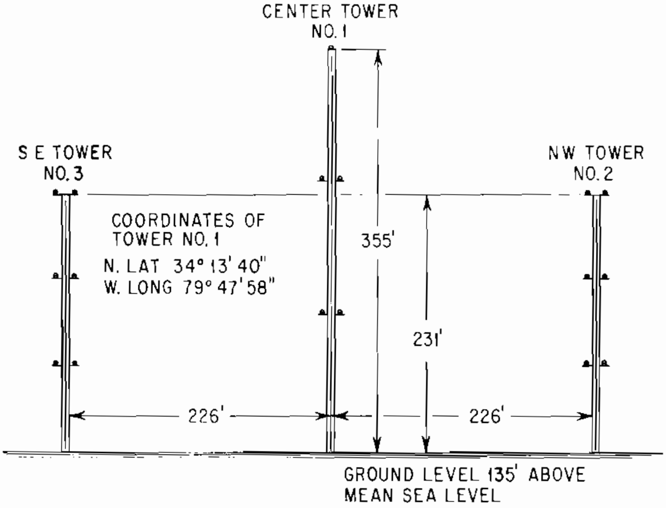


Fig. 2-1. Existing WJMX antenna system.

above the ground. This location proved to be unsatisfactory because of a very low signal-to-noise ratio.

Next, with proper authority from the FCC, the base-station antenna was mounted on top of our AM broadcast station antenna. This put the antenna 231 ft above the ground and proved to be well out of the ignition-noise area.

RG 11 U coaxial cable was used from the antenna to the base of the tower. At that point the coaxial cable was formed into a coil, and a fixed condenser placed across the coil (outer conductor of the coaxial cable). The coil was then tuned to the station frequency by "cut-and-try" adjustment of the coil tap.

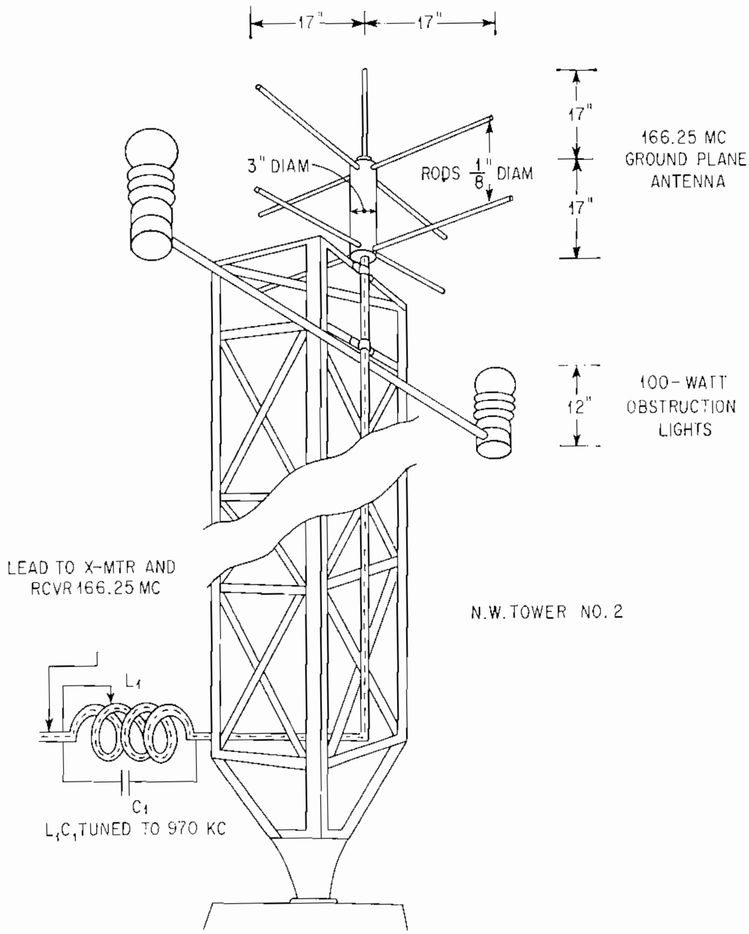


FIG. 2-2. Proposed method of mounting 166.25-Mc antenna to NW tower 2.

In some cases the FCC requires that a "skeleton" proof of performance be made in order to assure the Commission that the installation of the remote-pickup antenna has not adversely affected the operation of the AM antenna system. It is suggested that due caution be applied in such installations, particularly when a tower of a directional-antenna system is involved.

Conversion

The material needed for the conversion of the basic transmitter and receiver is as follows:

One Motorola-type FMT-1 crystal, frequency 3463.542 kc
One Motorola crystal, type D-14 (9,879.4 kc)

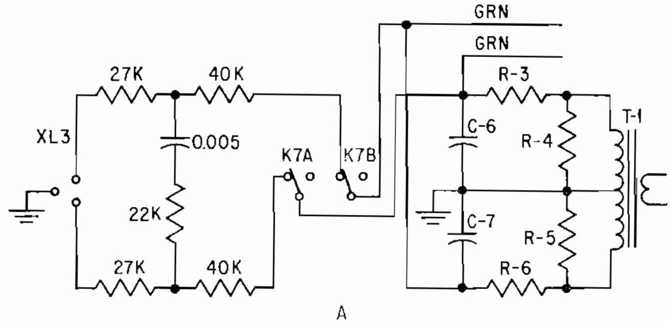


FIG. 2-3*a*. Mobile-transmitter audio and control modifications—frequency-compensation network.

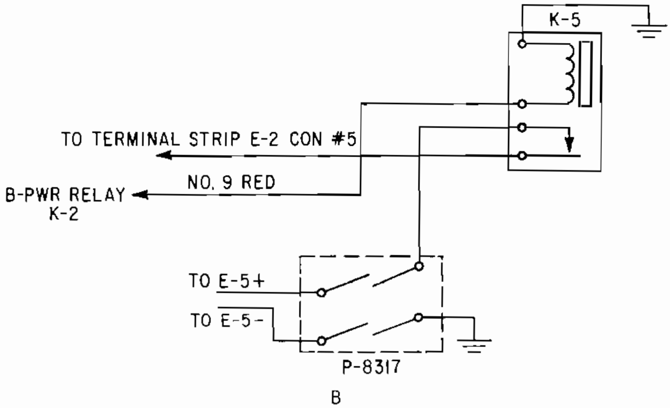


FIG. 2-3*b*. Mobile-transmitter audio and control modifications—dynamotor relay K-5 is included in some units.

One 3 PDT, 6-volt relay
One Cannon XL-3 connector
Two phono jacks
Two 27,000-ohm resistors
Two 40,000-ohm resistors
One 0.005-μf condenser
One 22,000-ohm resistor
One four-prong plug
One 100,000-ohm resistor, 1 watt
One 240,000-ohm resistor, ½ watt
One 0.001-μf, 600-volt condenser
One 0.05-μf, 600-volt condenser

The above list does not include the additional material required for the construction of the power supplies for 110-volt operation of either the receiver or transmitter, nor does it include the necessary parts for the construction of the frequency-compensating line amplifier.

Transmitter Conversion (RF)

1. Refer to the transmitter schematic in the construction manual and Fig. 2-3*a*, *b*, and *c* contained herein.
2. Replace the existing crystal with Motorola type FMT-1. Frequency 3,463.542 kc.
3. Tap down *one turn* on coil T5UA (plate side).
4. Shorten the PA plate line by moving C55 and C56 up on the lines as far as the wire will permit (approximately 1½ in.).
5. The transmitter is now ready for alignment.

Receiver Conversion (RF)

1. Refer to Fig. 2-4.
2. Install a new Motorola crystal, type D-14 (9,879.4 kc).
3. Disconnect C89, C91, and C93.
4. It may be necessary to remove one or more plates from C2 in order to tune the receiver to the antenna. In our case, one rotor plate was removed.
5. The receiver is ready for alignment.

At this point, the transmitter and receiver could be used for news and speech pick-ups; however, frequency response, distortion, and noise leave much to be desired. Considerable improvement in the response and distortion was noted by using the new transistorized mobile microphones in place of carbon mikes.

We proceeded to improve the over-all characteristics of the system to enable us to broadcast musical programs.

Inasmuch as the mobile receiver and base-station transmitter are not in the broadcast-air circuit, no audio modifications in these units was deemed necessary.

Mobile-transmitter Audio and Control Modifications

In the angular balanced modulator used, the deviation increases as the audio frequency increases. The maximum permissible frequency swing at low audio frequencies is limited by the allowable distortion. We found the maximum frequency deviation to be limited at high audio frequencies by the receiver bandwidth. For complete analysis, we used a frequency deviation meter, signal generator, and distortion analyzer. We found T1 to be unsatisfactory; therefore, a remote amplifier was used to feed the modulator grids through a compensation network. Furthermore, it was decided that on most remotes where music was to be transmitted, commercial power would be available, and in order to conserve battery power and to eliminate dynamotor noise, an a-c power supply would be used. We also decided to let the filaments operate from the battery, since d-c power was necessary for the control of relays. In order to do this and retain battery operation when desired, an additional 3PDT, 6-volt coil relay was added and wiring changes were made as shown in Fig. 2-3*a*, *b*, and *c*.

1. Install a Cannon XL-3 connector in the right side of the chassis.
2. Install relay K-7 (3PDT) under the chassis behind P2 and J3.
3. Install a phono jack on the front panel between P2 and J3 for the external carrier switch.
4. Connect one side of the coil of K7 to 4 on E2.
5. Connect the other side of the coil of K7 to 3 on J4.
6. The frequency-compensation network as shown in Fig. 2-3*a* is now connected between XL-3 and two of the normally closed contacts of K7 (K7A and K7B).
7. The movable contacts of K7A and K7B are connected at the grids (pin 4) of V2 and V3.
8. The normally closed contact of K7C was connected to the phono jack.
9. Disconnect the K2 and K3 coil leads at pin 3 of J4 and reconnect to the movable arm of K7C.
10. Connect the normally open contact of K7C to 3 of J4.

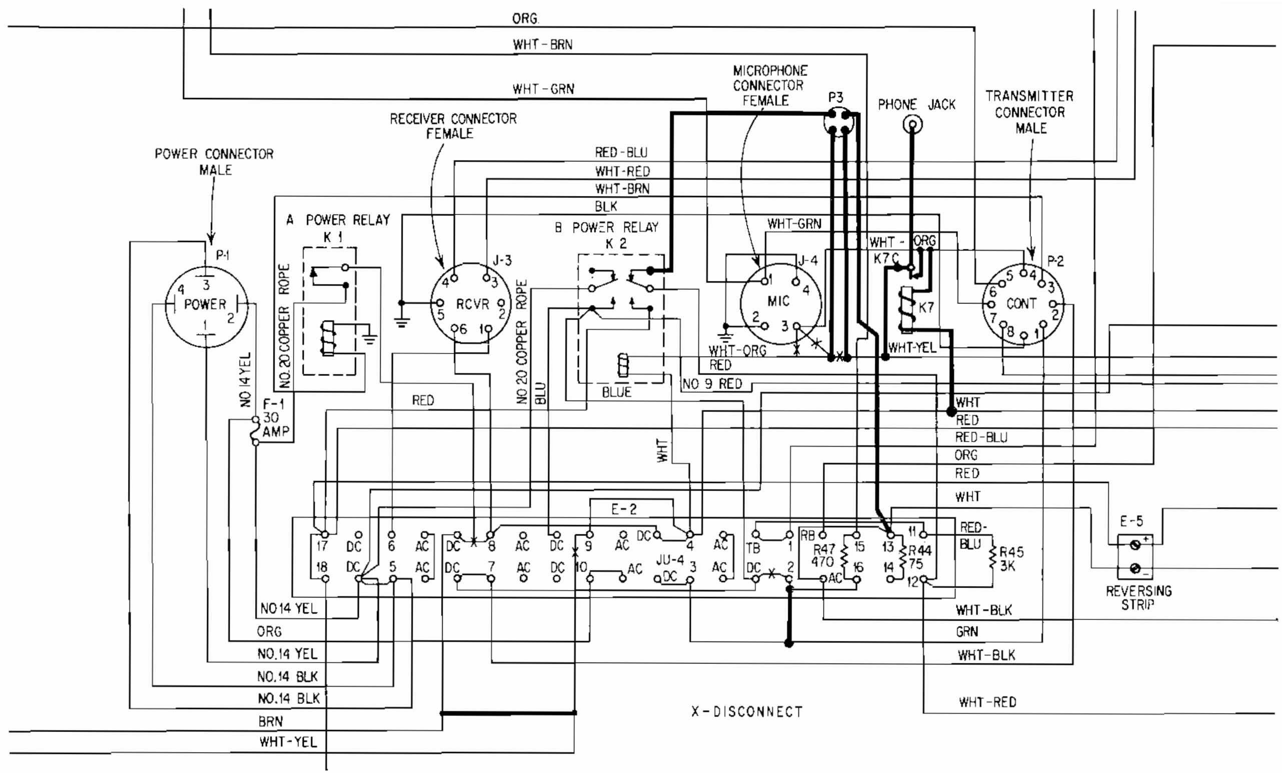


FIG. 2-3c. Mobile-transmitter audio and control modifications—external carrier switch and power connection.

11. B+ from the a-c power supply was connected to the normally closed B+ contact on K2.

12. B− from the a-c power supply was connected to 13 on E2.

The above connections were made through a four-conductor, four-prong plug (P3). The other two conductors were connected in series with K2 coil between K2 and K7C. These leads were connected to a pair of normally closed contacts of a relay in the a-c supply, which were opened by presence of d-c plate voltage from this supply. This allowed the dynamotor to operate automatically upon failure of d-c plate voltage from the a-c supply.

A standard power supply, delivering 420 volts at 280 ma with a low-current d-c normally closed SPST relay operated on B+ was constructed. B− is above ground.

The output of the remote amplifier was padded to give ±15-kc deviation of the transmitter when the VU meter indicated normal level.

Base-station Receiver Conversion

Because of distortion and poor frequency response in the receiver output stage, we used the output of the first audio stage to drive the frequency-compensation amplifier.

The following changes were made in the receiver (see Fig. 2-4):

1. Add a 100,000-ohm 1-watt resistor in parallel with R55.
2. Connect a 240,000-ohm resistor, ½ watt in series with a 0.001-μf 600-volt condenser to ground from pin 4, V15.
3. Connect a 0.05-μf 600-volt condenser to pin 3, V15. Bring out the other side of the condenser to a phono jack, which can be mounted on the front panel, next to the metering jack.
4. Disconnect C83.

The audio output of the receiver was taken from the phono jack and fed through a shielded cable to the frequency-compensation amplifier, indicated in Fig. 2-6.

The circuits of this amplifier were developed more or less by a cut-and-try method to produce the over-all response characteristics as indicated in Fig. 2-5. This response of the frequency-compensation amplifier was necessary because of the limited low-frequency response of the transmitter.

The vibrator supply in the receiver was removed, and a supply was constructed to deliver 180 volts at 100 ma and 6.3 volts alternating current at 3 amp and connected to J4.

Base-station Transmitter Conversion

The following changes were made to the base station transmitter to enable the use of an a-c supply:

1. Remove the dynamotor. It was necessary to separate the filament wiring from the relay coil wiring before applying 6 volts a-c.
2. Remove direct current to 8 jumper on E2.
3. Remove direct current to 2 jumper on E2.
4. Connect 2 to 3 on E2.
5. Break the filament line on 9 of E2 and connect to direct current formerly jumpered to 8. Six volts a-c connects to this point (see Fig. 2-3*c*).
6. Six volts d-c connects to the transmitter on P1.
7. HV (plus direct current) and (minus direct current) connects to the transmitter on E5.
8. One side of 6 volts a-c and 6 volts d-c connects to ground.

The base-station-transmitter a-c supply is conventional except for the necessary d-c mike and relay supply, which is approximately 1 amp at 6 volts d-c. Plate supply for full power requires 420 volts at 280 ma and filaments require 6 volts a-c at 4.5 amp.

