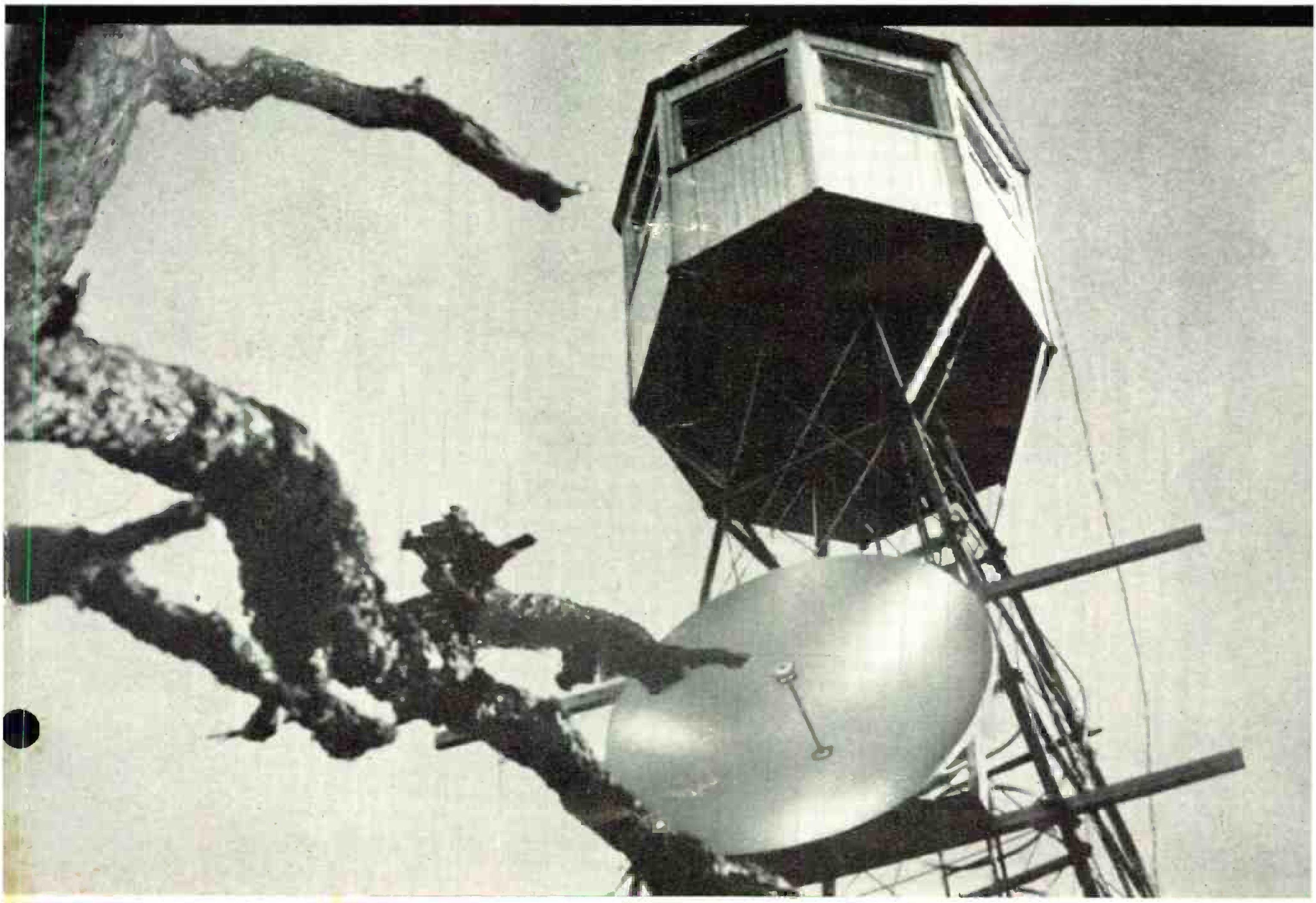
COMMUNICATIONS

INCLUDING "RADIO ENGINEERING" AND "TELEVISION ENGINEERING"



DECEMBER

★ ANNUAL INDEX FOR 1948

★ TELEVISION AND AUDIO FACILITIES AT WBZ

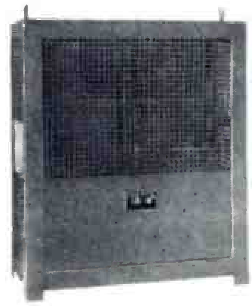
★ COMMERCIAL SINGLE SIDEBAND RADIOTELEPHONE SYSTEMS

1948

3-Phase Regulation

MODEL	LOAD RANGE VOLT-AMPERES	*REGULATION ACCURACY
3P15,000	1500-15,000	0.5%
3P30,000	3000-30,000	0.5%
3P45,000	4500-45,000	0.5%

• Harmonic Distortion on above models 3%. Lower capacities also available.



Extra Heavy Loads

MODEL	LOAD RANGE VOLT-AMPERES	*REGULATION ACCURACY
5,000+	500 - 5,000	0.5%
10,000+	1000-10,000	0.5%
15,000+	1500-15,000	0.5%

General Application

MODEL	LOAD RANGE VOLT-AMPERES	*REGULATION ACCURACY
150	25 - 150	0.5%
250	25 - 250	0.2%
500	50 - 500	0.5%
1000	100-1000	0.2%
2000	200-2000	0.2%

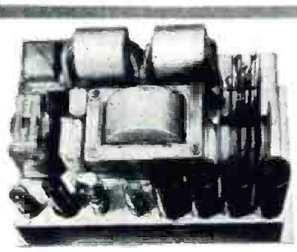
400-800 Cycle Line

INVERTER AND GENERATOR REGULATORS FOR AIRCRAFT.

Single Phase and Three Phase

MODEL	LOAD RANGE VOLT-AMPERES	*REGULATION ACCURACY
D500	50 - 500	0.5%
D1200	120-1200	0.5%
3PD250	25 - 250	0.5%
3PD750	75 - 750	0.5%

Other capacities also available



The NOBATRON Line

Output Voltage DC	Load Range Amps.
6 volts	15-40-100
12 "	15
28 "	10-30
48 "	15
125 "	5-10

• Regulation Accuracy 0.25% from 1/4 to full load.

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- Input frequency range: 50 to 65 cycles
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DECEMBER, 1948 VOLUME 28 NUMBER 12

COMMUNICATIONS

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COVER ILLUSTRATION

A *ptm* transmitting site for a 23-channel system developed to serve as a link in telephone service between New Glasgow, Nova Scotia and Charlottetown, Prince Edward Islands, Canada.

(Courtesy Federal Telephone and Radio Corp.)

Published monthly by Bryan Davis Publishing Co., Inc.
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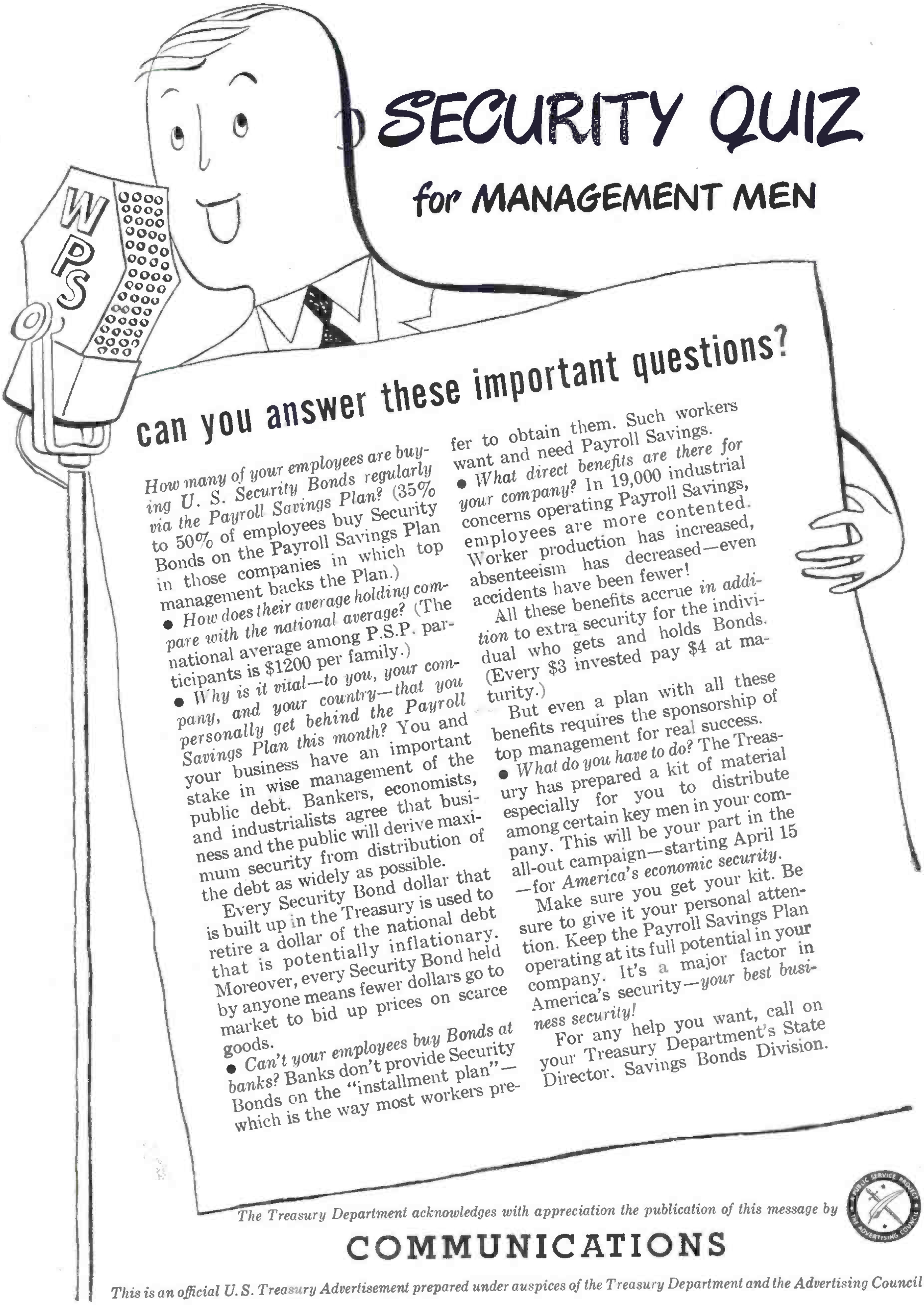

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for MANAGEMENT MEN
can you answer these important questions?
How many of your employees are buying U. S. Security Bonds regularly via the Payroll Savings Plan? (35% to 50% of employees buy Security Bonds on the Payroll Savings Plan in those companies in which top management backs the Plan.)
• *How does their average holding compare with the national average?* (The national average among P.S.P. participants is $1200 per family.)
• *Why is it vital—to you, your company, and your country—that you personally get behind the Payroll Savings Plan this month?* You and your business have an important stake in wise management of the public debt. Bankers, economists, and industrialists agree that business and the public will derive maximum security from distribution of the debt as widely as possible.
Every Security Bond dollar that is built up in the Treasury is used to retire a dollar of the national debt that is potentially inflationary. Moreover, every Security Bond held by anyone means fewer dollars go to market to bid up prices on scarce goods.
• *Can't your employees buy Bonds at banks?* Banks don't provide Security Bonds on the "installment plan"—which is the way most workers prefer to obtain them. Such workers want and need Payroll Savings.
• *What direct benefits are there for your company?* In 19,000 industrial concerns operating Payroll Savings, employees are more contented. Worker production has increased, absenteeism has decreased—even accidents have been fewer!
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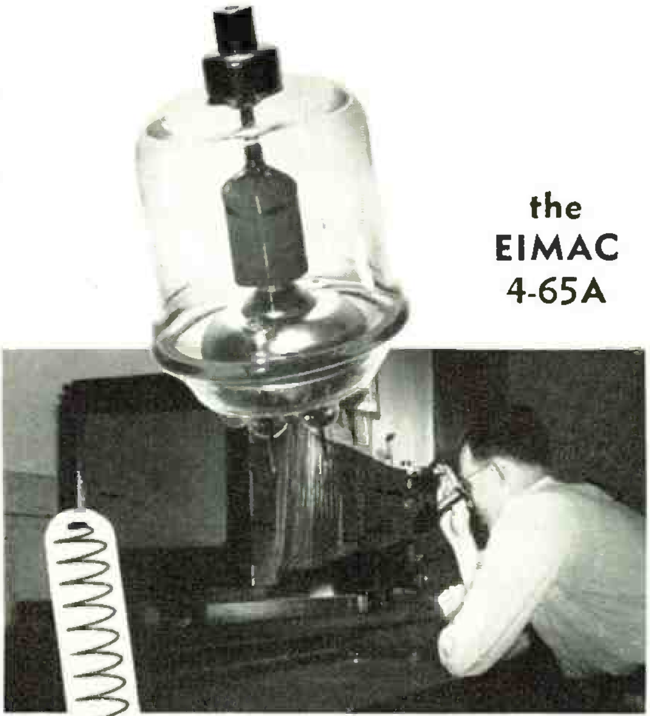
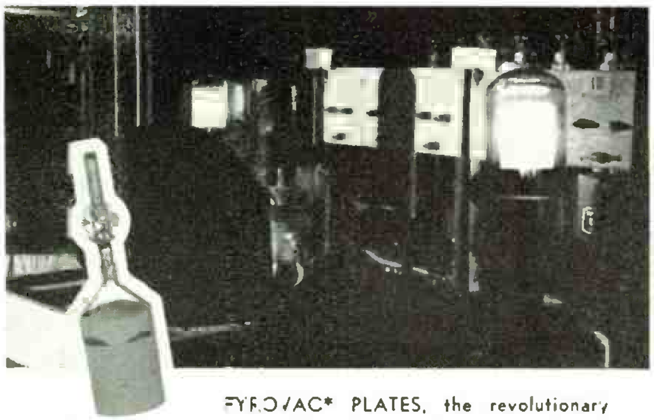
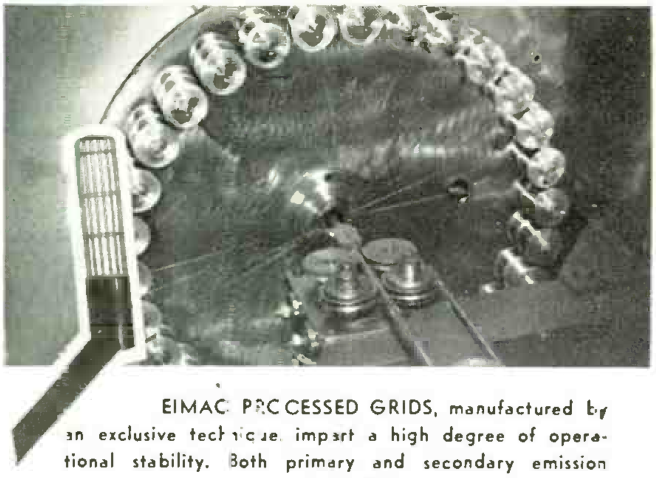
the
EIMAC
4-65A



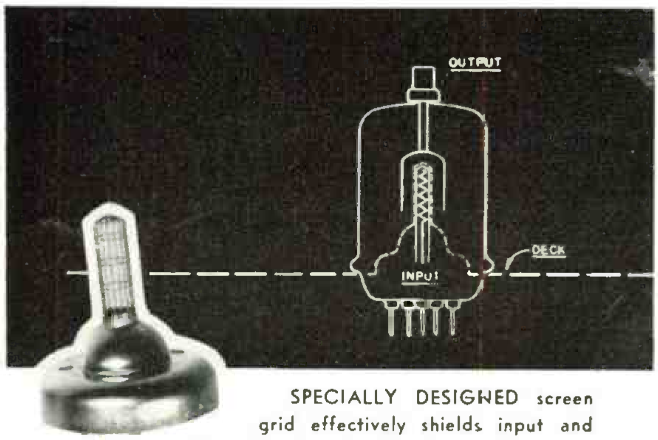
APPLIED RESEARCH by Eimac engineers has produced a thoriated tungsten filament with ample reserve emission. Its instant heating characteristics make the 4-65A well adapted to mobile application.



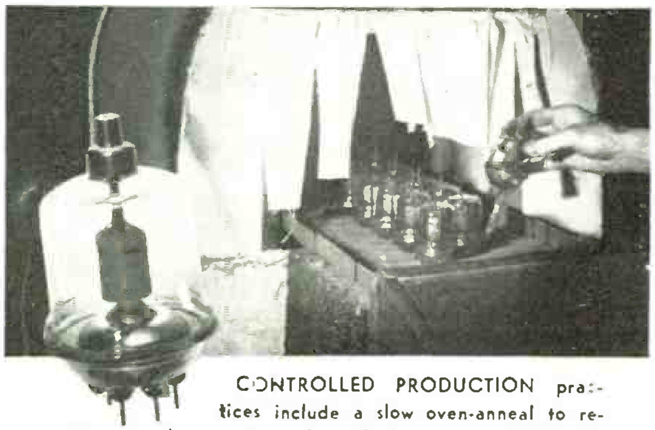
PYROVAC* PLATES, the revolutionary Eimac development, withstand excessive abuse. Manufactured by an advanced technique, these plates can handle momentary overloads in excess of 1000%, consequently they contribute appreciably to the tube's life.



EIMAC PROCESSED GRIDS, manufactured by an exclusive technique, impart a high degree of operational stability. Both primary and secondary emission are controlled.



SPECIALLY DESIGNED screen grid effectively shields input and output circuits, within the tube, without excessive screen power. All internal structures are self supporting without the aid of insulating hardware.



CONTROLLED PRODUCTION practices include a slow oven-anneal to remove the last vestige of residual strains, and four to eight hours of testing under severe VHF conditions.

*Trade Mark Reg. U. S. Pat. Off.

These are but some of the features that combine to make the Eimac 4-65A a better tetrode. It is unexcelled in its category as a power amplifier, oscillator or modulator. For example, in typical operation as a power amplifier or oscillator (class-C telegraphy or FM telephony) one tube with 1500 plate volts will supply 170 watts of output power with less than 3 watts of driving power. A complete comprehensive data sheet on the 4-65A has just been released. Write for your copy today.

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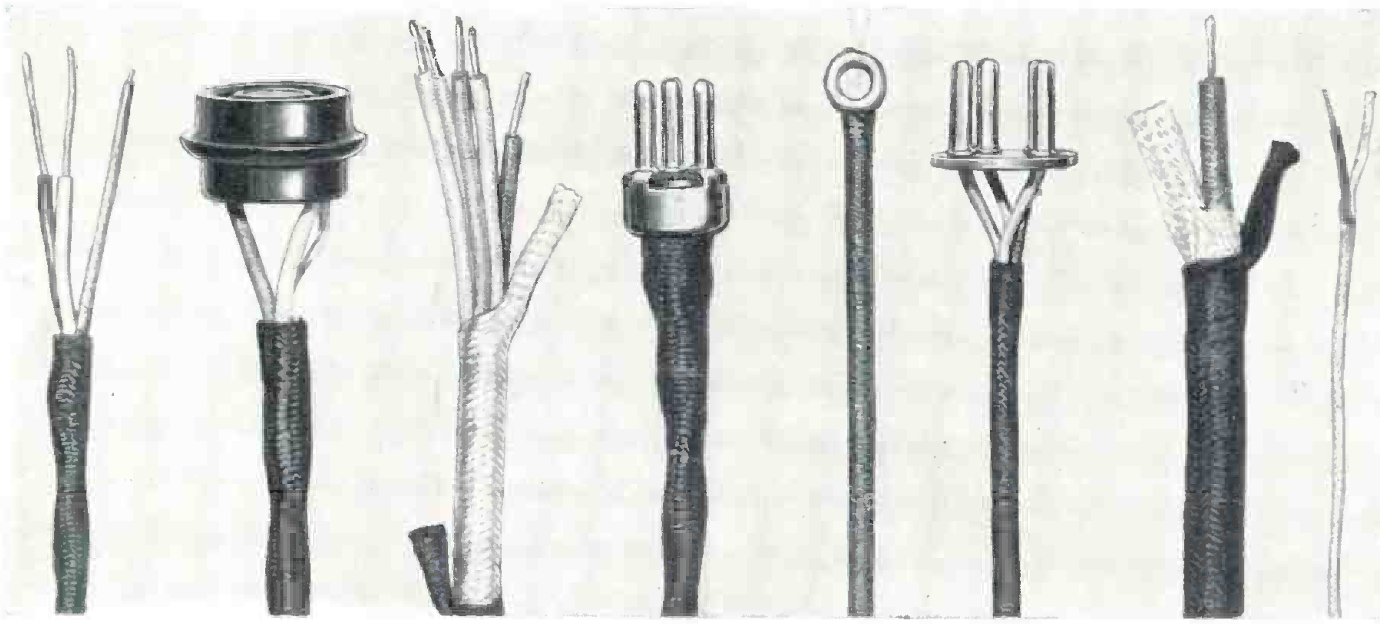
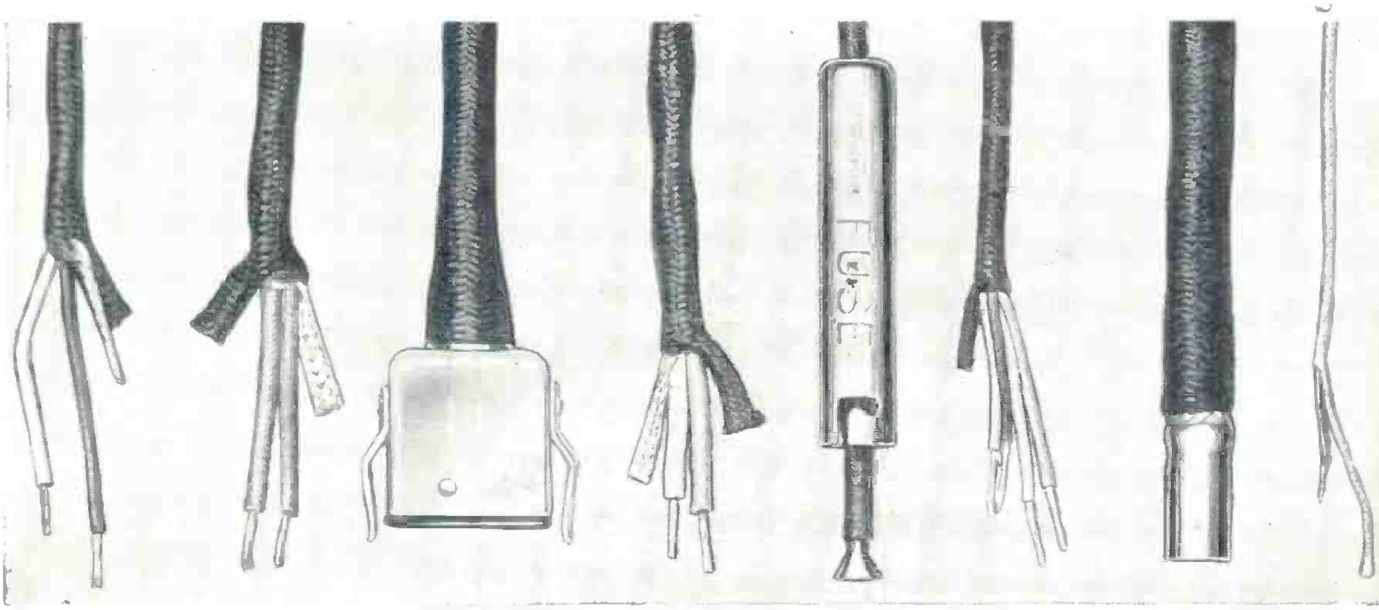




FUSE

COMMUNICATIONS

LEWIS WINNER, Editor

DECEMBER, 1948

THE TELEVISION ALLOCATION puzzle, which has prompted a score of round-the-clock FCC conferences and hearings in Washington during the year, appeared closer to solution than ever before at the latest TV engineering meeting which was concluded during the first week in December.