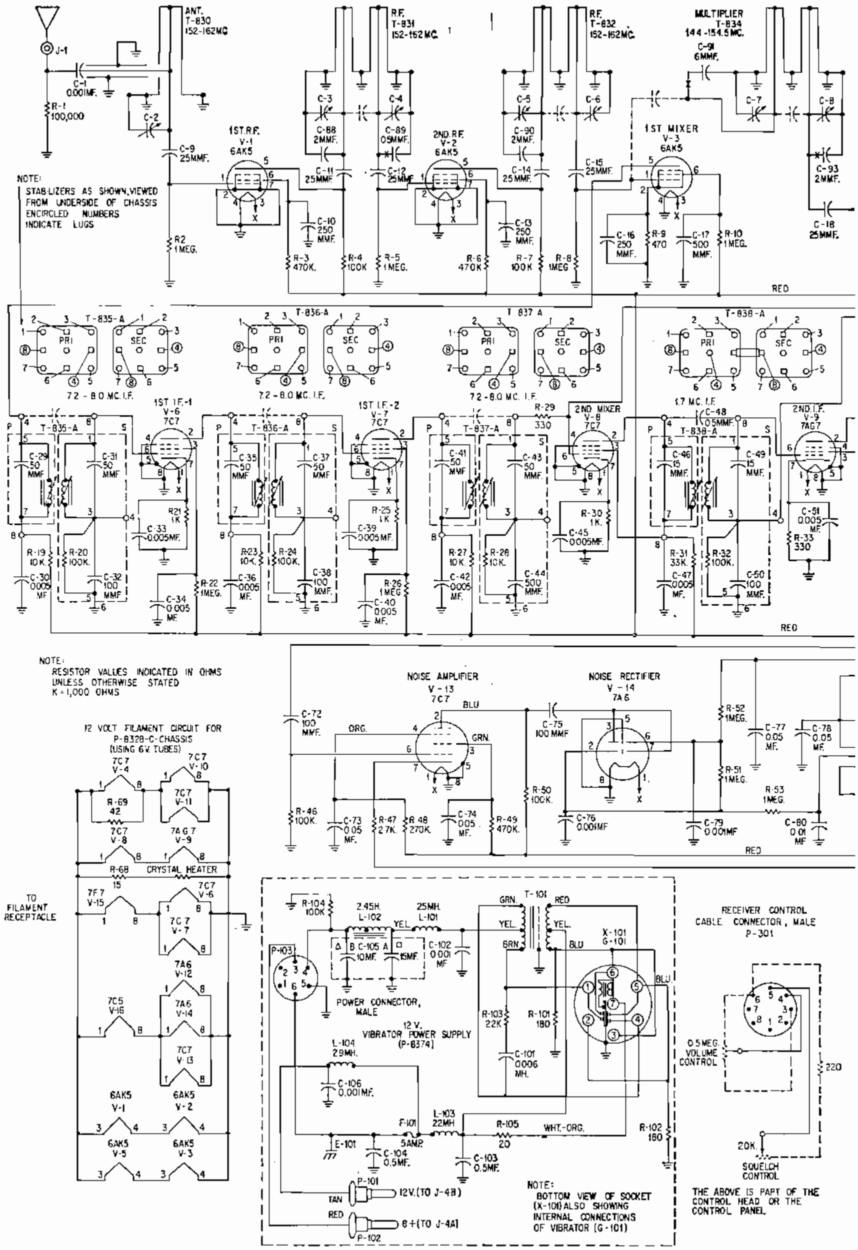
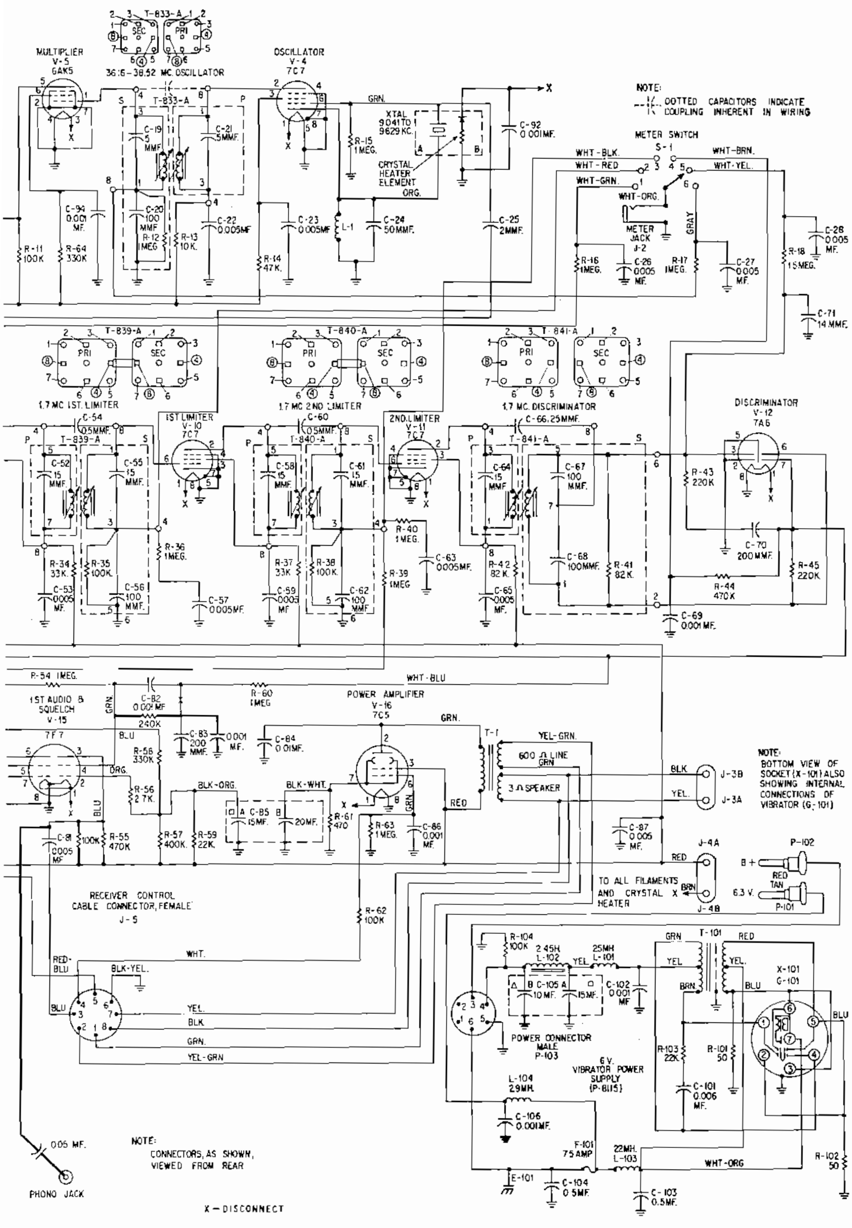


FIG. 2-4. Schematic diagram of Motorola receivers PA-8333-A and PA-8341-A. Heavy



lines indicate circuit modifications. *X* indicates removal from the circuit.

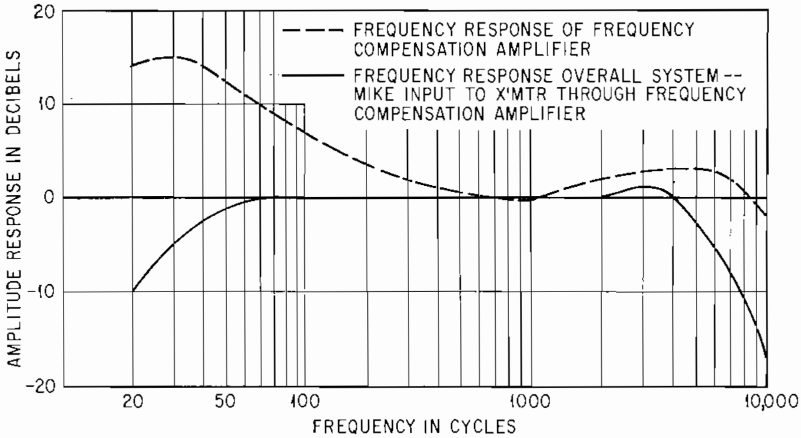


FIG. 2-5. Frequency-response curve.

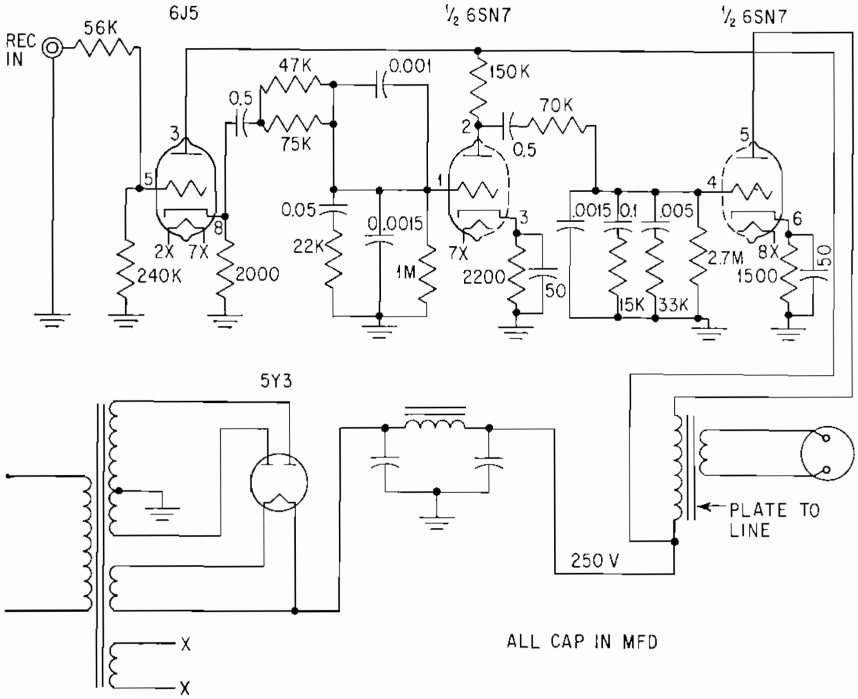
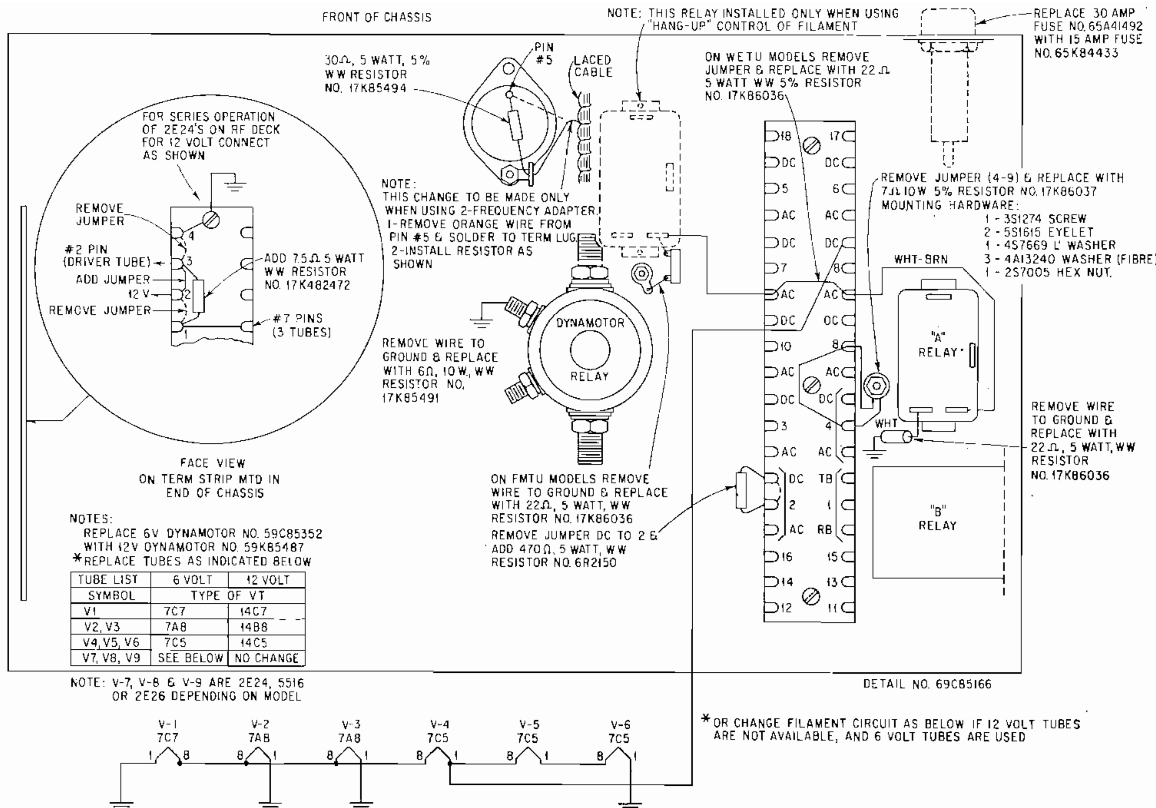
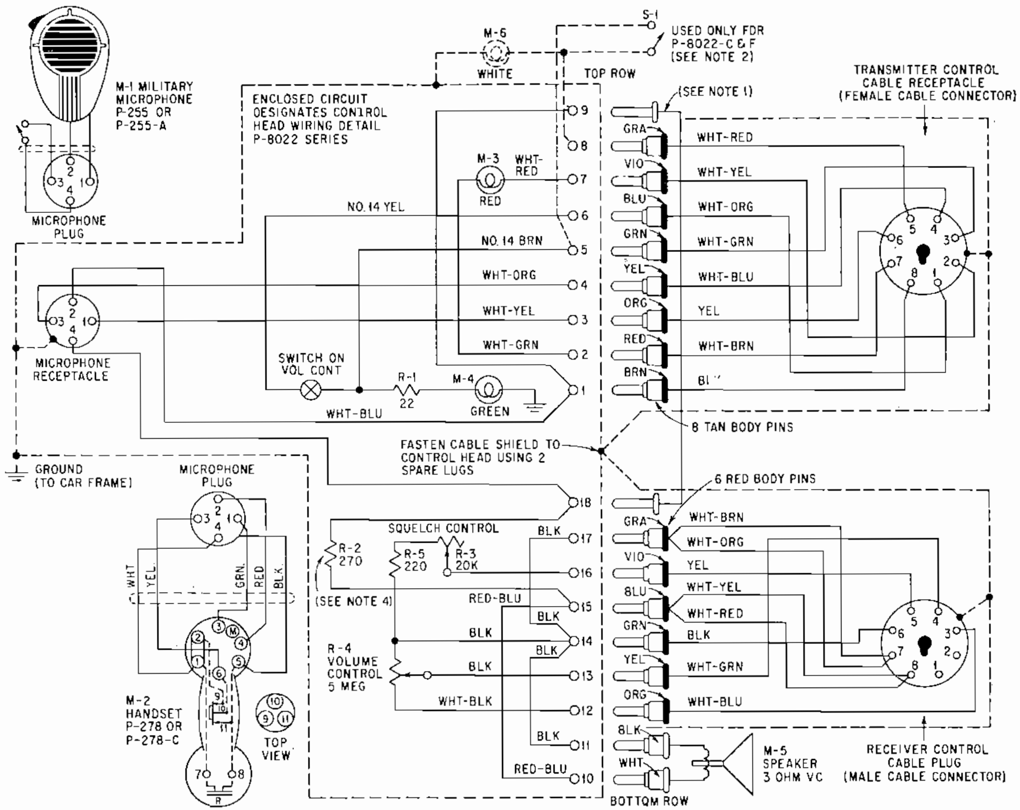


FIG. 2-6. Frequency-compensation line amplifier.



TUBE LIST	6 VOLT	12 VOLT
SYMBOL	TYPE OF VT	
V1	7C7	14C7
V2, V3	7A8	14B8
V4, V5, V6	7C5	14C5
V7, V8, V9	SEE BELOW	NO CHANGE

FIG. 2-7. 6- to 12-volt conversion detail for Motorola 152- to 162-Mc mobile transmitter.



NOTE 1: IF "M-2" HANDSET P-278 IS TO BE USED, DISCONNECT JUMPER FROM TERMINAL 9-18. IF P-255 MIKE IS USED CONNECT JUMPER FROM TERMINAL 9-18

NOTE 2: P-8022-C & F WIRED SAME EXCEPT FOR ADDITIONAL SWITCH AND LAMP FOR DUAL FREQUENCY TRANSMITER

NOTE 3: IF 500 OHM SPEAKER IS USED, MOVE LEADS ON RECEIVER CABLE (PART NO. 1881102MS) FROM 7 & 8 TO 1 & 2

NOTE 4: IF HANDSET IS USED WITH 500 OHM SPEAKER, R-2 IS TO BE INCREASED TO 3900 OHMS (MODEL P8022MS)

P-8022 6V 1 FREQ
P-8022C 6V 2 FREQ
P-8022E 12V 1 FREQ
P-8022F 12V 2 FREQ

12 VOLT SAME SCHEMATIC
M-3, M-4, M-6 ARE 12 VOLT BULB-T-3-¼ (TUNGSOL)

FIG. 2-8. Schematic diagram of control head.

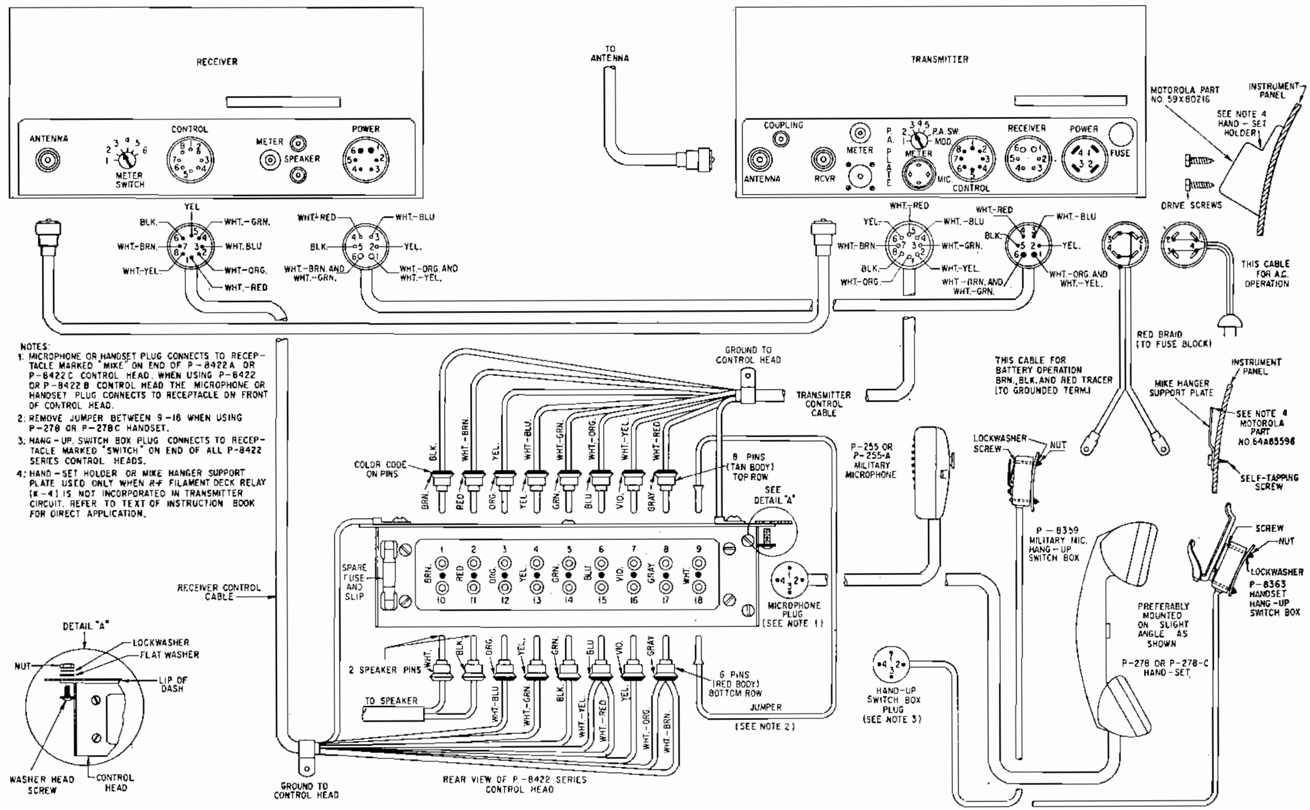


FIG. 2-9. Intercabling diagram, Motorola 72- to 76- and 152- to 162-Mc mobile and survey transmitter-receiver.

Conclusion

For remote control of the base station, we extended the carbon-mike/control cable. We also extended the receiver metering jack (normally switched to position 2) to provide an indication of signal strength.

The frequency-compensation amplifier was located adjacent to the receiver, and its output fed to a remote input on the console.

Figures 2-7 to 2-9 are included to aid in stalling, servicing, and 12-volt conversion of the equipment. Incidentally, 12-volt military surplus dynamotors were used for our mobile 12-volt system.

The equipment has proved to be very satisfactory and dependable, from the standpoint of both maintenance and quality. Under "low-noise" conditions, the quality is better than local telephone lines and, of course, far more versatile and economical. Over-all coverage with mobile units has been solid to 20 miles; however, signal-to-noise ratio has shown improvement by moving as little as 6 in. at some downtown locations. Fringe-area operation largely depends on terrain and antenna heights.