Several very plausible plans were submitted, one of which involved a carrier sync system which would permit satisfactory operation of co-channel stations 150 miles apart, in accordance with present separation practice. Reporting on the system, which has been used in sync tests between WNBT in New York and WNBW in Washington, Ray D. Kell, of RCA Labs, said that the tests indicated that if the level of the interfering signal produces barely visible bars in the picture under non-sync operation, a five to tenfold increase in the interfering signal level produces the same visible effect when the two carriers are synchronized. This value of improvement, Kell said, is for a random phase relationship between the two carriers, and at the most desirable phase position the improvement is about thirty times the voltage. It was pointed out that this phase relationship will change due to many factors and some mean value between optimum phase relationship and the most unfavorable phase relationship is a reasonable value of improvement to be expected. Kell declared that on this basis it was felt that an improvement corresponding to a reduction in interfering signal by a factor of about ten times in voltage may be reasonably expected.

The system has such merit, reported JTAC, that it should be considered as a factor in allocations planning.

In another solution approach, Philip F. Siling, of the RCA Frequency Bureau, said that the FCC should make its assignments upon the basis of protecting the 2 mv/m contour of metropolitan stations for not less than 90% of the time. Thus, he pointed out, the service areas of these stations would be extended to approximately the 500 uv/m contour for not less than

The TV Channel Problem

90% of the time by the use of synchronization of carriers, where that is required for adequate service. And when this is done, the stations should be protected to the 500 uv/m contour.

Siling also suggested that the FCC permit the use of directional antennas where such use will provide the operation of new stations without impairment of service from existing stations. It was also proposed that higher power be permitted in some areas.

Additional pertinent solution data were offered by T. T. Goldsmith, Jr., of DuMont, who reported on a series of troposphere, terrain and allocation tests recently completed. According to Goldsmith, the 500 uv/m contour of a station should be protected for a net service 90% of the time. It has been found that the shadows of hills and buildings materially change the measured average field intensity from that calculated from the smooth earth predictions. Field strength values for 90% of the measurements made were found between the values predicted by theory and values 20 db lower than these. Accordingly, said Goldsmith, some latitude should be allowed for this practical condition when choosing safe allocation spacings for stations.

Commenting on the present height-power formula, which was set up in an attempt to equalize service areas, Goldsmith stated that this formula would tend to discourage high antennas where the reduction of power were enforced. It seems as if the difficulty lies in the fact that the tropospheric interfering signals are primarily a function of power only and are relatively little affected by antenna height. However, the desired signal strength is influenced advantageously by increased height, particularly to those service areas at distances of 20 to 50 miles.

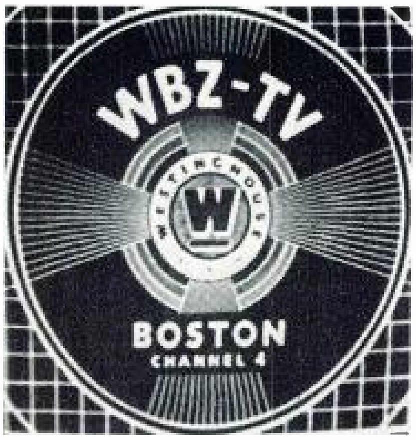
Goldsmith also revealed that measurements have indicated that receiver and transmitter improvements make it possible to detect signal interference when a ratio of 300 parts of desired signal to one part of undesired signal exists. For practical purposes, though, a 100:1 signal strength ratio is probably adequate. It was pointed out that this ratio should be the one which applies after having provided a terrain factor correction.

Discussing the sync approach, Goldsmith said that perhaps the use of sync oscillators for a pair of transmitters may make the co-channel beat between the carriers less prominent. It was indicated that the non-sync operation of the frequency-modulated sound channels must be considered. In some cases, he said, the sound distortion has proved as severe as the co-channel picture distortion. It was felt, declared Goldsmith, that the adjacent channel ratio at the receiver input terminals may safely be reduced to 1:1 for allocation purposes, but it was not believed that adjacent channel operation in the same service area is practical because of the signal distribution due to the terrain factor.

A ground-wave 2,000 uv/m contour as a primary service area, protected under all conditions, was satisfactory according to the report, which added that wherever possible protection should further be granted to the 500 uv/m as a secondary service boundary.

Testimony at the conference also revealed that the ultra highs were no longer being dismissed as remote areas. Many declared that these higher bands would be used and very soon, with both receivers and transmitters becoming available before long. It was indicated that the transmitting powers may be low, but sufficient for satisfactory localized coverage.

Since these solution proposals may be the answers to an effective allocation plan and the eventual lifting of the freeze, the need for immediate action was stressed by many. Accordingly a special committee was set up to evaluate the suggestions and perhaps arrive at a program which the FCC could adopt officially. It is believed that the committee's findings will be available in the early weeks of January. We hope so!—L. W.



Test pattern of WBZ-TV

TELEVISION

by SIDNEY V. STADIG

Technical Supervisor
WBZ-TV

TELEVISION IN BOSTON . . . January, February, March, April, May and finally T-Day, June 9, 1948.

At first, it was hoped that WBZ-TV would be on the air by early spring. Winter came upon us early last December and from then until late spring the erection of our tower was at a standstill.

Many days were too cold and windy, making it impossible for the riggers to work. For a full two months it was a continual battle in an attempt to keep the snow cleared from the tower steel. New England's worst winter in decades continued to be equally discouraging throughout the months of April and May. When it came time to hoist the TV pylon and super turnstile antennas atop the tower, it took a period of two weeks to do a routine three-day operation.

While this activity was going on outside, we lost little time within the confines of our building. Plumbers, bricklayers, carpenters, plasterers, etc., were busily laboring at their specific duties and in the middle of all this activity, our own crew was diligently working on the installation of our 5-kw television transmitter[1] under the supervision of William C. Ellsworth.[2]

Last January we were fortunate to be able to obtain two sets of field camera equipment.[3] This gear was set up in an antiquated studio of WBZ, then located at the Hotel Bradford in downtown Boston. This enabled us to form our technical staff to obtain firsthand working knowledge of the equipment prior to the time we would have to use it *on the air*.

Television interest in Boston actually got underway last December when NBC fed the Louis-Walcott fight for studio viewing. The program was piped in over the A. T. & T. microwave relay link into Bowdoin Square, from which point the New England Telephone and Telegraph Company's land wire facilities carried it to the WBZ studios. Over two hundred people viewed this telecast, received on nine *jeeped** receivers.

This instigated a series of feeds from NBC to WBZ which were sponsored by various receiver manufacturers. The demonstrations also afforded manufacturers an opportunity to set up receiver distributors throughout this area in anticipation of a signal emanating from WBZ-TV.

In April, television gained still more headway. In cooperation with the *Boston Post*, WBZ-TV and the Electric Institute of Boston, it was decided that television should be a keynote of Boston's *First Annual Electric Show*. Arrangements were made with various receiver manufacturers and distributors to set up over 100 receivers to be located at various booths at the show.

This presented two serious problems: (*1*), the distribution of both video and audio and (*2*), program makeup. The first problem was negotiated successfully by building a group of wide-band video distribution amplifiers and by stringing miles of coaxial cable all over Mechanics Building. Receiver manufacturers were then required to supply *jeeped* receivers.

In video work, proper line termination is as important as proper termination of antenna feeds for TV receivers in order to eliminate *ghosting*. Mismatch due to improper bridging and termination of lines necessitated serious consideration, for each of the five coaxial distribution lines had an average of twenty different types of receivers on them. Finally, this problem was ironed out and good pictures were received throughout the hall.

Program fare was supplied from

TV Facilities at New Center Include Four Major Points of Operation: TV Equipment Room with Sight and Sound Setup (Audio Facilities Include Consolette Which Permits Four Studio Microphone Positions, Two Turntable and Six Remote Input Positions for Projectors, Network Line, Remote Lines and Speaker Monitors); Projection Equipment (16-mm and Two 35-mm Film Units); TV/FM Transmitters, and Mobile Televan. Three-Bay TV Batwing and Two-Bay FM Pylon Mounted on Tower 656′ Above Sea Level.

[1]RCA TT-5B. [2]Westinghouse headquarter's engineer from Philadelphia. [3]RCA TK-30A.

at WBZ

At left: WBZ-TV transmitter operating console, in foreground, with TV transmitter (background), which is located in the main equipment room. Vestigial side-band filter is at rear right. At right: FM transmitter being viewed by officials prior to the increase in power to 10 kw (left to right)—W. C. Swartley, WBZ station manager; Gwilym Price, president of Westinghouse Electric, and W. H. Hauser, WBZ chief engineer.

three sources, each fed to the input end of the video distribution setup where the switching was made from one source to the next. All TV networks in New York sanctioned feeds to this show via existing microwave facilities.

WBZ-TV set up a temporary *iconoscope* camera chain with a 16-*mm* film projector at the studios and microwaved film shorts to the show. The feature program of the show was a *Miss TV* contest put on right at the hall. The WBZ-TV *televan*, mobile control truck, was set up inside the building to act as a control point for two camera chains on the stage. Each day a group of contestants performed before the cameras, with semi-finals and finals staged at the close of the week.

Station Facilities

WBZ-TV facilities may be subdivided into four separate groups: the main equipment room, television projection, television equipment and the mobile *televan*.

Main Equipment Room: In addition to the audio racks and recording machines[5] in the *main equipment room*, two TV monitor racks, transmitter, side-band filter and diplexer are on the left-hand side, and the FM transmitter[6] with its monitor racks on the right-hand side of the room. The master console for the TV transmitter is midway between the two transmitters.

In one of the TV monitor racks are the aural transmitter which contains a sound frequency and modulation monitor,[7] program amplifier,[8] and audio monitor amplifier[9] audio jacks and convenience outlet panel.

The second rack for the video transmitter contains a stabilizing (video line) amplifier,[10] a video carrier frequency meter,[11] an *rf* patch panel and necessary power supplies to operate the master monitor in the TV console, and the demodulator.[12]

The television transmitter is assembled in eight steel cabinets that contain the necessary components of both a video transmitter and a sound transmitter with their associated power supplies and control circuits.

The aural section utilizes an FM exciter,[13] followed by triplers and doublers that drive a power amplifier employing an 8D21 dual tetrode.

The video section employs a standard crystal oscillator followed by a tripler and doublers that drive another 8D21 final amplifier. This stage operates as a grid-modulator power amplifier.

Six 4D27s in parallel modulate the grid of the final amplifier. The video system is a high-gain, three-stage amplifier with excellent frequency and phase response, utilizing a *constant resistance* network in the anode of the modulator stage. This network makes the internal impedance of the power supply a part of the plate load, thus permitting frequency response down to and including *dc*. A *clamp circuit* type of *dc* restorer is used in the grid circuit of the modulator which clamps on the *back porch* of the horizontal pulse.

Dual unit *reflectometers* are included in both the sound and picture output circuits. These units are an invaluable aid in checking and maintaining proper output characteristics. They perform three main functions:

(1) Measurement of the *swr* on the main transmission line.
(2) Measurement of the peak of sync power output (when calibrated against the dummy load).
(3) Operates as an *rf* overvoltage output, thus protecting the transmission line against rupture due to lightning, bad mistermination or any trouble which causes excessive standing waves to occur.

The output of the picture transmitter is fed into the vestigial side band filter. Physically, this unit consists of a maze of coaxial transmission lines.

Electrically, it comprises a combination of two *m*-derived filters constructed of low loss coaxial transmission lines. Filter components of the common *l-c* construction would be difficult to manufacture and uneconomical to use because of the currents, voltages, and reactances involved. Hence, the coaxial-line construction.

The undesired side band is passed through one of the filter units into a

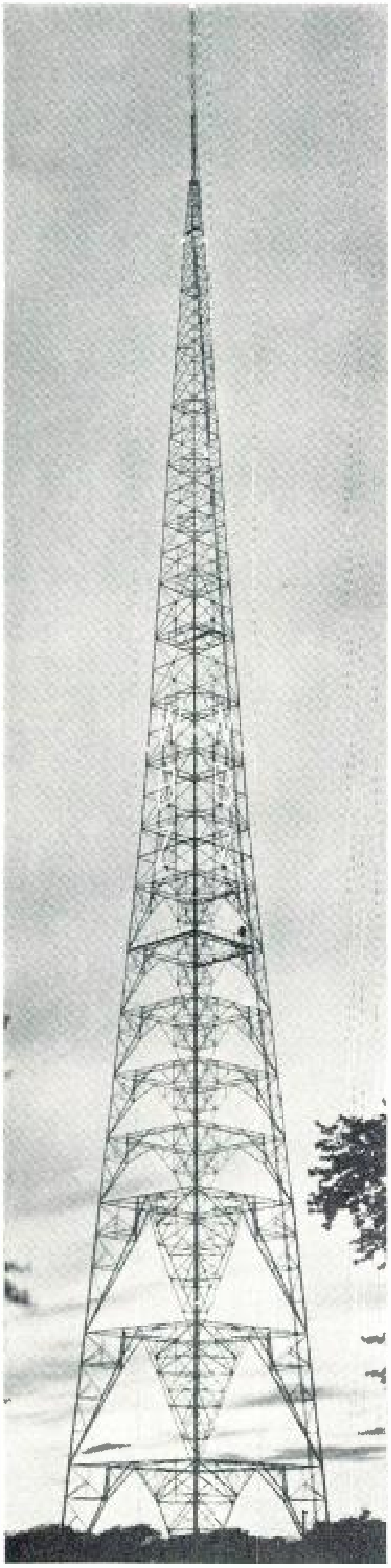
---

[4]The term *jeep* applies to the conversion of a standard TV receiver chassis so that it will take a standard 2-volt video signal, rather than picking up the television signal direct from the antenna. In reality, it is much like a *phono* audio input on a receiver when the audio is injected after the second detector, rather than deriving the signal through the *rf* and *if* stages. stages.

[5]Scully. [6]Westinghouse FM-10. [7]G-R 1170-AD. [8]RCA BA-3. [9]RCA 82-C1. [10]RCA TA-58. [11]RCA WF-49A.

[12]RCA WM 12A WM-13A. [13]RCA.

WBZ-TV-FM tower. Microwave for remote pickup may be seen immediately below WBZ neon call letters.



properly terminated transmission line that eliminates reflections of the lower side bands. This termination is in the form of a water-cooled load resistor; its resistance is equal to the characteristic resistance of the line.

The desired signal goes through the second filter and a notch filter. This notch filter is so designed to protect the sound frequency of the lower adjacent TV channel.

Both the aural transmitter and the video output of the side band filter are fed into a diplexer. In a simplified form, the diplexer may be considered to be a balanced bridge circuit in which there are four legs. The visual and the aural signals are fed to alternate diagonals of the bridge. Since the aural signal is fed into the circuit across the mid-points of the antenna and the reactors, no visual signal can go into the aural transmitter. In like manner, the visual signal is fed to the circuit between two points of equal potential with respect to the aural transmitter, so that no aural signal can get back to the visual transmitter.

The two output feeds of the diplexer feed the east-west and the north-south set of the turnstile radiators respectively. In order that a circuit horizontal radiation pattern be achieved, one set of radiators are fed 90° out of phase with the other.

Our transmission line installation departed from that usually installed for television. We used 3⅛" 51.5-ohm coax;[11] but instead of each 20-foot section hung in a suspension type hanger to allow for expansion, our line was secured at two points, one at the top of the tower, the other about half-way down. Immediately below these two points, a coaxial type of expansion joint designed especially for television, was inserted.

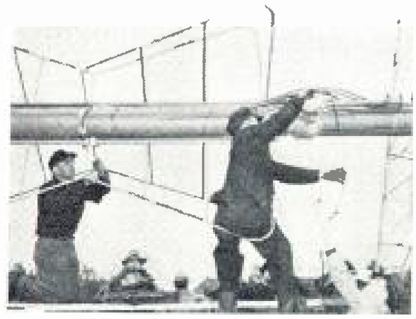
The line between these points is held to the tower by loose fitting clamps that allows the line to creep when it expands or contracts with temperature changes.

One thing of particular interest is the matter of suspending the inner conductor in the transmission line. Each 20-foot section has a rolled groove 12" from one end of the line. This groove was indented sufficiently so that when the line was placed in a vertical plane, the inner conductor insulator would catch on the groove and thereby suspend its own center conductor.

On the horizontal runs, the rolled grooves were alternated to allow for differential expansion. Each length of line was flanged and each piece of inner conductor milled so that the wire conductors could be fitted together with a *bullet*. The outer conductor flanges were bolted to each other to eliminate the need for any soldered joints in the line.

Should it become essential to cut a piece of coaxial line, it is necessary to solder on another flange but to insure that the line retains a flat characteristic impedance, it is necessary to cut the inner conductor midway between insulators, with the remaining length made up with a special type of inner conductor of slightly larger diameter.

[11] Andrew Company.



Rigging and final test of WBZ-TV batwing antenna.

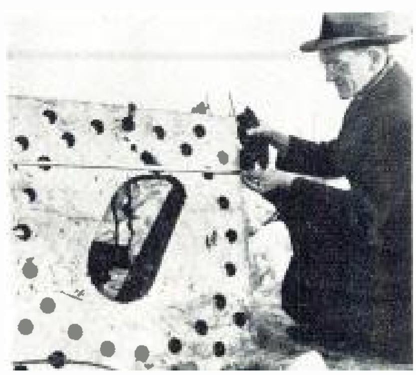
The TV Transmitter Console

The television transmitter console contains three sections: transmitter control, incoming and outgoing program monitors, and three-point video monitoring facilities.

The transmitter control section contains control circuit switches and indicating lights for remote operation of the transmitter. The center section of the console features two master monitors which enable simultaneous checking of the incoming as well as the outgoing program.

The right side of the console possesses a row of push buttons for moni-

W. C. Ellsworth measuring the huge base plate that mounts on top of the tower to hold antennas.



tor switching purposes. This system provides for viewing at any one of three points in the system: transmitter input, modulator output and transmitter output.

On this same panel is located another row of buttons for monitoring the signal from reproducers at any one of the foregoing locations. There also are additional controls for monitoring the audio at any of the points in the aural transmitter, as well as a *vu* meter for indicating audio level.

The wave-form demodulator depicts the amplitude of sync versus video plus overall percentage of video modulation and is observed on a 5-inch *crt* mounted in the master monitor. This 'scope has a variable sweep circuit and by means of a switch, it is possible to observe the vertical field or horizontal line presentation with their associated sync pulse blanking pedestal and video content.

The picture demodulator output is observed on a 10BP4 that is built into the master monitor.

The FM Transmitter

Our FM transmitter consists of three cubicles, the first of which contains a unit[15] for FM modulation and frequency stability circuits. This in turn drives a series of doublers and ends up in a pair of WL 5736s. This particular unit has a self-contained power supply and can be used as a 3-kw FM transmitter as well as the *rf* driver for the final stage, as we use it.

The center cubicle contains a three-phase rectifier for the final. The third cubicle houses a pair of WL-2500A3s that are air cooled and capable of delivering 10-kw output. It is a grounded grid final employing a form of tuned coaxial cathode and plate tank circuits.

This transmitter is piped into another coaxial line similar to the TV coax installation, which terminates into the two sections of a heavy-duty pylon antenna.

The tower itself rises 572′ above sea level, and the addition of the 2-section FM and 3 bay TV antenna raises the tower to an overall height of 656′.

Television Projection Room

The projection room is located on the first floor, immediately below the TV control room in the southeast corner of the building. It employs two film camera chains employing 1850-A iconoscope tubes, 16-*mm* film projectors, two 35-*mm* film projectors with its rack of associated sync light power supplies and picture monitor. There are also three 2 x 2 slide projectors[16] for use with 2 x 2 slides and 35-*mm* strip film, and one Bal-optican modified to project opaque slides and news tapes.

The 16-*mm* projectors are used in conjunction with one camera chain, the two 35-*mm* projectors with the second chain. This is possible by the use of a multiplexer. This multiplexer has two front surface mirrors, enabling each movie projector to be mounted at right angles to the film cameras and the reflected pictures to be focused on the mosaic of the iconoscopes through the front surface mirrors placed on a 45° angle.

This system allows greater flexibility of each film camera and simplifies the problem of switching video and sound from one projector to another. This switching is a duty of the projectionist.

There is a film camera control unit for each film camera. These contain a master monitor and a camera control unit that permits individual monitoring of each chain. Controls are readily accessible for shading corrections, a necessary operation with practically every change of scene illumination whether it is film or slide.

In addition, each camera chain requires two heavy duty, regulated power supplies. Four of these power supplies, along with a preamp for the 35-*mm* machines, fill a second rack in the projection room.

Adjacent to the projection room is a rewind and storage vault for 16- and 35-*mm* film. Here the film is spliced and edited before gain on the system.