REMOTE-PICKUP BROADCAST COVERAGE TESTS ON 152.93 MC [2]

Introduction

From the following data it will be evident that FM mobile relay broadcasting in the 152- to 162-Mc band will be of considerable value to the broadcaster who may encounter extreme and adverse conditions with respect to terrain in the operation of a remote-pickup broadcast service. It will be logical to conclude that where terrain conditions are more favorable, results exceeding those mentioned in this report can be expected.

Purpose of the Test

The accelerated wartime development of transmitters and receivers for use on frequencies between 100 and 200 Mc resulted in production of equipment suitable for broadcast use on channels in the 152- to 162-Mc band. The Facilities Section of the General Engineering Department of ABC, therefore, undertook to investigate the usefulness of the 152- to 162-Mc band for mobile relay broadcasting by determining the maximum useful range of transmissions from a mobile unit to a receiving point 900 ft above sea level in Manhattan. The results showed that this band would provide excellent coverage within line-of-sight distance.

Equipment

Transmitter

A transmitter powered from the 6-volt car battery was used in the mobile unit. It is designed for communication type of service and has the following specifications:

Assigned frequency, Mc	152.93
Output power, watts	15
Frequency stability, %	±0.005
Method of modulation	Phase
Frequency deviation for 100% modulation, kc	±20
Audio response	±1 db from 500–3,000 cps
Duty	Intermittent

[2] From tests conducted by the General Engineering Department of the American Broadcasting Company, 4th edition, "NAB Engineering Handbook."

Receiver

A receiver powered from 115 volts 60 cps was used. It was installed on the roof at 30 Rockefeller Plaza, New York City. This unit is designed for communication type of service and has the following specifications:

Sensitivity	1 μv for 20-db noise suppression
Selectivity	6 db down at ±20 kc, 85 db down at ±120 kc
Audio response	±2.5 db from 350–5,000 cps
Duty	Continuous

Signal-strength readings were made at the receiver by measuring the current in the first limiter grid circuit. The use of this method of measurement results in a scale of values which gives a good spread from no signal level to limiter saturation level. The receiver sensitivity was calibrated by feeding a measured signal in microvolts, as obtained from a signal generator, to the antenna terminals of the receiver. The current in the first limiter grid was measured as this input signal was varied from 0.2 to 60 μv. The curve of Fig. 2-10 was plotted from the above test. With this curve it is a simple matter to convert all the readings taken in this test to microvolts of signal at the input of the receiver.

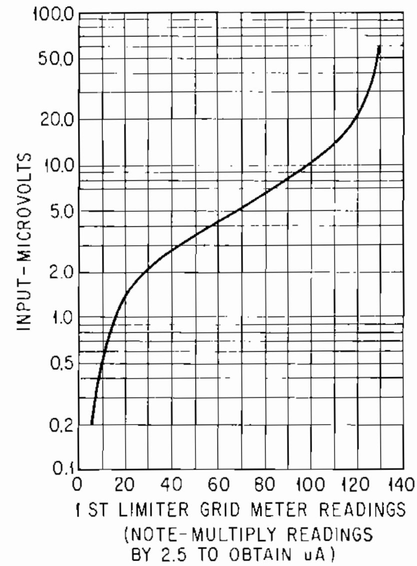


FIG. 2-10. Seusitivity curve of receiver.

Antennas

Transmitting. The transmitting antenna is a one-quarter-wave flexible whip mounted above the top of the car. The metal roof acted as the ground screen below the antenna. Ten feet of type RG-58/U coaxial transmission line having a nominal characteristic impedance of 53.5 ohms was used to connect the transmitter to the antenna.

Receiving. A five-element Yagi-type antenna was used for reception. It consists of a half-wave radiator and four parasitically excited elements—one reflector and three directors. A 300-ohm "ribbon"-type transmission line was used, delta-matched to the antenna. This line was connected to the 50-ohm input of the receiver through a one-quarter-wave matching section near the receiver. The antenna was installed in the clear, approximately 900 ft above sea level, at 30 Rockefeller Plaza, New York City. Since this antenna is directional, it was arranged so that it could be rotated. Vertical polarization was used at all times except during the cross-polarization test described later.

The antenna was directed toward the mobile transmitter during all these tests, although no attempt was made to rotate it for best results on each transmission. This practice was followed, as published data on multielement antenna arrays indicated that signals at the receiver should be essentially constant as long as the mobile unit was within ±15° of the heading of the array.

Receiving-antenna Pattern. In order to check the actual variation in received signal for the 15° maximum error of antenna heading held throughout the field tests, the pattern of the receiving antenna was determined. This was done by using it at the mobile unit for the transmitting antenna. During this test the mobile unit was located in a flat open field to reduce to a practical minimum any reflections of the

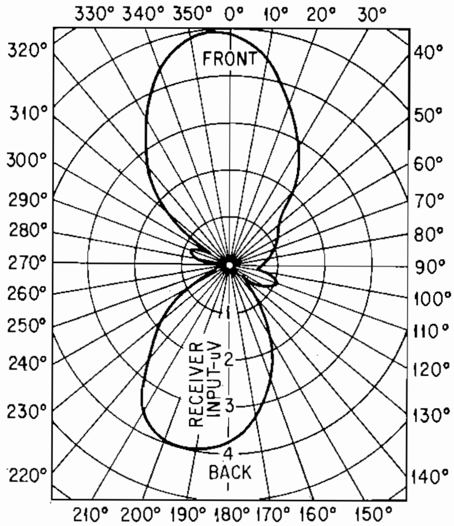


Fig. 2-11. Five-element Yagi-antenna radiation pattern—vertical polarization.

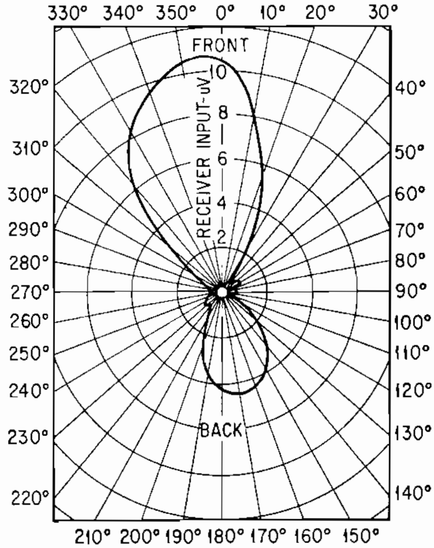


Fig. 2-12. Five-element Yagi-antenna radiation pattern—horizontal polarization.

signal. The receiver was located about ½ mile away with a clear line of sight path from it to the transmitter. A 4-in. length of wire was used for the receiving antenna in order that the received signal remain below the saturation level of the limiter at all times.

Using both horizontal and vertical polarization, the directional antenna was rotated in 10° steps and readings were taken of the receiver meter for each of these points. The results converted to microvolts input to the receiver were plotted as shown in Figs. 2-11 and 2-12.

From these curves we find that an antenna heading 15° off the actual transmitter location resulted in a decrease of signal strength at the receiver of approximately 10 per cent. For purposes of these tests, this 10 per cent variation was ignored in computing the signal levels at the receiver for the various locations of the mobile transmitter.

Results

Transmission from Car to Roof

Routes for the mobile transmitter were selected to give check points out to the limits of coverage in all directions from the receiving point. Transmissions were made from the mobile unit to the fixed receiver from hundreds of points along these routes, ranging from the immediate vicinity around the receiving point out as far as 42 miles from the receiver. In each case, a signal-strength reading was recorded at the receiver to be used in the final tabulation of results. Unfortunately, the requirement that the transmitter be operated on an intermittent duty cycle prevented the making of continuous recordings, but enough spot readings were obtained to give a close approximation of such a recording.

The results obtained were plotted on a map of the New York metropolitan area (Fig. 2-13), making the following information readily available:

1. Location of transmission point
2. Distance from transmission point to receiver location
3. Signal strength in microvolts input to the receiver from each transmission point
4. Relative usability of received signal

The received signals obtained from various points throughout the borough of Manhattan were of great interest in view of the difficulty experienced with numerous dead spots when operating on the 30- to 40-Mc channel. A very thorough coverage was therefore made of this area and included many transmissions from both avenues and cross streets from the Battery to the Henry Hudson Bridge. It was found that good signals were obtained from every point tried in this entire area with the exception of a short section of Front Street in the vicinity of Whitehall Street at the Battery. Here the signal level dropped to a nonusable value, but moving the car a short distance brought the signal level back to a usable value. The Wall Street region has in the past been particularly "dead" for 30- to 40-Mc transmission. Accordingly, a large number of tests were made from this district. These were made on Wall, Pine, Cedar, and other streets close by, along their entire traverse from the Hudson to the East River. Again good, usable signal levels were obtained with some instances of very quick signal dips. These, however, were of such short durations that it was found impossible to stop the car at any point which would produce a nonusable signal. Spot checks were made from many points in upper Manhattan, all of which gave good usable signals. It can therefore be assumed that, with the exception previously noted, complete coverage of the borough of Manhattan can be counted on.

It will be noted that practically all the transmission points in Manhattan fall within a 5-mile circle. Following the completion of runs in other directions, a general pattern of results based on distance became apparent. For example, inside a 5-mile circle, all transmissions except those previously noted and those from a small area near North Bergen, N.J., were received with good signal strength. The few points of nonusable signal within the 10-mile circle were caused by shielding from large buildings or hills close to the transmitter and directly in the transmission path. Beyond the 10-mile circle, results became somewhat erratic and were completely de-

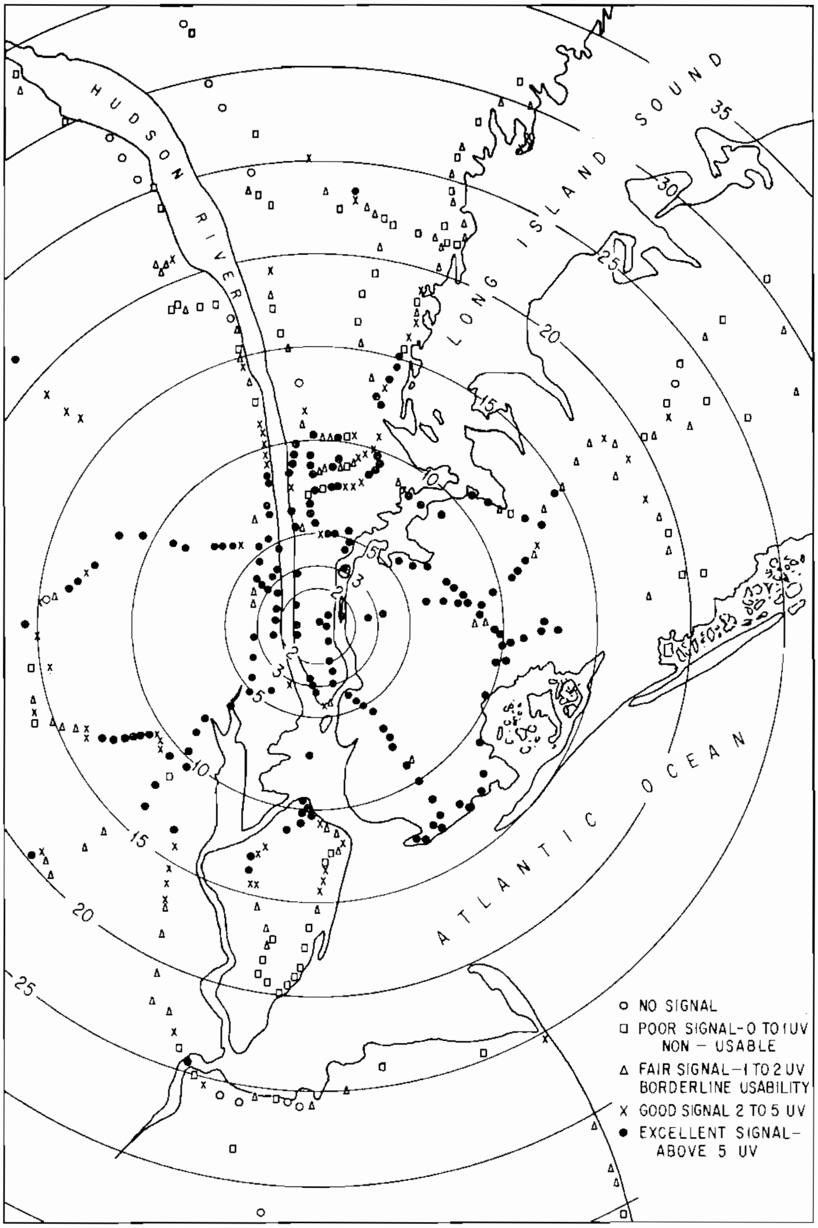


FIG. 2-13. Relay broadcast field test.

pendent on the terrain. Figure 2-13 shows the results obtained on all transmissions from the mobile unit to the fixed receiver.

Comparison of Antennas and Polarization

Changes in Transmitting Antennas

All the tests described so far were made using a quarter-wave whip antenna above the car and a five-element Yagi antenna on the building roof. Both of these antennas were vertically polarized. In order to determine the effects of some changes in antenna types and polarization, the following tests were made: The mobile unit was parked on top of Bear Mountain. This point is 42 miles from our receiving point, and there is a clear line-of-sight path between them. The receiving antenna was set for vertical polarization and carefully lined up for maximum signal from the transmitter. Transmissions were then made from the mobile unit using:

1. Quarter-wave vertical whip
2. Half-wave dipole
3. Half-wave folded dipole

The last two were operated both vertically and horizontally polarized at a height of 9 ft above ground. Signal-strength readings at the receiver were made for each of these transmissions. The receiving antenna was then changed to horizontal polarization, and the same series of tests repeated. Table 2-1 shows the signal strength ex-

Table 2-1. Signal Strength at Receiver Input in Microvolts

Transmitting antenna		Receiving antenna 5-element Yagi			
		Polarization			
		Vertical		Horizontal	
Type	Polarization	μv	Db	μv	Db
Quarter wave whip.	Vertical	10.8	0	6	−5.1
Half-wave dipole.	Vertical	14	+2.28	2.9	−11.41
	Horizontal	6	−5.1	20	+5.39
Half-wave folded dipole.	Vertical	16.5	+3.69	14	+2.28
	Horizontal	9.5	−1.14	26	+7.6

pressed in microvolts at the receiver input for each of these combinations. This table also shows the signal change in decibels for these antenna tests using the combination of the vertical quarter-wave whip antenna at the mobile transmitter and the vertically polarized Yagi antenna at the receiver as the 0-db reference level.

An additional mobile-antenna test was made from Staten Island. At a point on Hylan Boulevard 21 miles from the receiving point the received signal in New York was too far down in the noise to be useful. Two parasitic elements, a director and a reflector, were mounted around the quarter-wave vertical whip on the car top. Spacing between elements was one-quarter of a wavelength. An increase of 3.06 db was recorded at the receiver as a result of this change.

Change in Receiving Antenna

The five-element Yagi antenna was used for reception in all the tests so far. To check the gain of this antenna against a standard half-wave dipole, a series of transmissions were made from the mobile unit to the fixed receiver over a ronte extending from the Queensboro Bridge to the vicinity of Hicksville, Long Island, and return.

The Yagi antenna was used at the receiving point for the run out and the half-wave dipole for the return trip. While it is true that a single comparison would give a gain figure, it is of interest to check the actual results over varying terrain conditions and distance between the transmitter and receiver.

Signal-strength recordings were therefore made at the receiver for a representative group of transmitter locations using the same points on each run so that the difference in results could be attributed to the change in receiving antennas. The following readings were taken:

Table 2-2

Distance from receiver, miles	*Input to receiver, μv* Half-wave dipole	*Yagi*
13	3.6	7.5
13.5	10	6
16	1	2.1
19	1	2.5
21	1.8	3.6
22	0.7	1.8

From this table we can calculate that the average gain for the Yagi antenna over the standard half-wave dipole is approximately 6 db. In one case the half-wave dipole showed a higher signal level than the Yagi antenna, which can probably be attributed to effects of signal reflection due to the terrain.

Summary and Conclusions

The principal purpose in making the survey described above was to establish tbe utility of the 152- to 162-Mc band for short-range relay broadcasting. In addition, it was important to learn the maximum usable range of the specific equipment on hand. The test shows that with a 15-watt FM transmitter feeding a quarter-wave vertical whip mounted 6 ft above ground atop the mobile unit and with a directional receiving antenna having gain of at least 6 db mounted 900 ft above sea level in Manhattan, the following coverage around the receiving point can be expected:

1. Complete coverage within a radius of 5 miles
2. 95 per cent coverage within a radius of 10 miles
3. 85 per cent coverage within a radius of 15 miles
4. Some coverage within a radius of 30 miles, depending on the location of the mobile unit with respect to surrounding terrain

Previous experience with mobile operations using 30- to 40-Mc AM equipment has shown that coverage was very unreliable within the New York metropolitan area. Dead spots were numerous, and any attempt to follow a parade resulted in noisy reception at the pickup point from many spots throughout the parade route. Similar results would be expected in the 26-Mc band.

Part 3

REMOTE-PICKUP BROADCAST OPERATION ON 450 MC

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The use of the 450- and 455-Mc bands for remote-pickup broadcast station operation is becoming popular owing to the excellent propagation conditions. It has been found that for communications between a mobile unit and a base station the reliability of the circuit is virtually 100 per cent. There are practically no dead spots even in the "canyons" of New York, where line-of-sight conditions are far from a reality.

The fact that UHF transmission of television has many "dead spots" whereas UHF

FIG. 3-1. American Broadcasting Company television emergency mobile unit.

frequencies for remote-pickup services provide solid coverage can be explained by the fact that the ear is not so sensitive to the effects of phase delay in aural transmission as is the eye to its effect in television transmission. The fill-in in the canyons of a city come about by reflections from several objects all adding substantially but not exactly in phase. The slight time differentials are not objectionable to the ear, whereas a picture under the same conditions would be full of ghosts. Another reason for the better coverage is that the communications receivers used with their narrow

FIG. 3-2. 450-Mc unit as viewed from the video-audio operating position.

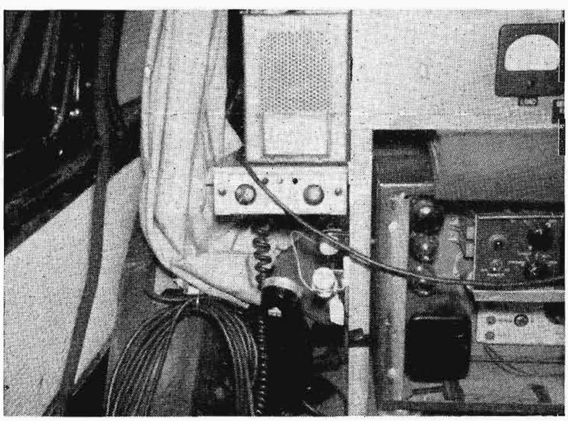

FIG. 3-3. Remote-control and speaker panel as viewed from the video-audio operating position.

bandwidth have a sensitivity of about 1 μv, which is considerably better than most UHF television receivers.