Television Equipment Room

In reality, the TV equipment room is the overall control point for all types of shows: film, network, studio, and remote. It is a beehive of activity and has gone through several major changes since T-Day. At that time, all of the control room equipment had not yet arrived, so we operated with a temporary setup employing field switching equipment, sync generator, etc. Since that time, a large percentage of our equipment has arrived and has been installed.

Of the six racks, two are devoted to audio. They have jack strips, line amplifiers, monitor amplifiers, and audio line termination facilities for network and remote feeds.

Additional audio facilities include a consolette which permits four studio microphone positions, two turntable positions, and six remote input positions that are wired up for use with the 16-*mm* projectors, 35-*mm* projectors, network line, remote lines and speaker monitor for projection room.

Two turntables are used for dubbing in musical background on news shows, sound effects, etc. These tables are equipped with cueing circuits. In addition to this, there are microphones[17] in the studio and announcer's booth. A large perambulator type mike boom is available for studio shows.

[15] Westinghouse MO-MP.

[16] SVE.

[17] RCA 77-D and 88.

(Continued on page 33)

The WBZ TV mobile truck. Technician Truman Craine is shown focusing image orthicon camera with 17" lens, while technician Robert Henderson (right) is beaming microwave dish. Technician Fred Moriarty is peering through escape hatch which leads from roof platform of truck to interior.

Audio Facilities At the

Charles Vassall checking a meter circuit in the master control board of the audio system at the WBZ Radio and Television Center. The volume indicator panel (left) gives a visible and audible check for entire standard band and FM studio setup, while the right bay provides for switching of eight studios and six channels.

One of the two transcription studios, with announcer Carl deSuze cueing in a transcription on one of the triple turntables, while announcer Malcolm McCormack makes the station break. Studio console with channel switching unit is in foreground.

THE TENDENCY in many installations of recent years has been toward complicated switching arrangements, particularly in the design of *master control* facilities, which has resulted in duplication of functions and equipment, and has thus reduced efficiency of operation.

The studio facilities in the *WBZ Center* were designed to facilitate the origination and production of programs.

This system, basically, provides a channel switching unit, custom built to match a standard consolette, in each studio control room. Any one, or all of six, transmitting channels may be selected by the technician in a studio control room by depressing appropriate buttons. Signal lights adjacent to the channel switching buttons indicate whether or not the channel is in use in any other studio.

The studio technician may therefore, after receiving the cue, feed his program to the appropriate channel or channels without dependence on, or assistance from, any other personnel.

In a centralized *equipment room* are located master monitor and switching units, containing interlock relays by which the switching system is controlled, the transmitting channel amplifiers and monitoring facilities. Nine standard racks contain this equipment, as well as terminating and equalizing equipment for all incoming telephone lines, recording amplifiers and measuring equipment. This array of apparatus is designed to be unattended. All regular circuits are normalled through to each studio, so only when it is necessary to patch in a special line or check the operation of the equipment is a technician required.

The *equipment room* is linked to each studio by twenty-two pairs of shielded wire, carrying audio circuits, a twenty-six pair lead-covered cable, carrying channel switching and signal circuits, and a fifteen-pair cable, carrying talking and other signal circuits. Adequate spare conductors are provided in each cable for future use if required.

Studio Layout

Six studios, designed primarily for sound broadcasting and varying in size, are provided to accommodate the diversified programs of a large metropolitan station.

Studios *A*, *B* and *C* are sufficiently large to accommodate orchestral and choral groups and studio audiences. They may also be used for television programming when required.

Studio *A* is an auditorium studio with a stage 25′ by 28′, and is provided with banked seats on the main floor, for an audience of 160 people. A balcony, located in the rear of this studio, may be used for motion picture projection, or as a television camera location. Ten microphone outlets are located on the stage, with two of these outlets paralleled half-way down the auditorium on either side, to be used for audience participation programs. A selective public-address system, installed as an integral part of this studio, can be used to reinforce any portion of a program.

Studios *E* and *F* are smaller studios, each containing about 120 square feet of floor space, while *D* studio is 170 square feet.

We have found a very definite need exists for a small, well-appointed, intimate studio, from which to originate talks by individuals or discussions by two or three people. Studio *D* was designed for this purpose. Its size approximates that of a living room in the average home, and it is furnished in that manner. The feeling which accompanies *mike fright* tends to be dispelled in these surroundings, resulting in better production.

Studios *E* and *F* are designed and equipped to produce transcription programs, news programs, and to serve as stand-by studios. In addition to a normal complement of microphones, each of these studios contains a custom-built transcription turntable cabinet, housing three dual-speed turntables.[1]

At WBZ, the announcers operate the transcription turntables and the refinements which have been built into this equipment result from suggestions of the announcing and production

WBZ Radio-TV Center

Radio-TV Center, on Banks of Charles River, Next to Harvard Stadium, Feeds Programs to 50-Kw WBZ, 20-kw WBZ-FM (92.9 Mc), WBZ-TV (Channel 4) and International Broadcast Station WBOS. Facilities Include Two Separate Monitoring Systems, Three-Dual-Speed Turntable Single-Unit Setups, and a 6-Channel Push-Button Switching System to Match Consolettes in Each Studio Control Room. Equipment Designed, in the Main, For Unattended Operation.

by CHARLES VASSALL

WBZ Audio Supervisor

staff, as well as the technical staff, in order to achieve a high order of satisfaction and efficient operation. In line with this policy, the use of three turntables in a single unit was decided upon. The three turntables are grouped in a semi-circle, with the pickup arms of both outside tables converging at a 90° angle, allowing the person operating the turntable to spot the stylus on the disc with greater ease.

The announcer is able to cue in three discs before a program begins, and thus is able to handle a transcribed program, consisting of theme, commercial announcements, and musical selections with the utmost ease, in contrast with the juggling of discs which often accompanies such programs.

Directly in front of the person operating the transcription turntables, and mounted at a 45° angle, is a small control panel, 5″ by 9″, on which are mounted three faders and three cue buttons. These controls facilitate cueing of records and transcriptions.

It occasionally becomes desirable to insert a transcribed theme, announcement or fill in a program originating in one of the larger studios where transcription facilities are not provided. Therefore, the output of studios *E* and *F* is permanently wired to push-button switches labelled *turntable* 1 and 2, respectively, in all studio control-room consolettes. By means of prearranged cues, a transcribed portion of a program may be inserted at will.

Studio Control Rooms

Each of the studios has a control room adjacent to it. A large window, constructed with non-parallel surfaces of glass to eliminate reflection, affords an excellent view of the studio for technician and production man.

The control rooms vary in size: For studios *D*, *E* and *F*, 8′ by 9′; for studios *B* and *C*, 13′ by 10′; and for studio *A*, 14′ by 15′. In the larger studios, where orchestral, choral, dramatic and other live programs are produced, sufficient space is made available in the associated control rooms for production men, agency representatives, etc.

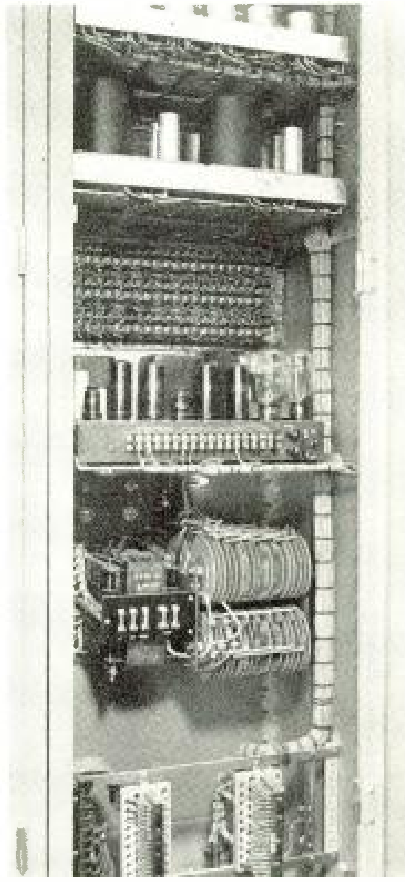
The control-room equipment for all studios is basically similar. Some additional equipment has been provided for the larger studio for special purposes.

A custom-built operating table, surfaced with linoleum top, 36″ wide and 27″ high, has been designed to fit into the space along the control-room wall facing the studio. The control-room window is located just above this table. This table is built to provide adequate leg room for the technician and production man, who normally occupy this position. Cabinets are provided for housing associated electrical equipment and drawers allow space for necessary papers, etc.

An enclosed trough, with a hinged top, is provided along the full length of the cabinet for wiring. This trough is 4″ deep by 14″ wide, and allows adequate space for all interconnecting cables.

A standard consolette[2] is mounted on the operating table and beside it is mounted a custom-built channel switching unit designed with the same physical characteristics as the consolette to provide an appropriate matching piece of equipment.

Recessed in the wall on one side of



Rear view of the WBZ master control racks with its six isolation amplifiers,** two power supplies,** jack layout, power amplifier for high-level speaker, buss and dual rectifier, 220-volt three-phase input and a 12-volt, 35 ampere output controlled in the primary by a three-phase variac. Lower section contains (l-r) power, signal and audio blocks. All racks have audio leads cabled in *stp* wire on right of each rack, signal circuits and power on left.

[1]Presto 64-A. **RCA. [2]RCA 76-C.

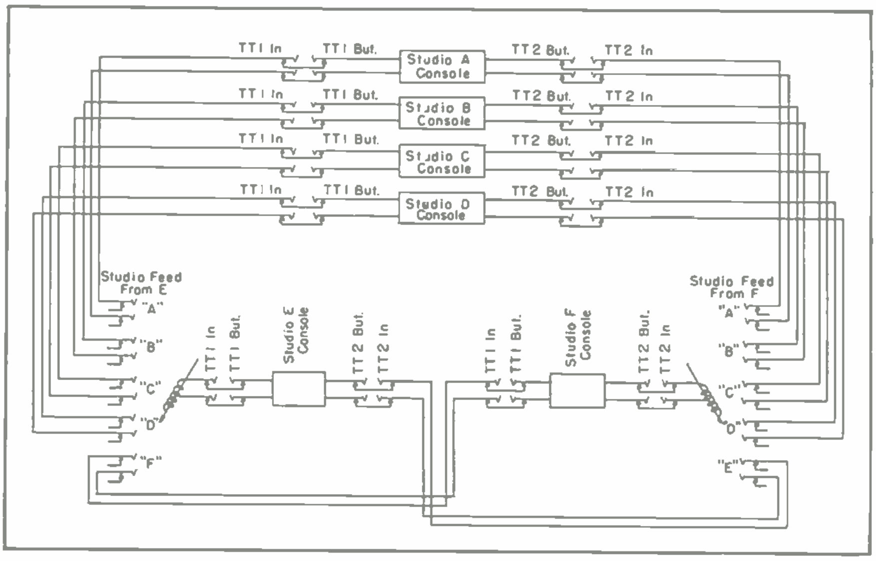


Figure 1
WBZ studio-turntable feed system. Studio *E* transcription tables appear as *TT1* and studio *F* tables as *TT2*. Setup permits one studio being on the air while the other is in rehearsal or standby.

the control table, and within convenient reach of the operating position, is a cabinet containing all jacks.

Located here are all microphone outputs normalled through to console incoming and outgoing trunks and all monitor circuits. Standardization of all booth equipment has been carried out so far as consistent with efficient operation. Each studio booth is supplied with power through a 15-amp arc circuit breaker from building mains, which affords protection in the event that anyone shorts any outlet in booth or studio. Only equipment used for program purposes is on the circuit breaker. An intercom[3] is installed in each booth.

Two telephones, one connecting to the main switchboard and the other connecting to remote pickup lines, together with a intercom unit, are provided on the operating table.

A monitoring loudspeaker[4] in a custom-built cabinet is mounted on the wall over the window, tilted toward the operating position.

It may thus be seen that all the necessary equipment is provided to permit a program to be fed to any outgoing channel from any studio control room without dependence on any other personnel.

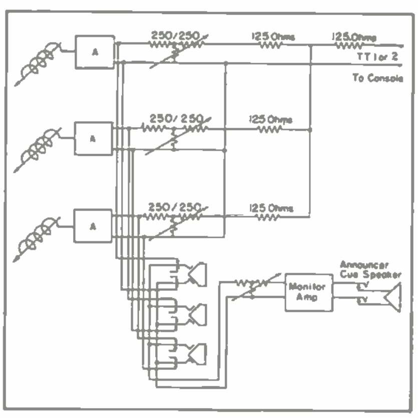
The auditorium studio control room differs from the foregoing equipment layout, in that additional facilities are provided to accommodate the use of a larger number of microphones and control of the *pa* system used in connection with this studio. An auxiliary four-position mixer is supplied as a companion piece to the standard consolette, permitting the use of as many as ten microphones if the necessity arises. The custom-built channel switching unit is expanded to incorporate volume controls, selectors, and switches, as well as a standard volume indicator for the studio *pa* system. The volume indicator is calibrated for proper sound levels for varying audience groups, which greatly facilitates the adjustment of sound reinforcing levels.

Audio System

Provision is made to observe and control, if necessary, the functioning of the channel switching system by means of master monitoring and switching units located in one of the racks in the *equipment room.* Audible and visual checking is possible at this one position.

The volume indicator circuits in the master unit may be transferred from the output of the channel amplifiers to their respective inputs by push-button switches. This affords a rapid means of checking studio output against channel amplifier output, and thus quickly detecting any trouble which may occur in the channel amplifiers.

Figure 2
The turntable pads and announcer cue-speaker setup in studios *E* and *F* of WBZ.



Supplementing the visual check, a row of interlocked push-button switches mounted on the same panel, permits an audio check.

The master channel switching unit is located in the rack to the right of the master monitoring unit. This unit shows the operator, at a glance, which studios and channels are in use by means of appropriate signal lights. Normally, with no studio in use, all green lights are lit, indicating that all channels are available for use.

When a technician in a studio operates a push-button switch on his studio channel switching control unit, the green light opposite studio letter and channel number on the *master channel switching unit* goes out and a red light is illuminated. At the same time a red light at the top of the panel under the channel number is illuminated.

Push-button switches are provided in the *master channel switching unit,* which allows a technician in the *equipment room* to take control of the system and release any studio from any channel and likewise to set up any studio to any channel. This refinement is provided for emergency use primarily, affording a means of transferring program from one channel amplifier to another easily in the event of trouble, without disturbing the technician handling a program in a studio.

One of the primary requirements of a modern broadcasting plant is an adequate monitoring system. Means must be provided for making several program sources available in studio control rooms and offices throughout the building.

Two separate monitoring systems are provided. A high level system provides an air check to ten monitor positions in the building, utilizing a monitor amplifier located in the *equipment room,* while a low-level system provides nineteen program sources to nine monitor positions located in executive offices where dial selectors were installed. In these offices the loudspeakers have been provided with individual amplifiers and volume control.

The nineteen program sources fed to the monitor systems are the outputs of the six studios, the outputs of six transmitting amplifiers (or channels), six radio receivers and the NBC network. To isolate the monitor circuits from program circuits, isolation amplifiers have been inserted, which prevent any interaction which might adversely affect the program circuit.

The NBC network line feeds two separate buses, one for making the network available at each studio control consolette, and the other to provide cue circuits. Since there is 10 db difference in the required signal level for these two services, it is desirable to feed on separate circuits. In the event of failure on the regular NBC program circuit to the studio control rooms, a technician may patch his monitor bus to the nemo circuit, in an emergency, providing protection until trouble is cleared. NBC nemo button and key are red for quick identification, and are located in same position[5] in each studio booth.

Recording

Since recording plays a major part in the activities of a broadcast station, we have provided in this new installation recording equipment capable of excellent performance.

Two recording machines[6] are centrally located in the *equipment room*, where they may be operated efficiently and where they may be viewed by visitors through a wide observation window.

One of the eight racks in the *equipment room* contains the elements comprising the complete recording system. This system provides service as two separate recording chains, recording two programs simultaneously, or as a single chain utilizing one recording machine at a time, or both in parallel if necessary. A high degree of flexibility is thus obtained.

The recording system consists basically of program limiting amplifier[7] feeding two amplifiers,[8] which in turn feed the cutting heads[9] on the recording machines.

The recording-control unit located between the recorders houses 16″ and 12″ recording disks in the lower portion. In the top part a monitor speaker is mounted directly in front of the engineer operating recorders. Three switches are provided, one master which starts suction pump and closes power to switches for starting recorders. This arrangement obviates the trouble of engineer starting recording without air suction in operation. Terminal blocks are contained in the bottom of the unit.

Equipment Room

The *equipment room* is 22′ by 28′. Viewing the room from the corridor through the large observation window, a visitor would see on the right side of the room, nearest the window, the eight racks of equipment described heretofore. Directly in front of the

[3]Dalmatron. [4]W. E. 755A. [5]Position 6 on RCA console. [6]Scully

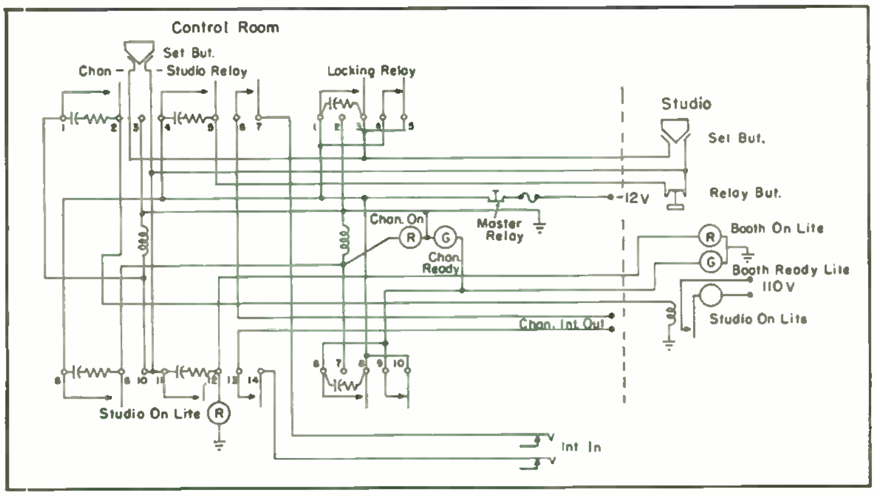


Figure 3
Channel-studio switch layout at WBZ.

window, and about one-third of the distance to the rear of the room, are located the recording machines. To the left in the forefront is a small room utilized for storing recording discs and other accessories. This room also houses the suction equipment for the recording turntables.

In the rear of the room the 10-kw FM transmitter[10] is on the right, and directly across the room on the left side, is the TV transmitter.[11] The television transmitter operating console is directly behind the recording machines.

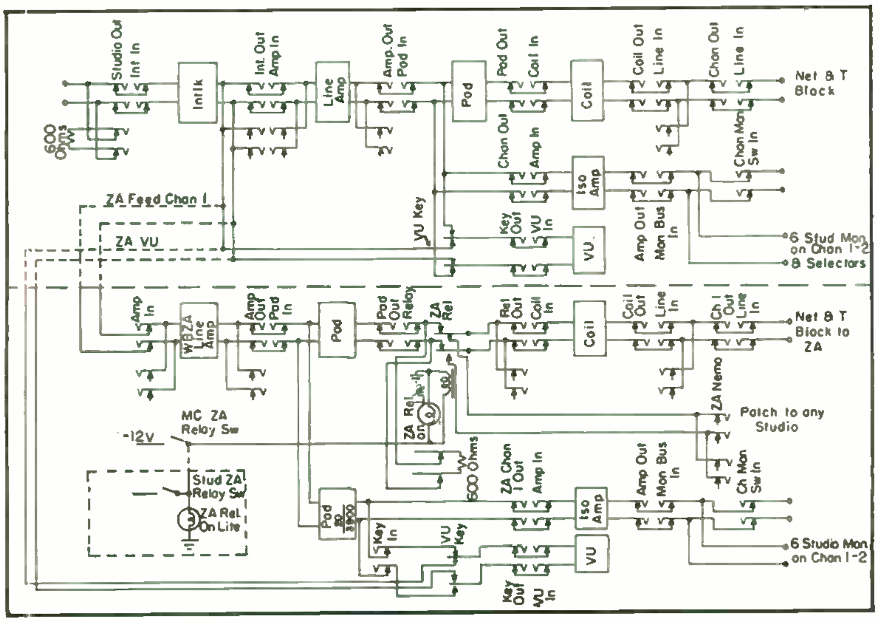
We know that the satisfactory operation of broadcasting equipment depends on proper maintenance, and therefore it seems appropriate to conclude this article with a brief discussion of the facilities available for maintenance.

Directly adjacent to the *equipment room* a shop 24′ by 18′ has been provided to handle both minor and major repairs of the plant. In addition to tools, mobile transmitters and nemo equipment are stored here. Above a work bench is a wall mounting jack cabinet[12] with tie lines to *equipment room* so that test circuits may be set up to check any equipment in the process of repairs and afford rapid communication between all studios, *equipment room*, shop and supervisors and plant managers' offices.

This system was wired up for two talking channels; position *1* ties in all points and position *2* is used for recording. Between studio and recording feeding this method has worked out better than anticipated for cues, feeds, etc.

[7]RCA 86A1. [8]Presto 88A. [9]RCA. [10]Westinghouse FM-10. [11]RCA TT-5. [12]RCA.

Figure 4
Block layout of the 1-6 channel setup; WBZA feed and vu on channel *1* only.



Microwave TV Networks

Concluding Installment With Data on 1900-2100 Mc Relay Equipment, Microwave Tubes, Antenna Systems and Gains, Transmission Line Construction and Applications.

by SAMUEL FREEDMAN

New Developments Engineer
DeMornay-Budd, Inc.

TV LINK systems have also been designed to operate at the lower microwave bands between 1900 and about 2100 mc. In one such setup[1] operation over the 1,990-2,110-mc band is provided with a transmitter which feeds about 50 watts to the antenna.

For remote pickup use the transmitter antenna is a portable 4′ diameter dish with a gain of 320, and receiving antenna is an 8′ diameter dish with a gain of 1,280. Beam angles (to halt power points) are 4.5° for the 8′ and 9° for the 4′ dish.

Transmitter output tube is a QK-174, a *c-w* oscillator magnetron, with provision for direct electronic frequency-modulation.

It is rated to deliver 125 watts maximum output and has a ±10 mc frequency deviation capability with electronic tuning.