The American Broadcasting Company has been operating 15-watt units in its television emergency mobile unit (Fig. 3-1). One of these operates on 450 Mc, and one on 455 Mc.

Thus, it is possible to have continuous program circuit and cue circuit from transmitter-receiver units mounted in the same mobile unit. Because of problems of selectivity of the receiving circuits, it has been found impossible to operate two-way circuits within the 1-Mc bandwidth of the 450- or the 455-Mc bands. For this reason, NAB has filed comments in connection with the FCC Proposed Rule Making (Doc. 11959, 11997) to retain two bands separated by about 5 Mc in the 450-Mc portion of the spectrum. The folded-dipole antenna for one of these units can be seen mounted on the right rear fender of the station wagon. The antenna for the other transmitter is located on the left rear fender. The fixed stations are located on the eighty-fifth floor of the Empire State Building, and uninterrupted communications have been experienced over a radius of 20 to 30 miles. Figure 3-2 shows one of these units as viewed from the video-audio operating position. Figure 3-3 shows the remote-control and speaker panel as viewed from the same position. Figure 3-4 shows the second unit as viewed through the rear window of the mobile unit.

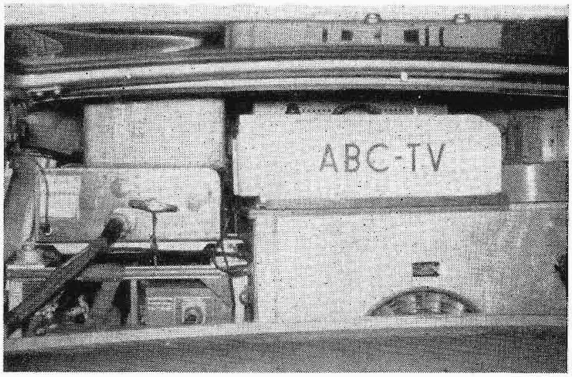

Fig. 3-4. Second unit as viewed through the rear window of the mobile unit.

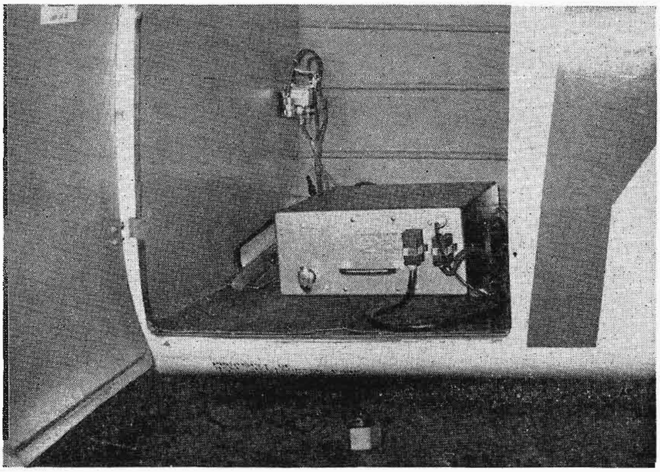

Fig. 3-5. 450-Mc transmitter-receiver mounted in the baggage compartment.

The American Broadcasting Company's radio station KABC in Los Angeles has been using 450-Mc remote-pickup broadcast equipment to broadcast traffic conditions on the Los Angeles Freeways from the vantage point of a helicopter. This equipment has been successfully used over a radius of 20 to 30 miles. The advantages of using a helicopter to report traffic conditions are obvious. The crew of the helicopter consists of a pilot and an announcer. Figure 3-5 shows the 450-Mc transmitter-receiver mounted in the baggage compartment. The antenna is a one-fourth-wavelength whip and extends down from the fuselage of the ship as shown in Figure 3-6.

Figure 3-7 is an over-all view of the helicopter. On the bulkhead back of the seat can be seen two transistor receivers, one of which is tuned to KABC and the other to the police frequency. As the electrical equipment for the helicopter was 24 volts, a separate 12-volt battery and generator was installed for the 450-Mc equipment. During the shakedown of the 450-Mc equipment a 3-watt 26-Mc handy-talkie was carried in the helicopter. The 26-Mc antenna can be seen in Figure 3-7 extending downward from the front of the passenger compartment. While the 26-Mc equipment worked

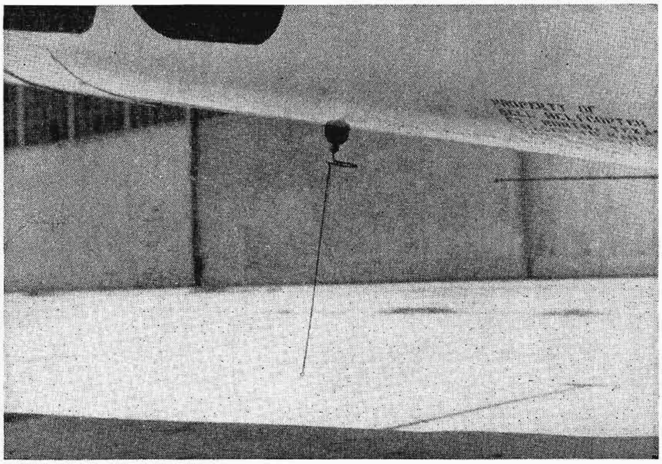

FIG. 3-6. One-quarter-wave whip antenna.

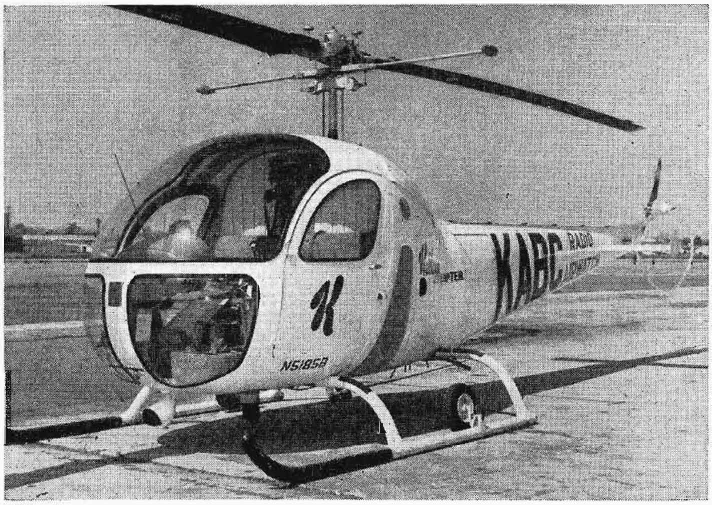

FIG. 3-7. Over-all view of helicopter showing 26 Mc antenna.

quite satisfactorily, its range was limited to about 2 miles. In addition to the remote-pickup equipment, the helicopter carries its own aircraft electronic equipment.

The American Broadcasting Company has a 30-watt remote-pickup station which was designed for operation on 150 Mc but was converted for operation on 450 Mc by adding a tripler stage ahead of the final amplifier. This equipment is kept available for use where it is necessary to have greater range than is possible with the 15-watt units.

The 15-watt 450-Mc remote-pickup stations are used for all types of broadcasts involving mobile units, such as disasters, fires, parades, presidential inaugurations, etc. The 15-watt units come in very handy in lining up microwave dishes, particularly on long or difficult paths. Several 0.1-watt Mc handy-talkie units are available for short-range pickups such as golf matches, political conventions, etc.

Four hundred and fifty-megacycle remote-pickup equipment is quite useful for radio backup of wire lines in CONELRAD cluster operation. The use of remote-pickup equipment for this type of operation has been recommended by the Federal Communications Commission. Figure 3-8 shows a simple one-way radio backup circuit for CONELRAD operation. The key station requires a 450-Mc transmitter and a 455-Mc receiver (or vice versa), and the other cluster stations require a receiver for reception of the transmissions of the key station. More complex circuits can be used to provide duplex channels, control by the alternate key station, etc. A radio backup circuit is shown from the circuit defense headquarters to the key station. Also, in some areas it may be desirable to have radio backup between adjacent CONELRAD clusters.

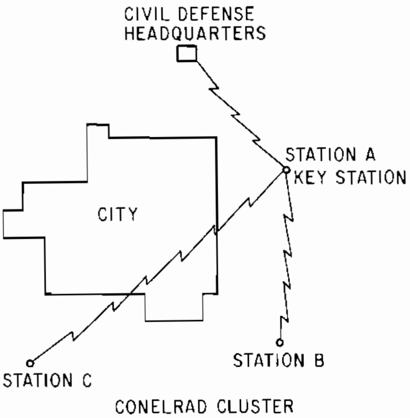

Fig. 3-8. Simple one-way radio backup circuit for CONELRAD operation.

It has been noted that more and more remote-pickup stations are being licensed for operation on 450 Mc, which is indicative of the general usefulness of this frequency.

Part 4

RADIO ON WHEELS

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With ever-changing programming formulas in radio, the station engineer's ingenuity is constantly being called upon to develop equipment to do simply and effectively disc-jockey remotes, which have become a feature of many radio stations.

The problem of today's remote has become far more complex than the old dance-band remote or the Saturday morning amateur hour from the local department store.

Portability is the prime requisite for today's remote. While station policy varies from station to station and method of operation in some stations calls for technical personnel to assist the disc jockey, other stations operate with nontechnical personnel only.

The author will endeavor to outline problems and solutions experienced by him in doing many disc-jockey remotes.

Radio is being put on wheels by many leading broadcasters. Equipment is monnted in either a permanent or semipermanent manner in the vehicle of the station's choice.

CHOICE OF VEHICLE

The choice of a vehicle for a studio on wheels is probably the most difficult decision to make when starting to put a studio on wheels. The size of the vehicle, of course, determines the amount of space available for equipment.

Experience has proved that there are many additional uses to be made of the studio on wheels in addition to just on-the-air use.

EQUIPMENT

In planning equipment for the studio on wheels, of course, the size of the vehicle determines the amount and size of such equipment.

Briefly the following is an outline of what the author found necessary for the studio on wheels. Details will follow:

1. Small console
2. Two three-speed turntables
3. Tape recorder
4. Public-address system

5. AM-FM tuner
6. 110-volt a-c generator (optional)
7. Power-distribution panel (optional)
8. Mobile radio system—FM (optional)

The Console. The determination as to what type of console the studio on wheels should contain, of course, depends upon the budget allowed for equipment. We endeavored to make the operation as simple as possible when arriving on location, and since space was available on the vehicle to allow for a small console, a commercially available four-channel console was installed. Small consoles are available from most commercial manufacturers which contain the necessary preamplifiers, line amplifiers,

FIG. 4-1. Turntables and console mounted in vehicle.

and monitoring amplifiers. In smaller installations the console monitoring can be substituted for the public-address system. While this method reduces initial installation cost, it is not recommended because of the limited amount of gain available.

Combining the turntables and the console on one desk simplifies installation in the vehicle and permits use of such equipment indoors should the need arise (Fig. 4-1).

In our operation all turntables are equipped with a cueing-type mixer. We have continued this method in the field because of the simplicity of operation.

While most commercial consoles provide a cueing position in the monitoring system, we chose to add a small additional amplifier to the console-turntable unit for cueing purposes. This does necessitate small wiring modifications to the console. These circuits are available on the audio terminal block. While this does mean a small additional expense, the convenience is well worthwhile (Fig. 4-2).

The console output is permanently wired to feed either land-line or radio relay facilities. In addition, outputs are available for taping on location plus a feed to the public-address system.

Bridging outputs are used to feed the public-address system and tape recorder. The bridging circuits can be transformers or balanced bridging pads or bridging controls. Care must be exercised since most high-level input circuits to public-address

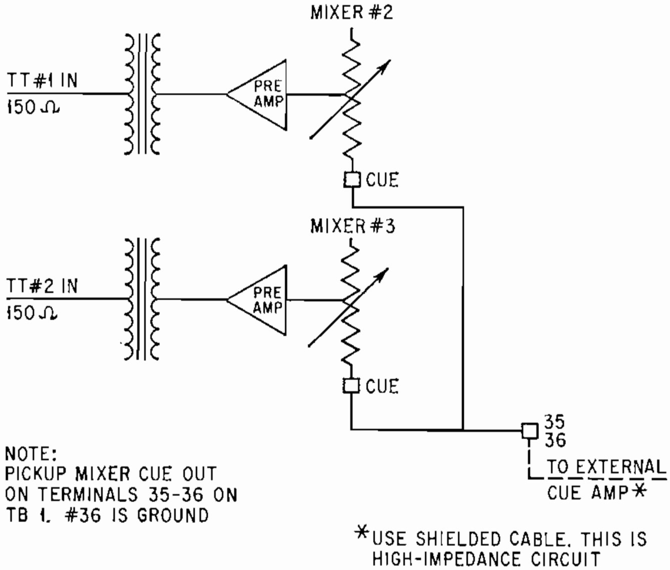

Fig. 4-2. Turntable cueing modification BC-5A console.

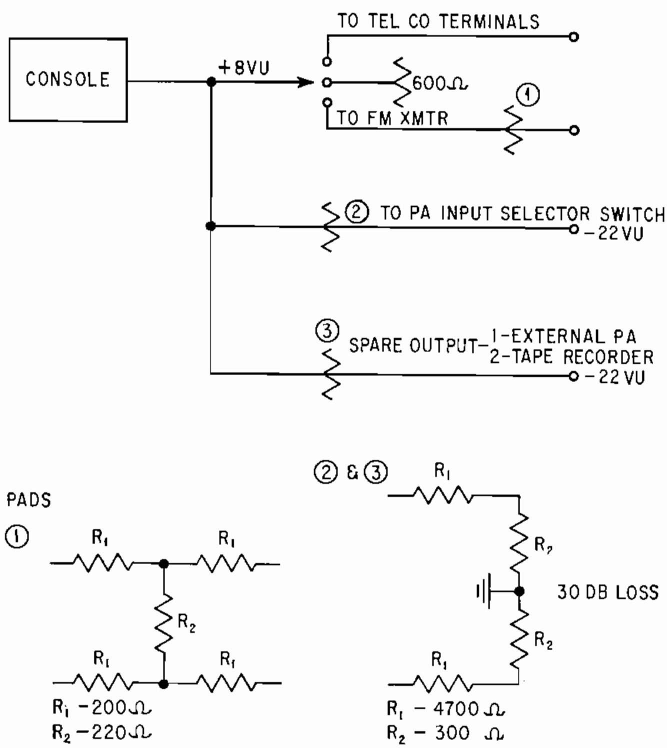

Fig. 4-3. Block diagram, console output.

systems and tape recorders are unbalanced circuits and telephone lines are balanced circuits. It is recommended that a 1-to-1 isolation coil be used on the public-address-system input to isolate balanced circuits from any unbalanced circuits that might be used (Fig. 4-6).

The station engineer can, of course, modify an existing remote amplifier to accomplish the same results. If cueing mixers are substituted for existing microphone mixers, the microphone preamplifiers can be used as turntable preamplifiers. Many remote amplifiers use high-level mixing. An existing microphone preamplifier can thus be used as a turntable preamplifier (Fig. 4-4).

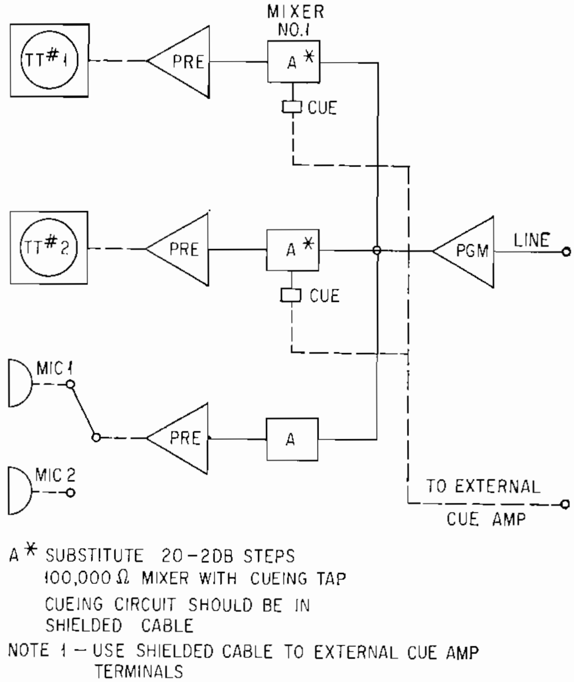

FIG. 4-4. Modified BN-2A amplifier.

If the amplifier uses low-level mixing, the problem becomes more complex. Modifying remote amplifiers that use low-level mixing is not recommended.

The Turntables. The choice of turntables probably is the easiest problem to solve. Available today are many models to fit almost any budget. The use of a record-changer-type turntable is not recommended, but it could under certain conditions give satisfactory service.

The biggest problem to be encountered while operating turntables in the field, particularly in a vehicle, is the need for some leveling device so that tone arms will track properly when using microgroove records on location.

Permanent installation of at least two small indicating levels on the turntable-console unit will aid operating personnel in setting up.

Experience has proved the need for some sort of device to level the turntable-console unit under varying conditions. The installation of four small leveling jacks on each corner of the unit will solve this problem under the most severe conditions encountered in the field (Fig. 4-5).

Since some record-compensating filter will probably be used, the type with low-impedance output will work very satisfactorily with microphone preamplifiers. Output of these filters on a tone record is −50 VU, which provides a satisfactory level for the microphone preamplifier.

The Tape Recorder. Here again any of the popular available models work satisfactorily.

If the station engineer chooses to install a tape recorder, the recorder should be one of the more popular units commonly used for portable use. The broadcaster will

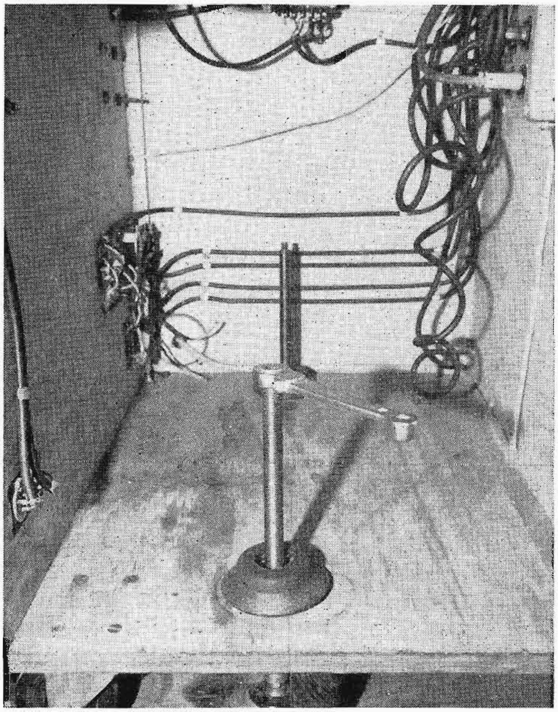

FIG. 4-5. Leveling device for turntable-console unit.

find many additional uses for the studio on wheels. Therefore the tape unit might be used to play back prerecorded tapes made on a studio unit.

Likewise the broadcaster might record a disc-jockey show in the field and play back on a studio unit.

The Public-address System. Any unit of the station engineer's choice will prove satisfactory. Any amplifier with approximately 25 watts undistorted output is sufficient.

When the public-address system is used in conjunction with an on-the-air show, because of feedback problems, any larger amplifier is not deemed necessary (Fig. 4-6).

AM-FM Tuner. The AM-FM tuner helps the broadcaster reduce overhead costs when doing disc-jockey shows from the field. The use of the tuner provides an excellent feed for the public-address system.

Any portions of the disc-jockey show that originate from the studios of the station are available to the audience at the pickup point.

If the station has FM facilities, the use of FM is more satisfactory than AM.

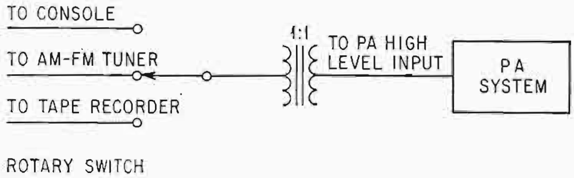

FIG. 4-6. Public-address-input selector switch.

FIG. 4-7. Interior of vehicle, note rack-mounted equipment.

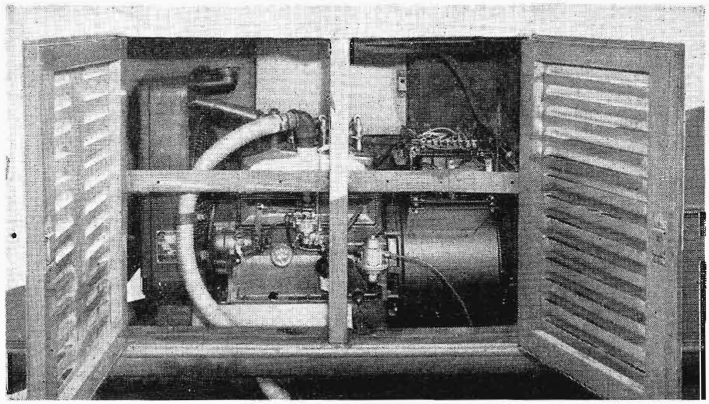

FIG. 4-8. 110-volt a-c motor generator.

A permanently mounted simple FM dipole antenna is recommended to be used with an FM tuner. Line cord FM antennas might prove unsatisfactory under some conditions.

It is recommended that all the units, the tape recorder, the AM-FM tuner, the public-address system, be rack-mounted (Fig. 4-7).

OPTIONAL ITEMS

The 110-volt a-c Generator. The installation of a 110-volt a-c generator in a vehicle in the author's opinion is a "must." The noise developed by such a generator does not prove to be a handicap for promotional activities when the vehicle is in motion (Fig. 4-8). Such a generator also is available in case of failure of commercial power while on semipermanent location.

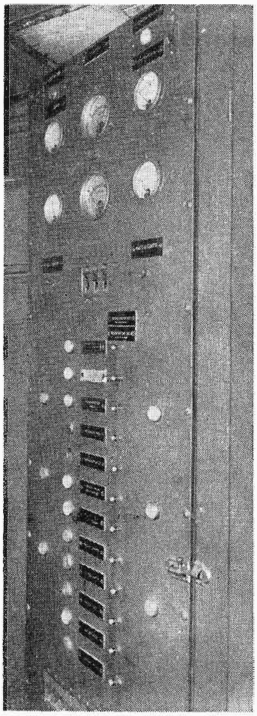

Fig. 4-9*a*. Power-distribution panel.

The size of such a generator depends, of course, on the load developed by the equipment and display lighting attached to the studio on wheels. Most available commercial generators guarantee 1 per cent frequency accuracy when the generator is operated within load limits. This is particularly important for proper operation of tape recorders or turntables when the generator is used as the power source. In planning a generator installation, manufacturers caution about oversizing such a generator. If the load is not sufficient, the engine driving the generator does not work hard enough. This could raise the maintenance costs of such a unit.

Should the station engineer choose to install a 110-volt a-c generator in the vehicle, care should be taken to allow for sufficient ventilation of the generator unit, since most generators can be equipped with safety cut-offs should the water temperature become excessively high. If the available space is small, supplemental forced air should be installed to guard against excessive heat building up. A fixed-position 110-volt a-c fan will work satisfactorily to force out any excessive heat.

Since the generator is a gasoline-driven device, provision should be made to obtain gasoline from the main tank of the vehicle. This permits the personnel to use the gasoline gauge of the vehicle as a guide for sufficient fuel at all times. A separate supplemental tank can be used, but generally there is no gauge for judging the amount of fuel in the supplemental tank.

Normal winter and summer protection for the cooling system must be observed, just as with the vehicle engine.

Power-distribution Panel. While the installation of a power-distribution panel will undoubtedly raise the initial cost of installation, the safety factor, particularly for generator protection plus protection of off-air time, should make the cost and effort worthwhile (Fig. 4-9*a* and *b*).

Mobile-radio System. While the above-mentioned facilities provide the broadcaster with all the necessary means for doing disc-jockey remotes by using land-line facilities, some broadcasters may desire to add mobile radio so that land lines are not always necessary.

Since the disc-jockey remote runs upward of 1 hr of air time, an a-c-powered transmitting unit must be used. The problem becomes more complex when using mobile radio.

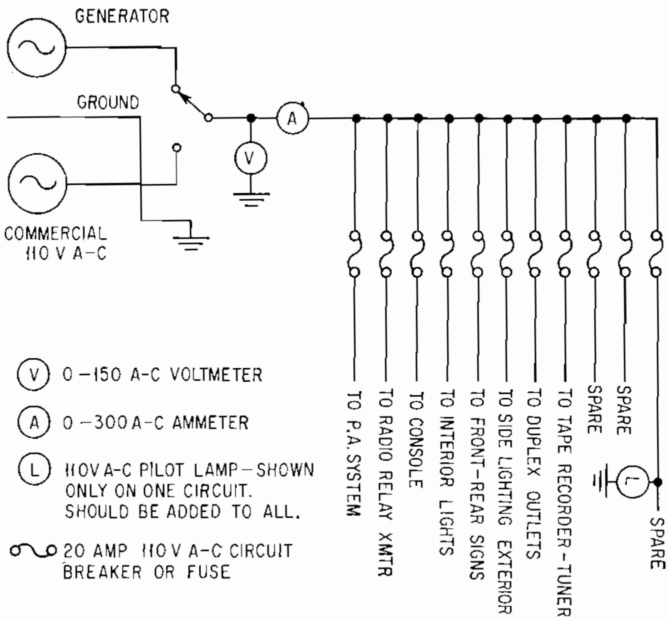

FIG. 4-9*b*. Schematic of power-distribution panel.

Because the broadcaster does not have exclusive use of the 152.87- to 153.35-Mc band, licenses for transmitting equipment in this band are issued on a nonexclusive basis only. Industrial services have priority of use for frequencies in this band.[1] This could prove to be a serious problem if the broadcaster is located in a large metropolitan area where many industries use mobile radio.

[1] See Frequencies for Use in the Broadcast Service, Sec. 1.

Part 5

TELEVISION REMOTE PROGRAM ORIGINATIONS

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Television Station WTOP-TV
Washington, D.C.

Unanimity of thought does not prevail among television stations regarding the best equipment or procedures to follow in the origination of television remote programs. Consequently, the following discussion of equipment and methods employed by WTOP-TV in Washington, D.C., is not intended as a standard for the industry but only as a guide for stations unfamiliar with the problems involved.

A discussion of "television remotes" or "nemo" programs can be divided into two general categories: (1) equipment and facilities required and (2) operation of a typical remote, including problems normally encountered.

EQUIPMENT AND FACILITIES

Mobile Unit

General Requirements

The basic function of a television mobile unit is to provide a transportable control room for remote program originations. The obvious answer to this requirement is a motor vehicle with a specially built body. For monochrome remote programs, this vehicle is usually a 1½-ton truck chassis with a custom-built body (Fig. 5-1). The engine should be capable of transporting the fully loaded vehicle at reasonable highway speeds. Minimum size is an important consideration since narrow alleys, sharp turns, and low overhead clearances are often encountered. Weight distribution of the fully loaded mobile unit must be such that no instability results when driving over rough roads. The roof of the mobile unit should be capable of supporting the weight of two cameras, two cameramen, a microwave transmitter, and operator (Fig. 5-2). Tie points to anchor the tripods securely to the roof must also be provided (Fig. 5-3). Access to the roof can be made by a ladder or built-in steps (Fig. 5-4).

Control-room Requirements

Opposed to the requirements of minimum size of the mobile unit for ease of handling are the requirements for maximum interior space to accommodate the control-room personnel, operating equipment, and storage of technical equipment. The first consideratiou that determines interior size is the maximum number of

FIG. 5-1. RCA type TJ-53A mobile unit (foreground) designed for three-camera monochrome operation. This particular mobile unit was modified by WTOP-TV to accommodate four cameras. An older RCA model TJ-50A mobile unit is also shown.

FIG. 5-2. The television mobile unit should provide a sturdy roof platform capable of supporting cameras, microwave transmitter, and operators.

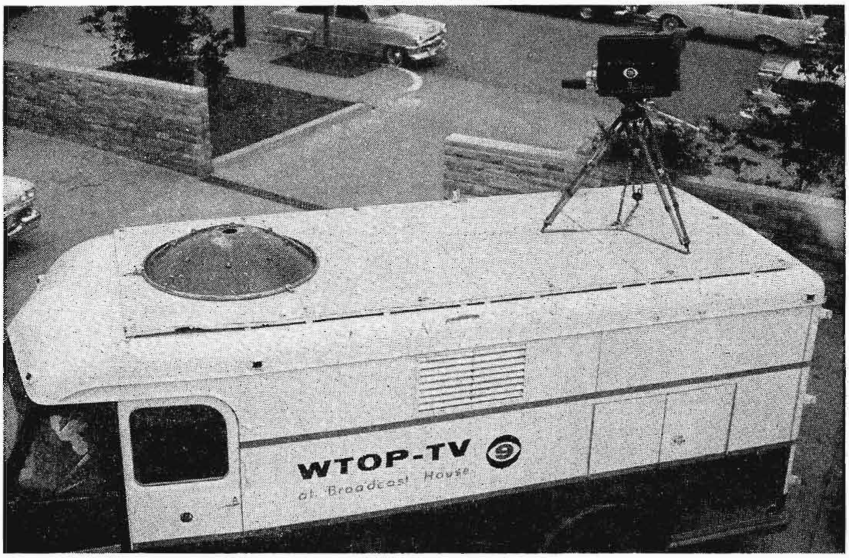

FIG. 5-3. Microwave reflector storage is shown on the left. On the right a camera is secured to the mobile-unit roof by use of a metal T and a chain from the tripod to a hook welded to metal roof.

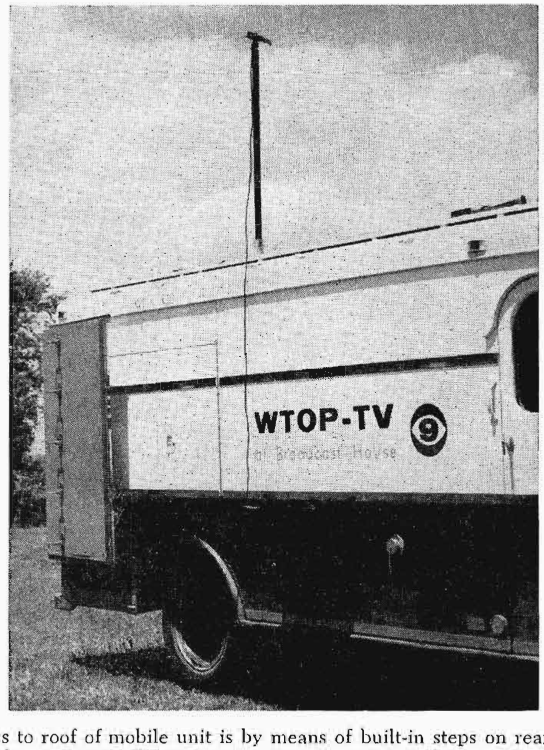

FIG. 5-4. Access to roof of mobile unit is by means of built-in steps on rear door. Detachable mast is used to support off-the-air receiver antenna as well as camera and microphone cables when required to bridge sidewalks.

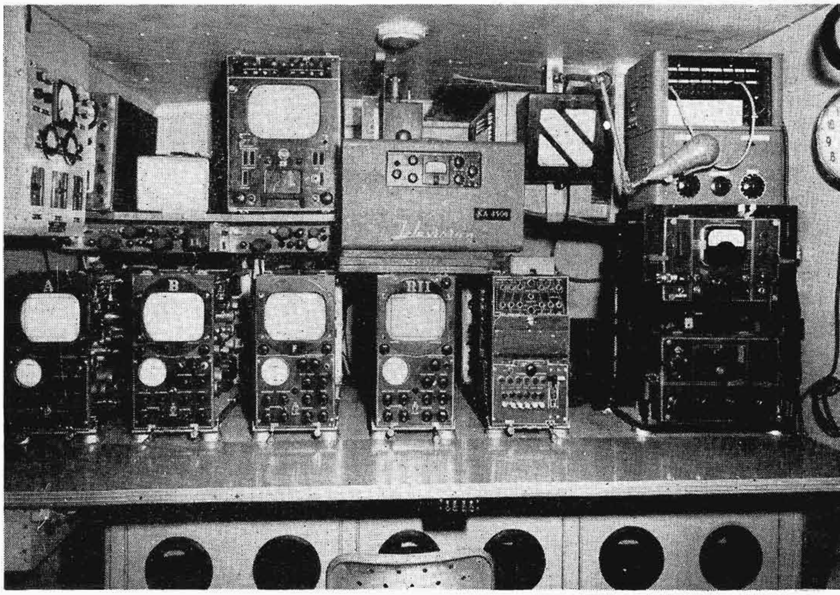

Fig. 5-5. Interior view of mobile-unit control room. Four camera control units, video switcher, and audio mixer are mounted directly to top of control desk. Above these units from left to right are a-c voltage control panel, oscilloscope, 8-in. off-air receiver, master monitor, microwave transmitter control, air conditioner (rear), cue speaker (front), audio patch panel (above), audio bridging and matching unit (under patch panel), and clock. Ventilated enclosure for power supplies and sync generator are visible beneath desk.

Fig. 5-6. Removable curtains darken the control room during a remote for better visibility of the television picture monitors.

cameras to be accommodated. In the past, two cameras were considered adequate. Three or four cameras are now used on most TV remotes. Occasionally five or more cameras are required, but in this case it is usually necessary to use an enclosure near the program area for a control room, using the mobile unit primarily for transporting the equipment.

A mobile unit providing four-camera operation seems to be a good compromise between size and program requirements. Control-room space should therefore be

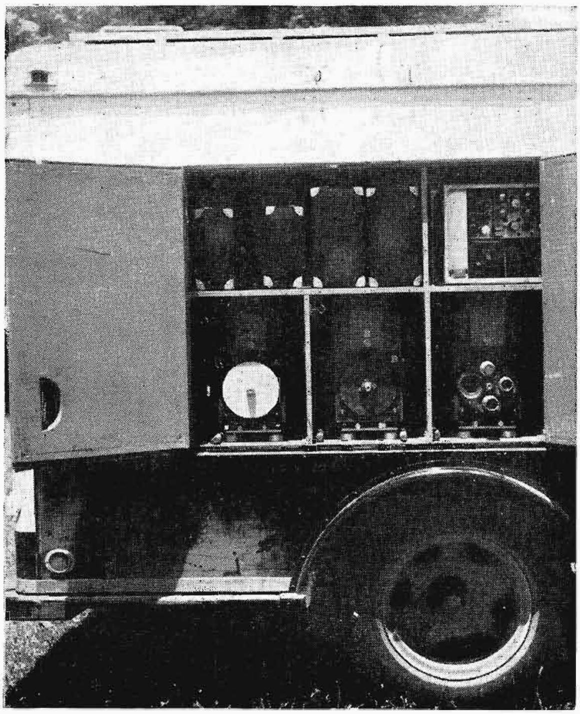

FIG. 5-7. Cameras are transported on shock-mounted bases to prevent damage to camera components. Suitcases contain extra lenses, headphones, etc. A spare sync generator is visible at upper right.

provided for the four-camera control units, a video switcher, an audio mixer amplifier, a microwave relay transmitter control, and three technical operators (Fig. 5-5). In addition to the above space for the technical crew and control equipment, space must also be provided for a director and producer. Both should be able to see the video monitors. The director's position should be near the video switcher and audioman for giving instructions during the program. Provisions must also be made to darken the control-room area for viewing the television monitors (Fig. 5-6).

Storage Requirements

Since it is desirable that the TV mobile unit transport all necessary technical equipment used with a four-camera remote, as well as a microwave relay transmitter, considerable storage space should be provided. Camera control units, power supplies, video switcher, master monitor, video distribution amplifiers, sync generators, microwave transmitter control, and audio amplifiers can be transported in place on shock-mounted bases. Cameras, view finders, and microwave transmitter should be stored on shock-mounted bases also (Fig. 5-7).

Storage space is needed then for camera cable (Fig. 5-8); tripods (Fig. 5-9); microwave "dishes" microphones, and cable (Fig. 5-10); lenses; spare tubes; test equipment; etc.

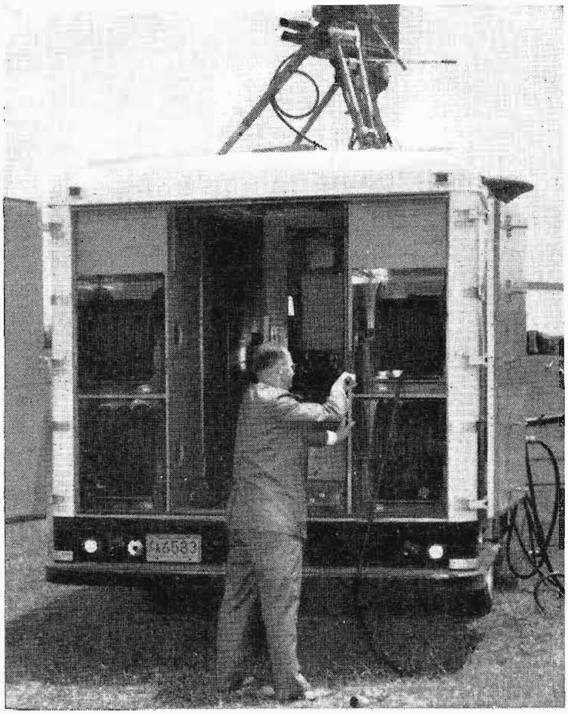

FIG. 5-8. Camera-cable storage.