Microwave Link Tubes

The tubes used in most microwave communication and relay equipment, now commercially available, are either of the reflex klystron or disk-seal types. The power, in the case of the reflex klystron type is fractional watt, and with the disk-seal tube the power varies from 25 watts on the lowest microwave frequencies to a fractional watt as the frequency reaches 2000 mc.

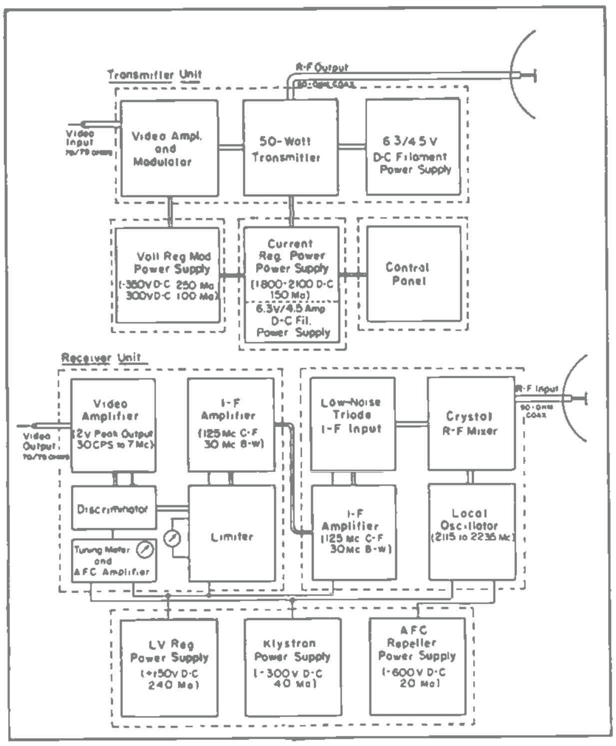
Typical tubes used in existing systems are 2K56 reflex (Bell System 3700-4200 mc), 2K26 reflex (RCA TTR and TRR-1A 6800-7050 mc), SRL17 reflex klystron (Federal 900 mc), 2C43 disk-seal (Federal 2000 mc), 2C39 disk-seal (Philco 1400 mc), and SRL7 reflex klystron (G.E. 2000 mc).

Antenna Gains

The antenna gain in all instances depends on the size of the parabola or dish reflector with respect to the operating wavelength. Typical examples include the metal lens antennas of Bell System (4000 mc), about 10,000 times; 4′ dish at 7000 mc, about 5000 times; 6′ dish at 7000 mc, about 11,500 times; 6′ dish at 900 mc, about 400 times; 10′ dish at 2000 mc, about 4000 times; and 10′ dish at 5000 mc, about 16,000 times.

Identical Two-and-From Dishes

If both transmitting and receiving points have the same reflector provisions, the overall gain for the system will be the above gains, squared. For example, a gain of 400 times at each end is equivalent to raising the power 400 × 400 or 160,000 times. Likewise, a gain of 16,000 times at each end is equivalent to raising the power 16,000 × 16,000 or 256,000,000 times. These gains make up for the low transmitter powers, the use of crystal detector in the receiver, attenuation due to atmospheric absorption of microwave energy, etc.



Block diagram of Raytheon relay equipment. In video amplifier and modulator, designed for 1-volt peak input and 100-volt peak output to a 800-ohm load, for operation from 30 cps to 6.5 mc, are one 6AK5, three 6AG7, one 4D32, and one 6AL5 (dc restorer). A QK174 is used in the transmitter. In the video amplifier of the receiver are three 6AK5 voltage amplifiers, one 6BA6 voltage driver and a 6J6 cathode follower.

Transmission Lines

The transmission lines between the equipment and antennas are coaxial cable in portable applications and for frequencies below about 3000 mc. Above that frequency, waveguide dimensions become convenient and they are invariably preferred for reasons of efficiency. The development of suitable waveguides correct for each system is still expensive since each frequency involves a different size for maximum efficiency. It also involves components of the most precise design if the efficiency is to be maintained over the entire wide band required for television. Bell Labs are using waveguide components checked with swept oscillators for a voltage standing-wave-ratio not exceeding about 1.012 as compared to 1.05 for standard precision plumbing.

[1] Raytheon RTR-1A.

Cavity Resonators As Filters At VHF

Cavity Resonator Filters Found to Provide Increased Selectivity and Solve Problems of Interaction and Jamming, Particularly in Relay Transmission Work in VHF Mobile and Point-to-Point Radiotelephone Communication Systems. Filters Also Found to Permit Operation of Several Transmitters or Receivers on the Same Antenna.

by H. W. JADERHOLM

Development Engineer
Canadian Marconi Company

Due to the mushroom growth of services using *vhf* equipment for mobile and point-to-point communication, interference between stations is increasing so rapidly as to cause alarm to many.

The interferences are heard as undesired whistles and unexpected signals which destroy the desired message. These gremlins have been labelled spurious responses, which together with their nefarious partner, spurious radiations, have until recently been the bug-bear of radio installation engineers.

The interfering signals from other transmitters can originate on either adjacent or remote frequency channels. FM transmitters usually contain several stages of frequency multiplication which may emit intermediate frequencies. Furthermore, signals in the lower *vhf* region are sporadically favored by enormous skip-distance propagation which causes interference with local communication systems from distant transmitters. This effect is aggravated by the allocation of identical operating frequencies in different regions.

To combat these responses technical improvements in transmitters and receivers are imperative. A quick cure can sometimes be effected by a slight change to the oscillator frequency and a corresponding detuning of the *if* amplifier. If the trouble is of the spurious radiation type the multiplication factor of the transmitter may be changed to eliminate the objectionable emission. These methods have been used successfully.

However, the long term answer to the growing problem of interference is the elimination of all spurious radiations from the transmitter and the provision of considerably greater selectivity in the receiver.

Use of Cavity Resonators

Cavity resonators with their high efficiency provide a convenient method of obtaining greater selectivity. Their characteristic efficiency results mainly from the fact that the oscillating energy is confined to the inside of a metal container, thereby eliminating radiation losses. The remaining (eddy current) losses in the walls can be minimized if the ratio of cavity volume to inner surface is made as large as possible. For high Q the cavity diameter should be large.

The cavities employed at *vhf* are usually of the *hybrid* variety, where the cavity is a section of coaxial transmission line, shorted at one end. The length of the inner conductor determines the operating frequency, being nearly a ¼ wavelength. It is also necessary to allow for an end correction due to the diameter of inner conductor.

Coupling to Cavity Filter

An electromagnetic field, as shown in Figure 1, is excited in the cavity by a coupling loop. The magnetic lines circle the central conductor and are concentrated at the short circuited bottom. The electric lines start on the inner conductor and terminate on inside of outer conductor. They have the greatest concentration at the open end of the cavity.

When the cavity is used as a filter, energy is usually fed into it through a coupling loop and extracted from it through another loop, diametrically opposite. As in coupling systems using coils, the cavity is loaded by the loops coupling it to external circuits. As the coupling is increased the loaded Q of the cavity is reduced. With tighter coupling it is thus possible to pass more energy through the cavity. Figure 2 shows the Q of the cavity as a function of coupling.

Application of Cavities in the Field

Some two years ago, a point-to-point radiotelephone system,[1] with which we were concerned, was suffer-

Figure 1
How the electromagnetic field is excited in the cavity by a coupling loop, the solid lines indicating a magnetic field and the dotted lines the electric field. In the analogy shown here, a vibrating quarter-wave rod has been clamped at one end.

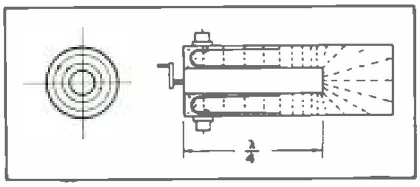


Figure 2
The Q of the cavity as a function of coupling. Curve *a* illustrates the coupled Q of a cavity resonator, while curve *b* illustrates the insertion loss of a cavity resonator.

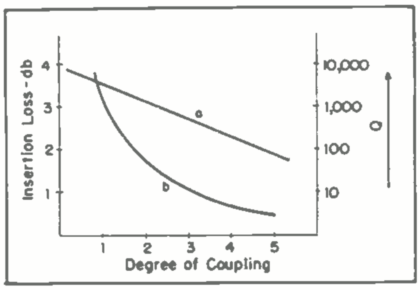
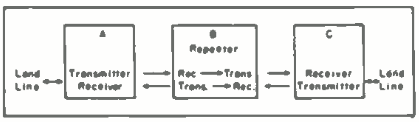


Figure 3
Typical cavity installation.



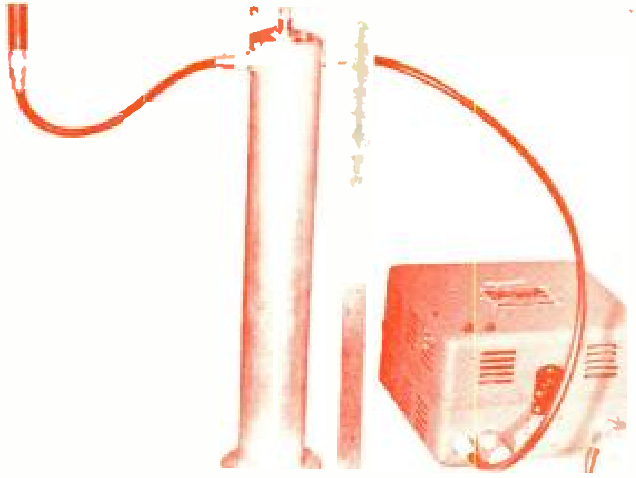


Figure 4
A view of the cavity coupled to a receiver.

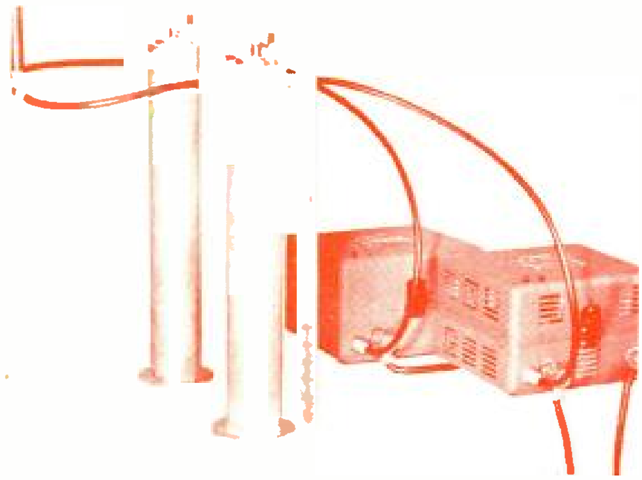


Figure 5
A pair of transmitter-receivers, operating press-to-talk on the same antenna at two frequencies within a few megacycles of each other, cavities operating in the 152-162 mc region.

ing from severe interference both from external sources and from spurious transmission and reception.

This communications and telephone circuit had been installed to operate in lieu of a land-line, which was out of the question due to the impossible terrain. The main transmission path extends over 160 miles of water with a repeater station located on an island joining two links of 80 miles each. The repeater station was designed for automatic carrier control and to be capable of 24 hours unattended service, all stations to operate fully *duplex*.

After this system had been in operation for some time it was found that long distance interference, due to press and code stations, produced objectionable audible signals in the radiotelephone circuits. Over the 160 mile path, in the more easterly portion, interference was more pronounced.