Electric-power Considerations

A commercial source of a-c electric power at the remote site is normally used to operate the television equipment. Means must therefore be provided in the mobile unit to distribute this power to the various pieces of equipment. Initially, a power-connecting cable of ample capacity is needed to feed from the source to the mobile unit. Since the available power source may be 110 volts a-c, 220 volts a-c single-phase with or without a neutral, 120 to 208 volts a-c three-phase four-wire, or possibly, three-phase with no neutral (Fig. 5-12-1), it is evident that the number of conductors in the power cable could be two, three, or four. If an isolation transformer is used in the mobile unit, the simplest arrangement is to use a two-wire rubber-covered power cable with large enough conductors and connectors to handle at least 70 amp of current (Fig. 5-11). If the isolation transformer can be switched to handle 110 or 220 volts a-c at the primary winding (Fig. 5-12-2), the two-conductor power cable can be connected across either a 110- or 220-volt a-c single-phase power source or across 208 volts a-c of a three-phase source. A connection across two phases of a three-phase source will unbalance the feed power, but this does not ordinarily cause much concern if the source of power is more than adequate. *A very important safety consideration must be mentioned at this point and is required*

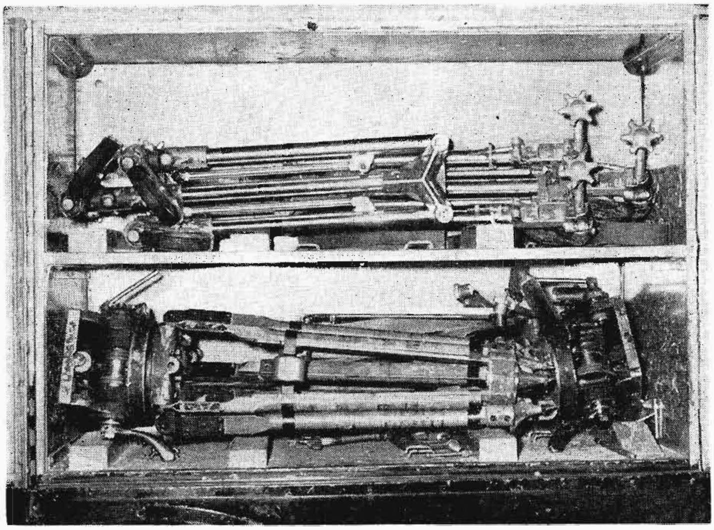

FIG. 5-9. Tripod and dolly storage compartments are accessible from the outer side of mobile unit.

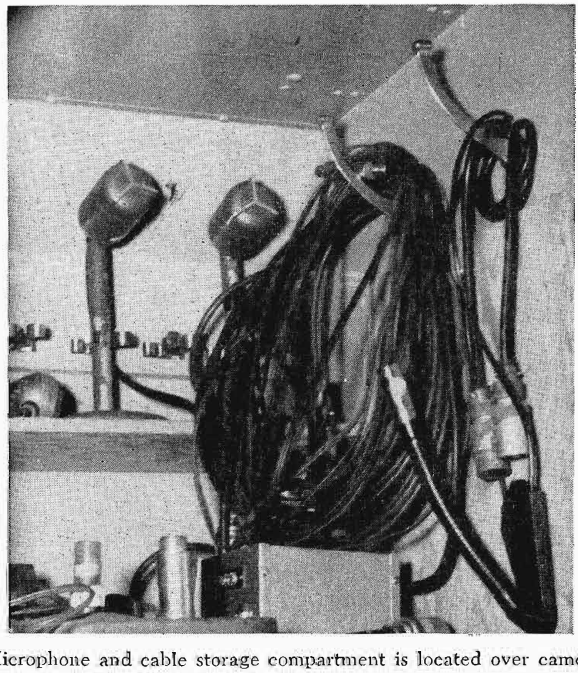

FIG. 5-10. Microphone and cable storage compartment is located over camera cable reels.

FIG. 5-11. 70-amp two-conductor rubber-covered power cable and connector are shown at right. Audio-video patch panel (left) provides rapid and convenient connection between mobile unit and cameras, microphones, telephone lines, microwave, etc.

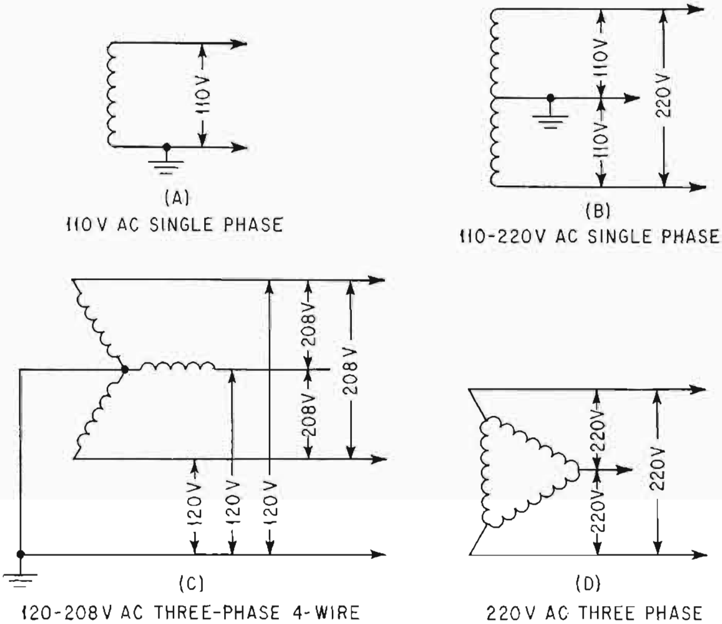

FIG. 5-12-1. Four possible arrangements of commercial power sources from which electric power can be taken to operate mobile unit equipment. The 120- to 220-volt switch and isolation transformer shown in Fig. 5-12-2 permits two conductor power cable to be connected to any of the four power arrangements shown. In (*A*), the switch would be thrown to the 110-volt position. In (*B*), (*C*), or (*D*) the switch would be thrown to the 220-volt position. Since a neutral wire is not used in the last three cases, electrical codes and safety precaution require that the mobile unit be connected separately to a good electrical ground.

by most electrical codes. A heavy-duty ground wire must be connected between the mobile unit and ground. The ground must be a metal stake driven into the earth, an underground water pipe, or a connection to the ground circuit of the electrical power source. If this precaution is not observed, a shock hazard will exist when stepping from the mobile unit to the ground if any piece of equipmeut develops a partial or direct short in its electrical wiring.

The isolation transformer in the mobile unit should be of sufficient capacity to

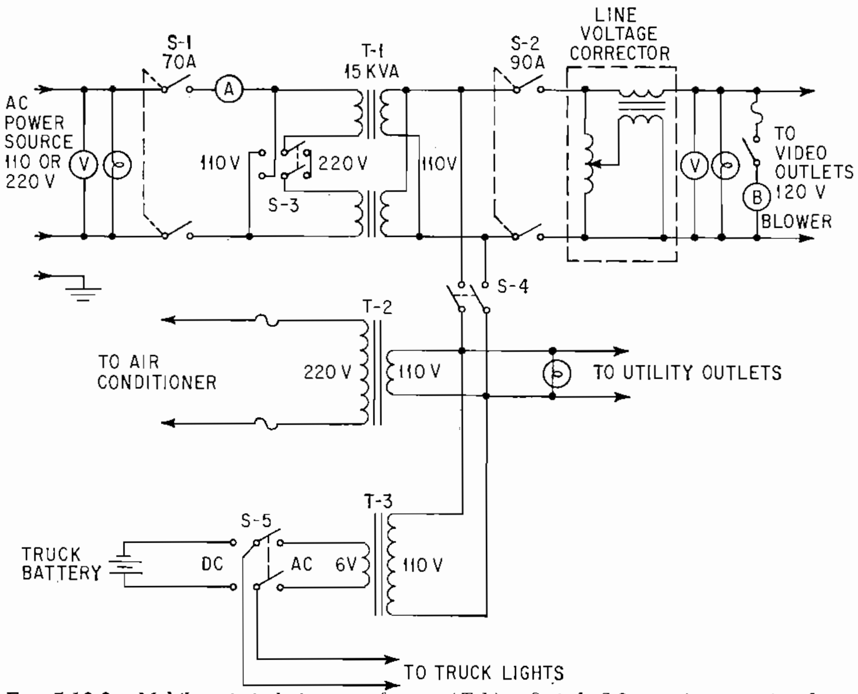

FIG. 5-12-2. Mobile-unit isolation transformer (*T*-1). Switch *S*-3 permits operation from either 110- or 220-volt source. Voltage to video outlets is regulated to 120 volts.

handle the total electrical load used by the television equipment. A rating of 15 kva seems adequate. The secondary winding should, of course, be 120 volts to provide correct voltage to the various pieces of equipment. The transformer should be protected with a 70-amp circuit breaker, and means should be provided to regulate the secondary voltage automatically or manually. If manual operation is provided, the control should be located in the mobile-unit control room convenient to a technical operator of the television equipment. A primary winding or input voltmeter and ammeter are desirahle, as well as a secondary wiuding or output voltmeter.

For the rare occasions when commercial electric power is not available, a stable, well-regulated, portable 60-cycle gasoline generator having a minimum capacity of 10 kw is a very desirable addition to the TV remote equipment. This generator can be trailer-mounted and drawn by the TV mobile unit or a station wagon. (Fig. 5-13*a* and *b*).

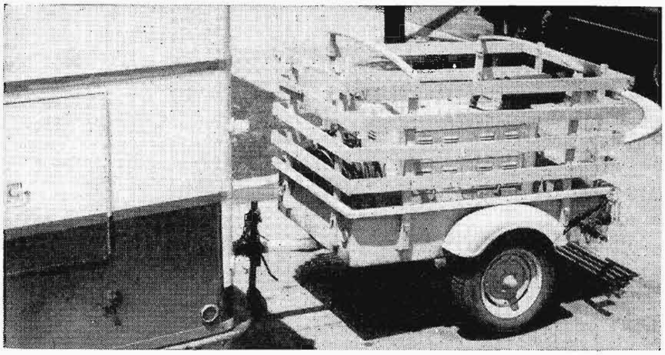

FIG. 5-13*a*. A trailer-mounted gasoline generator (6 kva) attached to mobile unit. Two cameras only can be accommodated by this particular generator.

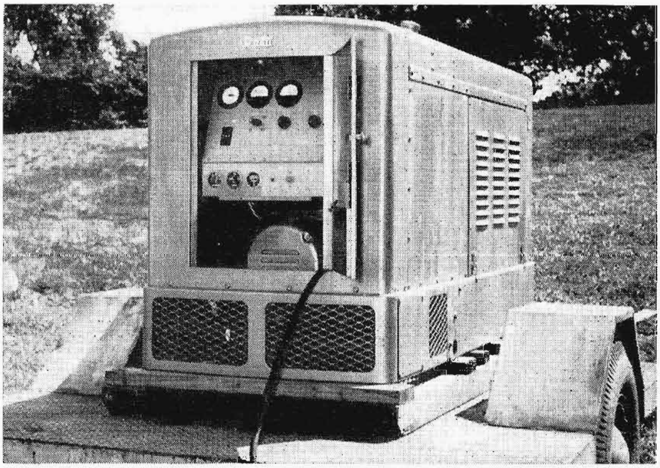

FIG. 5-13*b*. A larger gasoline motor-generator (35 kva) was used to supply power for four cameras on a *Jimmy Dean* water ski show on the Potomac River. Commercial power was not available.

Audio-video Connections

A time-saving feature of the mobile unit is a patch panel convenient to the outside of the control room on which all connections can be made to camera cables, video coaxial cables, incoming and outgoing telephone lines, microphone cables, etc. From the patch panel, all cables are connected semipermanently to the proper equipment in the mobile-unit control room.

Auxiliary Equipment

Heat generated by the various pieces of equipment and operating personnel in the control room added to the heat and humidity of a hot summer's day readily points up the need for air conditioning of the mobile-unit control room. Part of this heat can be exhausted separately from enclosures housing power supplies and sync generators, but the camera control units, audio amplifier, switcher, line and air monitors, microwave transmitter control, etc., normally must be exposed to the control-room air and soon add excessive heat. An air conditioner having a minimum cooling capacity of 1½ tons is required for the size control room described above. A 1½-ton unit generally requires 220 volts a-c for operation. This voltage can most conveniently come from the 120-volt secondary of the main isolation transformer using an additional 120- to 220-volt step-up transformer to feed the air conditioner. An air conditioner of 1½-ton capacity will put a load of approximately 3 kva on the transformers.

In order that control-room lights can be operated from the mobile-unit d-c battery before connecting to a commercial power source and to operate from a-c power

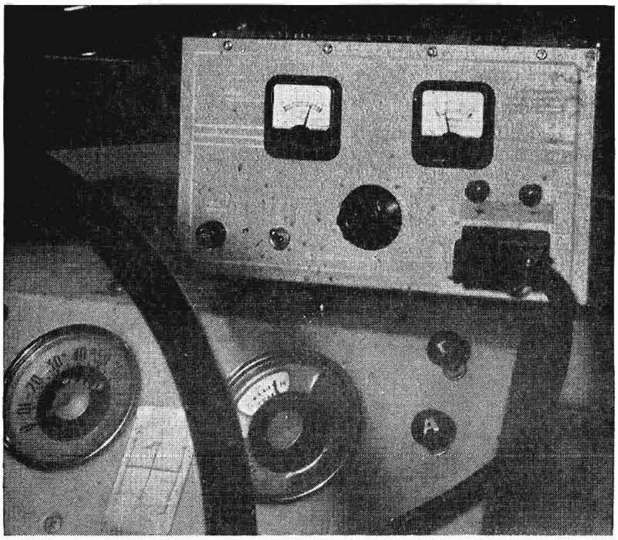

FIG. 5-14. Portable battery charger permits continuous use of battery-operated communication transmitter.

during a remote program, a 120- to 6.3-volt a-c transformer is needed. A switch to select the appropriate source should be provided.

A built-in battery charger is very desirable, since normal usage of the mobile unit does not always keep the battery fully charged. The battery charger can be used when the mobile unit is on standby status or during a remote program (Fig. 5-14).

Experience has shown the need for an "off-the-air" TV receiver mounted in the mobile unit control room. An outside antenna is usually required. This can be supported by a detachable mast on the outside of the mobile unit. The mast can also serve to support camera cables, microphone cables, etc., if required to run above sidewalks from the mobile unit.

Microwave Equipment

Whether a television station chooses to do its own microwave relaying or to engage the services of the local telephone company, the same problems exist and similar equipment is used. Microwave equipment generally used by the broadcaster operates within a 25-Mc channel in the 7,000-Mc band. The telephone companies have channels allocated to them in this band [1] as well as in the 4,000-Mc band. Channels are also available to the broadcaster in the 2,000- and 13,000-Mc bands. The high-frequency transmitter has relatively low power (1/10 or 1 watt) and relies on the

[1] Three channels in the 7,000-Mc band.

power gain of its parabolic reflectors to relay the signal from the remote site to the receiver location at the studios. A microwave receiver tuned to the transmitter frequency receives the transmitter signal over a line-of-sight path (Fig. 5-15). A parabolic reflector is also used with the microwave receiver to increase the antenna

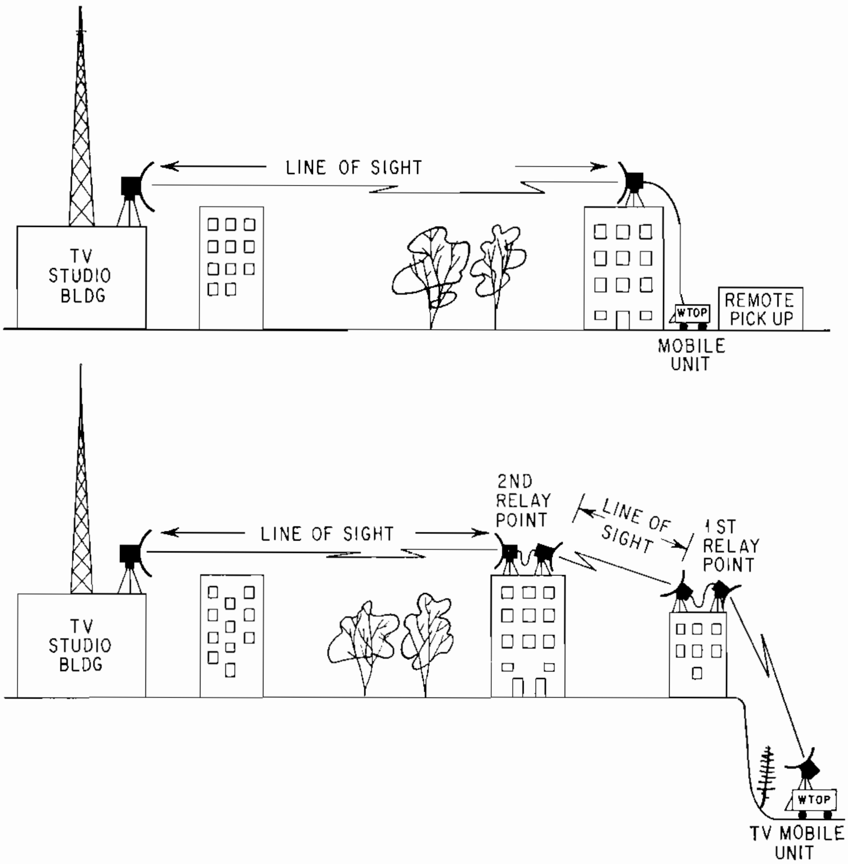

Fig. 5-15. Line of sight must ordinarily exist between microwave transmitter and microwave receiver. Obstructions between remote site and studio building may require use of multiple-hop microwave equipment.

gain. A 4-ft parabolic reflector increases the antenna gain by approximately 5,000. When a 4-ft reflector is used at 7,000 Mc, the resulting microwave beam is very narrow—approximately 5° between the half-power points (Fig. 5-16). Therefore, it is obvious that both the transmitting and receiving reflectors must be accurately and securely aligned in order that the signal not be lost during a program. If there are trees with leaves in the path of the microwave signal, it may not be possible to transmit the signal to the receiver because the leaves create high attenuation of the signal. With the more recent 1-watt 7,000-Mc transmitters, it is sometimes possible to get enough signal through trees, but for extended distances this is not probable. An advantage of the lower frequency (2,000 or 4,000 Mc) equipment seems to be that its signal will usually pass through some trees without serious attenuation. It is generally required, however, that a good line-of-sight path between microwave transmitter and receiver be chosen on all microwave bands. No intervening buildings or structures can normally be tolerated. It may be necessary to use two or more sets of microwave equipment in a "double hop" or "triple hop" in cases where the pickup site is low or obscured from the receiving point by trees, buildings, etc. A pair of binoculars is invaluable for determining the best locations for microwave equipment. In some cases it is advisable to employ a crane in order to elevate the microwave transmitter sufficiently to clear trees near the remote site (Fig. 5-17*a*). For other uses of a crane on TV remotes see Figs. 5-17*b* and *c* and 5-18*a*.

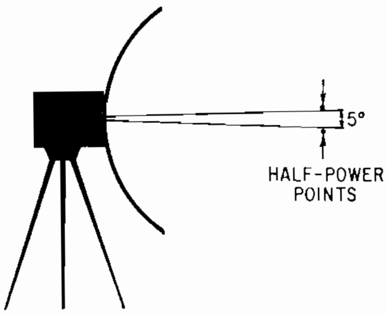

Fig. 5-16. Illustration of narrow beam of microwave equipment (using 4-ft reflector at 7,000 Mc).

When telephone lines are available from the remote site to the studios, they are ordinarily used for the audio signal. It is very desirable, however, to have microwave equipment with provisions for multiplexing both the visual and aural signals. When insufficient time prevents installation of telephone lines, the importance of this feature is apparent.

By using 4-ft parabolic reflectors, 7,000-Mc microwave equipment can be used over line-of-sight distance to approximately 30 miles.[2] Six-foot reflectors will extend this range somewhat but are cumbersome to handle and difficult to keep aligned because of the narrow beamwidth of approximately 2½° and the excessive wind loading. Twelve- or twenty-four-inch reflectors can be used up to several miles separation between transmitter and receiver. These smaller reflectors are useful especially with a transmitter installed on a moving mobile unit or other vehicle, since the accuracy of panning is less stringent owing to the wider beamwidth (Fig. 5-18*a* to *f*).

Radio Communications Equipment

If time does not permit the installation of adequate telephone communications facilities between the remote site and a station's master control room, it is desirable to be able to use radio communication. A radio telephone installed in the mobile unit or accompanying vehicle may suffice in many such cases (Fig. 5-19). This equipment is somewhat limited in that the telephone company radio channel may be in use by another customer when needed urgently to communicate between the remote and master control.

The FCC has allocated FM communication channels in the 26-Mc band which can be used by broadcasters to expedite remote-program setups. The use of transceivers in aligning microwave transmitter and receiver "dishes" is particularly valuable. All such radio communication transmitting equipment must, of course, be licensed and operated in conformance with FCC Rules.

A typical arrangement of radio communication equipment as used by WTOP consists of a 50-watt transmitter-receiver operated from the master control room of the station (Fig. 5-20*a* and *b*) and a battery-operated 35-watt transmitter-receiver installed in the mobile unit (Fig. 5-21). These transmitters are tuned to the same frequency. Two "walkie-talkie" transceivers tuned to the same frequency as the master control and mobile unit are used to align microwave—one at the remote microwave transmitter and one at the microwave receiver (Fig. 5-22). In many cases, the walkie-talkie transceivers can be used directly to align the microwave. However, if the distance is too great, it may be necessary to relay alignment informa-

[2] Distances over 100 miles have been used.

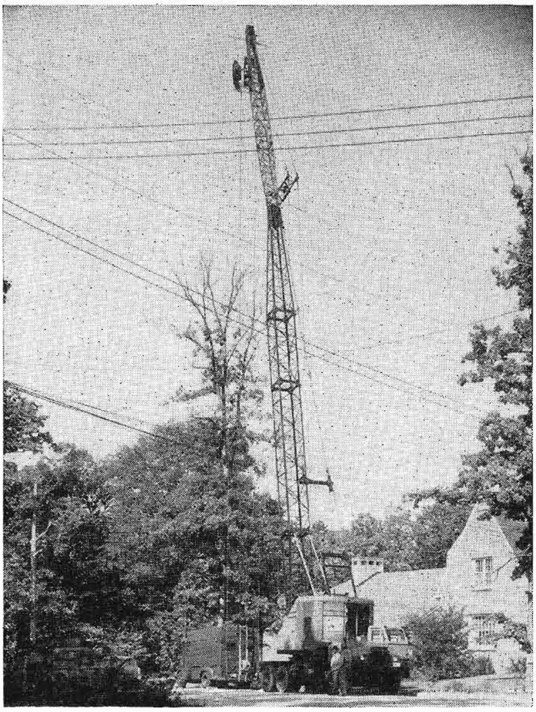

FIG. 5-17*a*. A crane was employed by the local telephone company to elevate microwave transmitter sufficiently to clear nearby trees for Edward R. Murrow's *Person-to-Person* remote from Secretary of Agriculture Benson's residence in Washington, D.C. A crane can also be useful as a camera platform (see Figs. 5-17*b* and *c* and 5-18*a*).

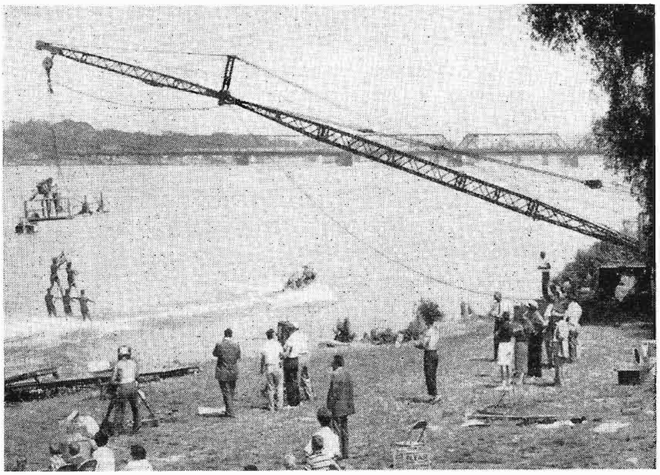

FIG. 5-17*b*. A crane was used for an overwater camera platform on *Jimmy Dean Water Show* (Potomac River, Washington, D.C.).

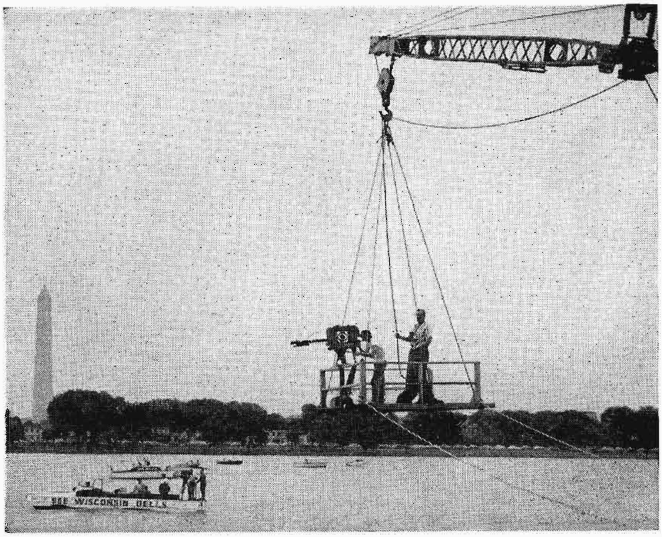

FIG. 5-17*c*. A crane-supported camera above Potomac River in operation with a field Zoomar lens. Left foreground shows camera-equipped amphibious "Duck." Washington Monument appears in background.

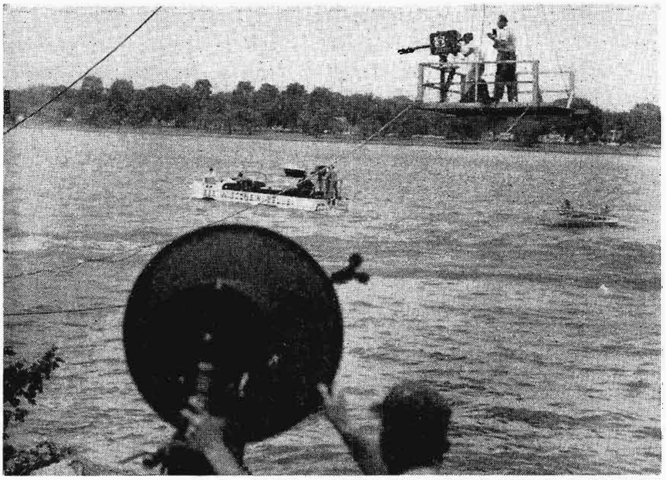

FIG. 5-18*a*. 2-ft microwave reflectors are used on the receiver (above foreground) and on the microwave transmitter in the "Duck" because of the broader microwave beamwidths as compared with the more common 4-ft reflectors. Note aiming sight attached to rim of reflector.

FIG. 5-18*b*. Close-up view of gasoline motor-generator (left), camera control unit, microwave transmitter, and camera installed in amphibious "Duck" for *Jimmy Dean Water Show*. Note 2-ft reflector used on microwave transmitter.

FIG. 5-18*c*. The gasoline motor-generator used to power camera and microwave transmitter must be well regulated at 60 cps to ensure steady pictures.

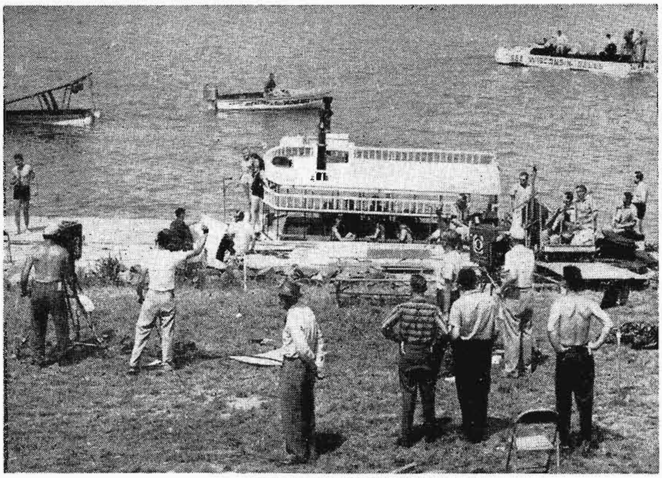

Fig. 5-18*d*. *Jimmy Dean Water Show* in progress. The camera-equipped amphibious "Duck" provided close-up pictures of water stunts.

Fig. 5-18*e*. This Packard convertible was used during the inaugural parade in January, 1953, to relay continuous close-up pictures of President Eisenhower to a microwave receiving point on the roof of the U.S. Capitol. Not visible is the 3-hp gasoline motor-generator installed in the trunk. Accurate panning of microwave reflectors is required to prevent loss of picture signals.

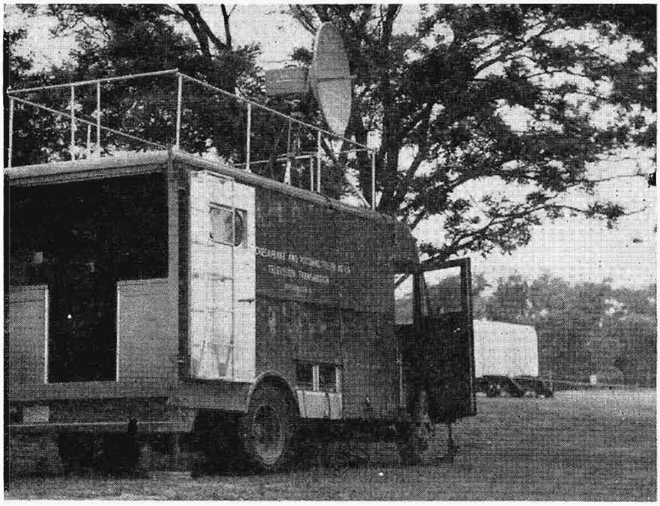

Fig. 5-18*f*. Local telephone company microwave operating on 6125.5 Mc. Note jacks under mobile unit to stabilize microwave beam. The microwave transmitter and tripod are securely anchored to roof. A gasoline motor-generator was used to supply electrical power.

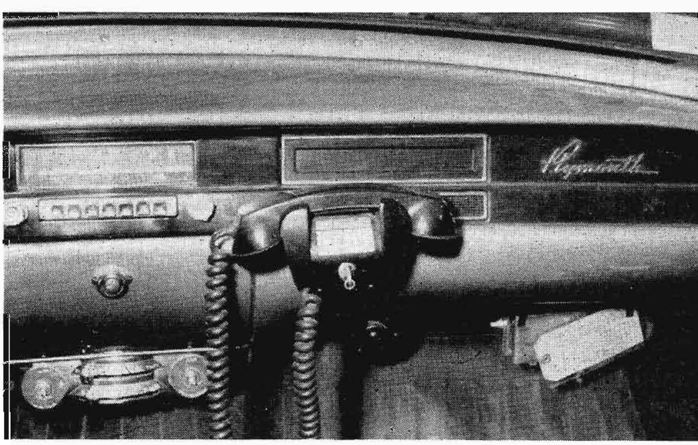

Fig. 5-19. Radio telephone installed in WTOP station wagon.

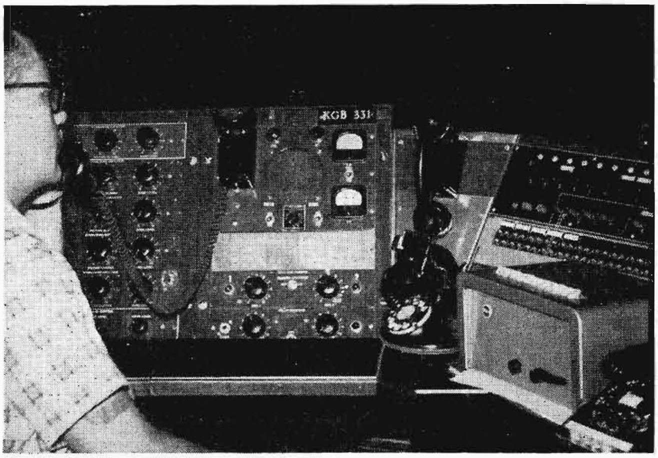

FIG. 5-20*a*. The control equipment for the 50-watt 26-Mc radio communications transmitter-receiver is operated from TV master control desk. This equipment is used for communications with the TV mobile unit.

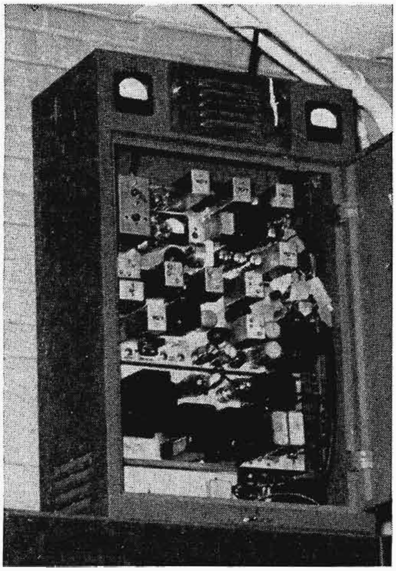

FIG. 5-20*b*. 50-watt 26-Mc FM transmitter-receiver operated from WTOP-TV master control.

Fig. 5-21. 35-watt 26-Mc FM transmitter-receiver temporarily installed on mobile-unit roof for communicating with boats during *Jimmy Dean Water Thrill Show* on Potomac River. "Walkie-talkies" transceivers (see Fig. 5-22) were used in a boat towing Dean on water skiis as well as in the amphibious "Duck" (see Fig. 5-18*c*). Contact with WTOP-TV master control was also possible (see Figs. 5-20*a* and *b*).

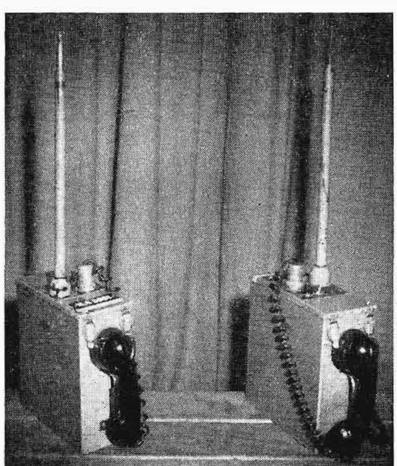

Fig. 5-22. "Walkie-talkie" FM 26-Mc transceivers operate on same frequency as mobile unit and TV master control room communications transmitters-receivers. Alignment of microwave transmitter and receiver reflectors is simplified by use of these units.

tion via the more powerful mobile unit or master control transmitters. Following the microwave alignment, the larger powered eqnipments are used to relay program timing and cue information, etc.

Video Equipment

1. Portable field camera equipment is used on remote pickups. The cameras, view finders, camera controls, power supplies, sync generators, video switcher, and monitors are normally equipped with carrying handles for convenient handling. Rain covers shonld be provided for cameras. Camera cables of lengths from 25 to 200 ft are carried on reels in the mobile unit. Cables longer than 200 ft are too heavy for convenient handling.

2. Lenses ranging in focal length from 35 mm to 100 in. have been used on remotes by WTOP. Each camera should have a "normal" complement of lenses: a 50, 90, and 135 mm and an 8-in. Other lenses frequently used are 35 mm and 10, 13, 15, 17, 20, and 25 in. Zoom lenses which operate from approximately 2½ to 7, 2½ to 15, and 3 to 22 in. are also frequently used. Forty-inch lenses are available for television cameras but not often required. A 100-in. lens owned by the Army was used on one program, primarily as a "gimmick."

3. Stndio-type tripods are nsed on remotes. Portable tripod dollies are nsed almost exclusively, since the heavier pedestal dollies are cumbersome to handle. The portable dollies should be capable of negotiating a 30-in. doorway, and large wheels (about 6-in.) are desirable where cameras are required to be dollied over rugs or rough floors.

A tripod T is required when a dolly is not used. These T's can be either of metal with sockets for the tripod legs or of wood in which the sharp leg fixture can be embedded (see Fig. 5-2). T's prevent the older models of wooden tripods from collapsing accidentally and protect floors, etc., from being marred. It is a good practice to anchor the tripod to a T or platform to prevent cameras from falling if a leg is inadvertently kicked by the cameraman.

Audio Equipment

Amplifiers

A portable remote audio amplifier having four microphone inpnts will usually be adequate for most remote programs. The microphone inputs should be balanced and low impedance to prevent stray electrical pickup. It is desirable that the remote amplifier be powered with batteries with a change-over switch to operate from alternating current. Another feature which wonld be helpful but is rarely found in a remote amplifier is a multiple line feed by which two or more program lines can be fed simultaneously. It would also be advantageous if one of the line outpnts incorporated a switchable pad to reduce one output to microphone level so that another station at the remote site desiring a low-level feed could be accommodated or, alternatively, to feed an additional remote amplifier in cascade where more than four microphones are required. The amplifier should, of course, incorporate a VU meter and a master gain control.

Microphones

Low-impedance microphones having low wind noise are used for remote pickups. Some types of microphones which would be satisfactory for studio use produce excessive wind noise when used in only moderate winds because of their physical structure. These types must be avoided in outdoor pickups.

Radio microphones are sometimes used on remote programs such as Edward R. Murrow's *Person-to-Person* show when considerable movement of the participants is involved and where it is required that microphones uot show in the televised pictnres.

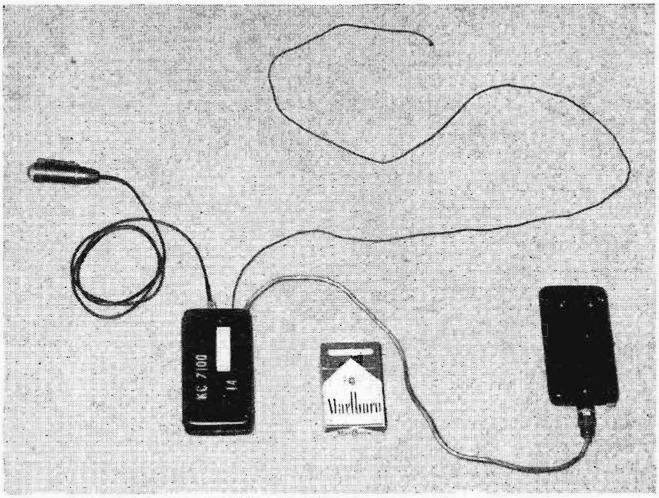

Fig. 5-23. Budelman radio microphone worn by participants in Edward R. Murrow's *Person-to-Person* television shows. Microphone is shown at upper left, 26-Mc transmitter at lower left, antenna wire (top), and battery pack at right.

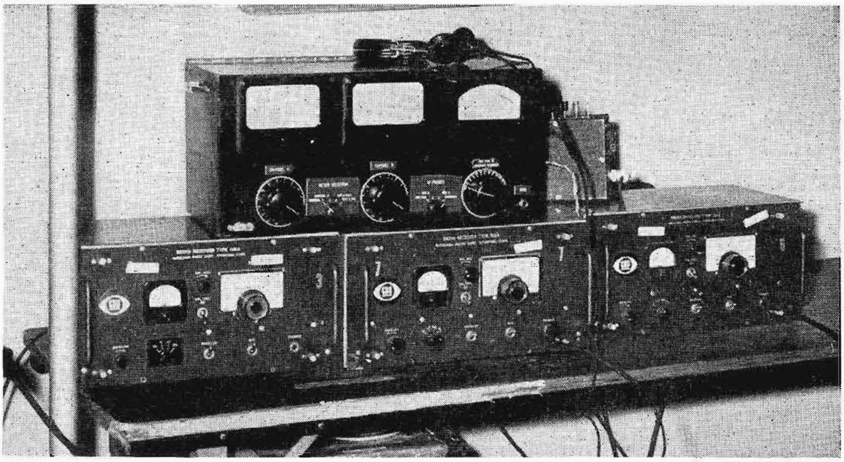

Fig. 5-24. Three Budelman radio microphone receivers are shown side by side on table. A diversity mixing amplifier is on top. The primary participant's radio microphone signal is picked up by two receivers on left, and the receiver outputs are then fed to the diversity amplifier above. This procedure minimizes fading caused by movement of participant. The remaining receiver is tuned to a separate radio microphone channel used by secondary participant.

These radio microphones are actually miniature battery-operated transmitting equipments. The microphone, transmitter, antenna wire, and battery are worn by the participant concealed beneath clothing (Fig. 5-23). The equipment used on *Person-to-Person* operates on approximately 27 Mc, and each radio microphone must operate on a separate frequency. The transmitting equipment must be licensed and operated under FCC Rules. The participants need not be licensed, however, as long as a licensed operator is responsible for the operation of the equipment. Because of the low power output from the radio microphones, there is no danger from burns or shock hazard. The usable range varies up to about a quarter of a mile depending on transmission conditions. When radio microphones are used inside a building constructed of metal materials, multipath reflections will occur and cause erratic operation of the equipment. It is sometimes necessary to run considerable receiving antenna wire to various rooms to ensure proper operation of this equipment. Two radio microphones and three receivers are normally used on *Person-to-Person* programs (Fig. 5-24).

Microphone cable used on remotes preferably should be three-conductor, shielded, flexible, insulated, and lightweight. Rubber-covered wire is heavier and generally less satisfactory than some plastic-covered varieties.

Lighting Equipment

Two general types of lighting equipment are used in television studios—fluorescent and incandescent. Fluorescent lighting is meeting with less favor because of its limited

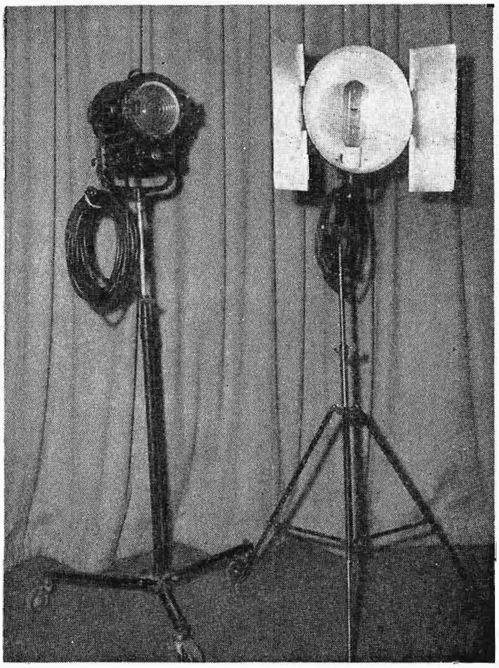

FIG. 5-25. Focused narrow-beam Fresnel spotlight type (left) and broadbeam "scoop" with "barn doors" on right.

"throw" of light and the large and cumbersome fixtures involved, and in some cases it causes flicker in the TV pictures. Incandescent lighting is used almost exclusively on remote pickups.

Incandescent-lighting equipment is available in two general types—focused narrow-beam types for high-intensity light over a small area and the broad-beam types for wider area illumination (Fig. 5-25). Adjustable-height stands with roller caster bases are available for both types of fixtures and are almost always required on a remote.

The narrow-beam spotlight types are usually equipped with a Fresnel lens in front of the lamp and a reflector behind the lamp with provision to vary the lamp-to-reflector distance, thereby broadening or narrowing the light beam as desired. The usual sizes of spotlights used on remotes are 500, 750, 1,000, 2,000, 3,000, and occasionally, 5,000 watts. The larger sizes are needed to illuminate auditoriums or other

FIG. 5-26. Vertical "polecat" consists of telescoping spring-loaded aluminum tubing. "Clip-on" lights are shown attached to polecat.

large areas, while the 500- to 750-watt sizes are usually adequate for close lighting up to about 25 ft.

The broad-beam-type lights usually consist of a 750- to 1,500-watt inside-frosted lamp in a 15- to 18-in. parabolic reflector. These lamp fixtures may also be rectangular in shape. In general, this type of light is used for broad illumination and "fill" lighting.

Another type of fixture which is used where a number of small areas must be lit is the "clip-on" light. This consists of a regular house-lighting socket secured to a rubber-covered spring clamp that can be attached to a board, chair, pipe, etc. (Fig. 5-26). Reflector flood or reflector spot lamps are generally used with the clip-on fixtures in sizes up to 300 watts. A convenient mounting in rooms of ceiling heights of about 8 ft is the "polecat" (Fig. 5-26). This is a telescoping tubing about 1 in. in diameter and is used vertically between floor and ceiling. These can also be used horizontally between walls (Fig. 5-27). The telescoping section is spring-loaded, which holds the unit firmly in place. Of course, padded ends are used to prevent marring the floor or ceiling. The clip-on fixtures then clamp at the desired height.

Cables for lighting fixtures should be rubber-covered, should be capable of carrying the required current (about 43 amp in a 5-kw lamp), and should incorporate an equipment-grounding wire to run from the fixture to the common ground point to reduce shock hazard. A lighting-distribution panel incorporating fuse or circuit-breaker protection for each circuit with ample capacity is a must for remotes (Fig.

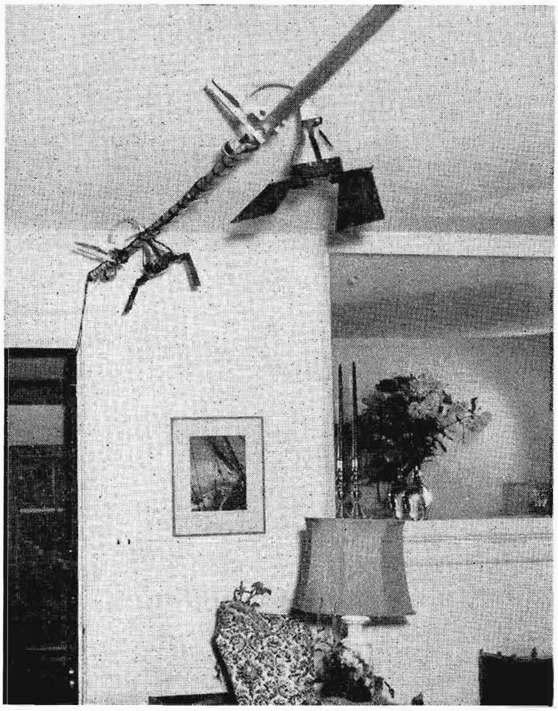

FIG. 5-27. Horizontally mounted polecat showing two "clip-on" light fixtures with barn doors for preventing direct light from falling into camera lenses.

5-28). For reliable operation and to meet electrical code requirements, the distribution system must be carefully planned and constructed. Since most stations use different methods of lighting and types of connections, this panel is usually custom-built.

OPERATION OF A TYPICAL REMOTE

Preparing for a television remote program, as contrasted with a studio program, involves a multitude of technical problems. Assuming that the program department has informed the engineering department of the general requirements for a remote pickup such as place, date, time, and number of cameras required, the following sequence of steps is taken by the engineering department to prepare for the event:

1. Ascertain that sufficient engineering personnel will be available.
2. If cameras are taken from the studios, determine which cameras will come from which studio and when they can be freed for the remote.
3. An on-the-spot survey of the proposed remote program site is then undertaken with the following people (together if possible):
   a. The producer and director of the remote program.
   b. The engineering department representatives (usually the engineer in charge and the technical supervisor assigned to the show).

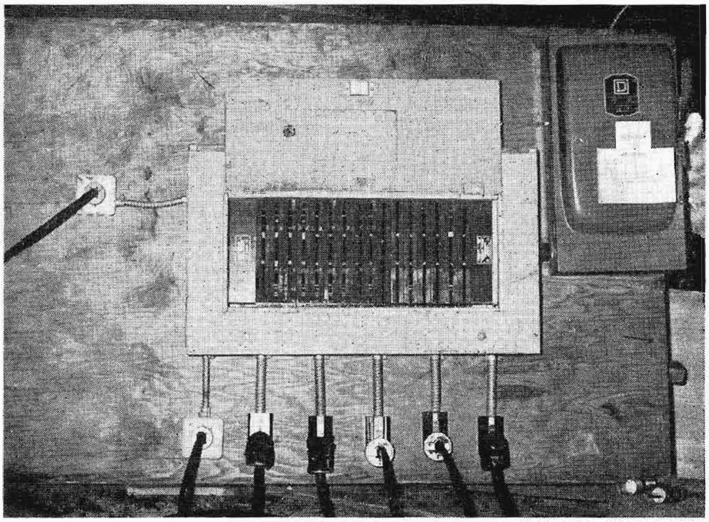

Fig. 5-28. Lighting- and power-distribution panel used on remotes where a large quantity of electric power is needed. The circuit breaker panel is fed by a 200-amp disconnect switch which can be wired for single-phase or three-phase four-wire power. Ordinarily a special temporary service is provided by local power company direct to power panel.

Fig. 5-29. A "Public Space" permit was required for this *Person-to-Person* remote because the sidewalk was needed for camera and Fearless dolly operation. The mobile unit occupied public space for approximately 12 hr and also required permit. Electric power was fed to distribution panel (see Figs. 5-30 and 5-31) from manhole in sidewalk.

c. A master electrician of an electrical contracting firm who is authorized to take out necessary electrical permits who will provide adequate wiring facilities from the maiu power source to the television mobile unit and supply a licensed electrician for standby during the remote program if considered necessary.

d. A representative of the local telephone company concerned with video microwave relay (if the station does not choose to use its own microwave equipment and personnel).

e. A representative of the local power company if sufficient power is not immediately available at the site.

f. Anyone concerned at the remote program site such as owner or manager of the premises, chief engineer of the building, etc., depending on the place and nature of the proposed remote pickup.

4. If it is determined from the survey that the mobile unit will occupy public space, it will usually be necessary for the engineer in charge to make application at the local license bureau for permission to park the mobile unit and give details of the program such as sidewalks or alleys to be blocked off, time and duratiou of vehicle on public space, etc. This step usually involves the local police in that special "No Parking" signs may have to be posted for the general public, traffic rerouting, etc. (Fig. 5-29).

5. If the proposed remote is inside a building, plans for needed lighting should be made during the technical survey. This phase can present problems other than technical when newsreel cameramen or other television stations having a differeut technical union are involved in a pickup of the same program. The problem is normally resolved in the Washington, D.C., area by using the facilities of a stage lighting company satisfactory to all parties and the cost of the lighting is shared by the television and newsreel companies.

6. Following the technical survey, the uecessary audio and video circuits are ordered from the local telephone company if the program is to be fed to the master control of the station. Iu the event that the program is to be fed directly to the network instead of the master control of the station doing the pickup, it will then be necessary to contact the person iu the network traffic department, since a local station cannot order facilities directly to the network. The usual order for an average remote television pickup will consist of:

a. A video transmit circuit.

b. An equalized 5-kc audio transmit circuit.

c. A nonequalized audio receiving circuit (used for cueing).

d. Two nonpublished business telephones in the mobile unit (one for program and one for engineering).

e. Additional private-line facilities if required.

7. The next step is to determine the "time iu" for the technical crew. Based on the complexity of the particular remote program and whether or not rehearsal is required, the crew assignment may be from 2 to 10 hrs ahead of air time. At this point the show is theoretically "on the road," but invariably changes affecting some phase of the program will arise, at which time it is necessary to contact the person or persons involved in the program changes.

8. A complete list of technical equipment to be used for the remote program should be made by the technical supervisor, and immediate steps taken to accumulate and check out the equipment (Fig. 5-30). The mobile unit should be kept in good mechanical condition at all times. Some of the items to bear in mind are:

a. Condition of the mobile-unit battery.

b. Gasoline and oil levels.

c. Condition of tires, lights, cooling system, and brakes.

These items seem unimportant but any one can delay starting on a remote. If time permits, the complete camera setup should be checked out before leaving for a remote, including a close observation of the sync generator pulses. A spare sync generator is always desirable.

9. Before the technical crew departs for a remote, provisions should be made to see that they are able to get a lunch period if the remote is of extended duration. This item is quite important because of the extra physical exertion involved in this type of

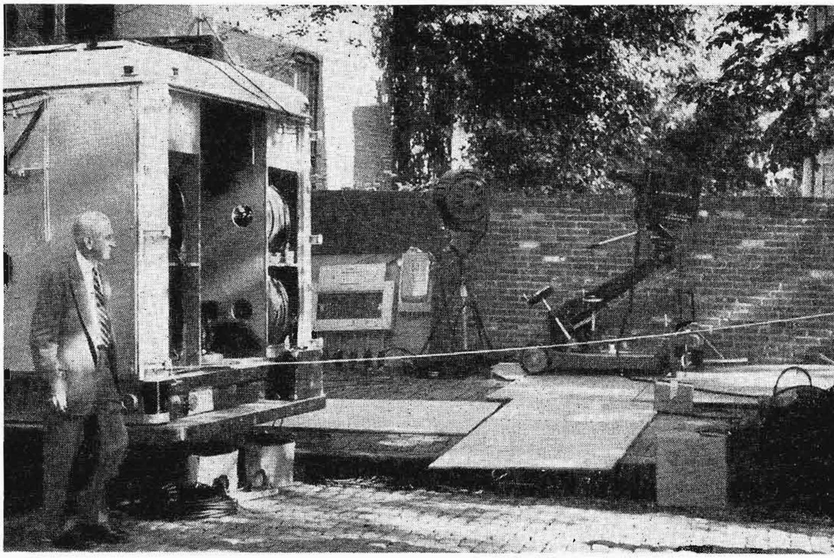

FIG. 5-30. The equipment used on a television remote can be quite extensive. On this remote, 18 sheets of 4- by 8-ft plywood were used to provide a smooth surface for Fearless camera dolly operation. Since the show was aired at 10:30 P.M., considerable lighting equipment was needed to illuminate sidewalk area and garden beyond wall.

FIG. 5-31. *Person-to-Person* television remotes usually require more electric power than is available in the homes visited. Consequently, a special temporary electric service is needed. A power-company crew is providing this service at a Georgetown, Washington, D.C., residence.

television program. Also, on many remotes in Washington, D.C., it is necessary to get security clearance for technical crew members. This is required on all remotes involving the President of the United States.

If a thorough surveying and planning job has been made, the remote pickup should proceed with only minor technical problems. When the technical crew arrives on the site with the television mobile unit (and station wagon for extra transportation), the first item of business is to park the mobile unit at the predetermined spot. The telephone representative should be on hand to point out the location of previously ordered audio and telephone lines and the coaxial video cable for picture transmission. The supervisor will direct camera and platform placement (at predetermined spots), camera cable routing, and microphone placement and cable routing. The electrician should have an adequate power source available for the mobile unit (Fig. 5-31). This should be the predetermined single-phase 110 or 220 volts a-c or three-phase 208 to 220 volts a-c, depending on the particular requirements (Fig. 5-12). The capacity should be at least 25 per cent above the maximum anticipated load to provide a margin of safety. Lighting fixtures and cables are placed in position by the technical crew, and then all equipment is turned on and checked out.

If required, video monitor and communication cables are run to the announcer and floor director positions from the mobile unit. A multitude of minor changes are usually made in camera, light, and microphone placements that almost invariably become necessary.

Prior to air time a check is made with the station to synchronize the mobile-unit clock. If time permits, the audio and video signals are sent to the master control of the station to set levels and check on pulse widths, picture and sound quality, etc. Immediately prior to air time, the remote director establishes communication with the control studio director and exchanges last-minute bits of program information. Then the show is ready to begin on cue.

Section 8

MEASUREMENTS, TECHNIQUES, AND SPECIAL APPLICATIONS