It was also observed that these undesired signals entered by way of the antenna. Consequently additional selectivity was essential to prevent desensitizing of the receiver caused by the close proximity of the transmitter and receiver antennas.

Various types of wave traps and suppression devices were tried at first, but it was soon found that lumped constant type networks did not provide sufficient selectivity.

The need being acute, the cry for more selectivity was heard in Montreal. Several cavity resonators were designed and sent to the east coast.

Two cavities were installed at repeater point *B* (Figure 3) in each of the receiver antenna circuits, where severe destruction of signals from both sides had been observed. With the cavities the duplexing problems were solved and re-transmissions were no longer subject to the knock-down effects due to the adjacent transmitter.

[1] System was established shortly after the end of hostilities along the Atlantic coast by the Canadian Marconi Company.

Figure 4 illustrates the use of a cavity to protect a receiver, inserted in the line between the antenna and the receiver antenna terminal. In this case, the cavity is equivalent to a series acceptor circuit which will pass the desired signal with only a slight loss in signal strength, but at the same time sharply attenuates all unwanted signals.

Cavity Filtering

The filtering properties of the cavity are purchased at the cost of a small transmission loss. If the interference is near the operating frequency, the cavity Q must be high and consequently the cavity losses will be higher.

If the frequency separation of the transmitter and receiver is several per cent of the operating frequencies, a lower Q cavity can be used with smaller losses in the pass-channel.

Figure 5 shows two transmitter receivers, operating press-to-talk, on the same antenna at two frequencies within a few megacycles of each other, with cavities designed for the 152-162 mc range. Where a cavity is used to prevent spurious radiation from a transmitter only, the insertion loss may be reduced if the cavity is placed in the ouput circuit before the final power amplifier.

Figure 6 is a close-up of a 74-mc cavity resonator. The plate, shown at the lower left, has been removed from the window to show the inner conductor. The coupling loop and coaxial connector used to excite the cavity are attached to this plate. Another part is located diametrically opposite. The length of the inner conductor is adjusted by the crank shown at the left providing the tuning adjustment with a much needed vernier effect.

Advantages of Cavities

From the foregoing it may be seen that cavity resonators which are a *must* in the *uhf* range, are very helpful at *vhf* also. In addition to their uses to protect receivers from adjacent or remote transmissions and to prevent spurious radiations from being emitted by transmitters, they may also be used to operate several transmitters or receivers on the same antenna.

Figure 6
A 74-mc cavity reasonator. The plate at left, removed from window to show inner conductor, is connected to the coupled loop and coax connector to excite the cavity.

VETERAN WIRELESS OPERATORS ASSOCIATION NEWS

Personals

OLDTIMER FRED McDERMOTT reported at the recent Fall Meeting that he began his key clicking days way back in 1911 with the Navy and spent eighteen consecutive years with the boys of blue. In 1940 he rejoined the ranks and remained with the U. S. boys until 1945, when he retired as chief radio electrician. At present he is with the A.T.&T. in the program transmission and television department. . . . Veteran A. Barbalate told those at the meeting that he started with United Wireless at Seagate (WSE) in 1912 and remained at that post until 1917. Then he went on to the U. S. Navy and was located at New London, then East Moriches and finally Easthampton. He opened the Mackay station at Southampton, Long Island, after his stay with the Navy and in 1935 joined RCA Communications. At present he's at the RCAC offices at 66 Broad Street, New York City. . . . Peter Podell says he would like to hear from Hal Styles and Bill Payne of Los Angeles, since he is planning a trip out there and would like a bit of travel guidance. . . . Quite an interesting bit of background information was supplied by E. N. Pickerill at the Fall Meeting. ENP told us that he started his wireless days with Doc DeForest in 1904, and remained with him until '07. Then he went over to the United Wireless Telegraph Company and pounded brass for that outfit for five years. A seven-year stay with American Marconi followed and in 1919 he joined the ranks of RCA, where he has been ever since. We learned that ENP operated a two-way system aboard the world's first radio-equipped plane on August 4, 1910 over Long Island, communicating with a portable ground station. . . . From oldtimer A. T. Rehbein we have learned that his operating days began in 1911 with the United Wireless Telegraph Company, which a year later was absorbed by the Marconi Wireless Telegraph Company of America. In 1914 he joined the Panama Railroad Steamship Line. At the outbreak of World War I he became an operator for the American Hawaiian Steamship Company and remained with them for four years. After the AHSC lines became a part of the United American Lines, he joined them once again and in 1921 was appointed assistant radio supervisor, a post he held until 1923. After dabbling around auto electrical work for several years he once again joined the AHSC lines and is now Atlantic Radio Supervisor with the company. . . . Ye secretary Bill Simon reported that during the past few months he has completed a modernization program involving the United Fruit Company's entire fleet radio equipment. New receiving and transmitting equipment were installed. Bill also said that the United Fruit radar installation program is well under way now. . . . We have just learned that Captain Fred Muller, who is on the VWOA board of directors, is in the Naval Hospital, St. Albans, Long Island, and fortunately is on the way to recovery. . . . Assistant secretary Henry T. Hayden, Jr., also is hospitalized and is in the Veterans Hospital, in the Bronx, N. Y. City. We're happy to report that HTH is also recovering.

New Ship Radio Officer Law

WITH THE PASSAGE of Public Law 525 by the 80th Congress and approved May 12, 1948, all sea-going operators become *Ship Radio Officers*. The law, which becomes effective April 1, 1949, states that no radio operators will be signed on Ship's Articles even though he possesses an FCC license unless he has also met all requirements of the U. S. Coast Guard. The Coast Guard will examine *Sparks* under new regulations now being prepared to be known as Subpart 10.13, entitled *Licensing of Radio Officers* under "Rules and Regulations for Licensing and Certificating of Merchant Marine Personnel."

At the recent VWOA Fall Meeting held in New York City: W. C. Simon. Paul K. Trautwein, R. H. Pheysey. W. J. McGonigle, J. T. Maloney, A. F. Rehbeim, V. Villandre, Sam Schneider, J. J. Michaels, Captain Fred Muller, Lt. Comdr. R. L. Fischer, J. Flood, J. F. Rigby, R. K. Davis, G. N. Mathers, L. C. Brown, R. J. Iversen, E. N. Pickerill, Peter Podell, Ben Beckerman, C. D. Guthrie, H. T. Hayden, Jr., A. Barbalate, Clarence Seid, Kenneth Richardson, Herman H. Parker, F. McDermott, A. C. Tamburino, George H. Clark, Donald McNicol, Charles Cooke, Edward Ballentine, F. Orth, Roscoe Kent, Eric L. Bisbie and Joseph L. Sarick.

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TUBE Engineering News

Miniature and Proximity-Fuze Type Tubes in Hearing-Aid Type Receiver and Miniature Transmitter Designed for Coaching. Tetrodes in Single Sideband Transmission and In Class C FM and AM Applications.

MINIATURE HF receiver-transmitter units have become quite popular in broadcast and other remote type field work.

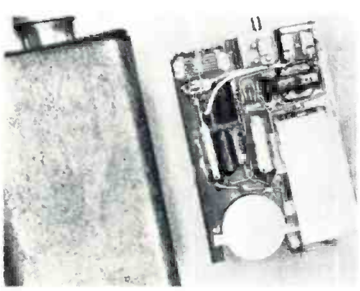
A unique application of this form of equipment was demonstrated recently by Charles Lundgren,[1] who developed a 1-watt 27.255-mc unidirectional *rf* setup.

The equipment, which operated under the station call of W10XVD, has a 1L4 crystal oscillator, 1L4 tripler, 1L4 final amplifier, and a 1L4 modulator. The unit is powered from two 67.5-volt *B* batteries connected in series and a 1.5 volt *A* battery.

A telescopic antenna closes flush with the case. No tuning is required, it only being necessary to depress the mike switch for push-to-talk operation. In conjunction with the receiver, the range of the signal was about ½ mile radius.

The uniqueness of the system lies in the receiver, which is housed in a leather-covered aluminum case about the size of a tobacco can and is fastened to a leather belt; the antenna is built within this belt. The receiver is worn on the small of the back and thus renders the wearer complete freedom of movement. Attached is a hearing aid phone which directs the sound to the wearer's ear. Three proximity type tubes are employed, and the unit is self contained and powered from a small 30-volt *B* battery and a small *A* cell.

Rear view of the receiver used in the electronic director.



Single Sideband and Tetrodes*

THE INTEREST in single side-band transmission has accented the possibilities of the tetrode application in this service.

For instance, the 4-65A[1] may be operated as a class *B* linear amplifier in *sssc* operation and peak power inputs of over 300 watts may be obtained. This is made possible by the intermittent nature of the voice. If steady audio sine wave modulation is used, the single sideband will be continuous and the stage will operate as a *cw* class-*B* amplifier. With voice modulation the average power will run on the order of 1/5th of this continuous power.

Due to the widely varying nature of the load imposed on the power supplies by *sssc* operation, it is essential that particular attention be given to obtaining good regulation in these supplies. The bias supply, especially, should have excellent regulation, and the addition of a heavy bleeder to keep the supply well loaded will be found helpful.

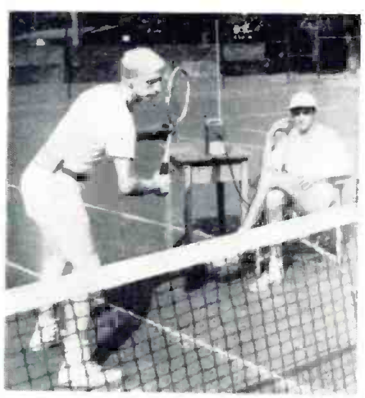
Under conditions of zero speech signal, the operating bias should be adjusted so as to give a plate dissipation of 50 watts at the desired plate and screen voltages. Due to the intermittent nature of voice, the average plate dissipation will rise only slightly under full speech modulation to ap-

[1]Developed at Johanson Manufacturing Corp.

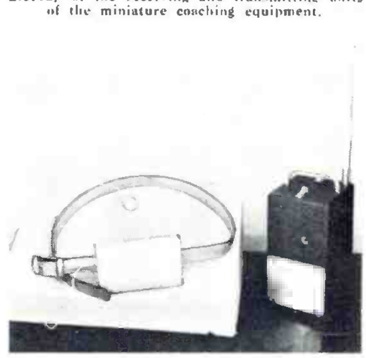
[1]Eimac. Radiation cooled tetrode, with a maximum plate dissipation rating of 65 watts.

*Based on copyrighted data supplied by Eitel-McCullough, Inc.

Charles G. Lundgren with his miniature transmitter and receiver development.



Closeup of the receiving and transmitting units of the miniature coaching equipment.



proximately 65 watts. At the same time, however, the peak speech power output of over 300 watts will be obtained.

SSSC Tuning Procedure

Tuning the *sssc* transmitter is best accomplished with the aid of an *af* oscillator and a 'scope. The audio oscillator should be capable of delivering a sine wave output of a frequency of around 800 to 1,000 cycles so that the frequency will be somewhere near the middle of the pass-band of the audio system. Since successful operation of the class-*B* stage depends on good linearity and the capability of delivering full power at highest audio levels, the final tuning should be made under conditions simulating peak modulation conditions. If a continuous sine wave from the audio oscillator is used for tuning purposes, the average power at full modulation would be about five times that of speech under similar conditions of single sideband operation and the final amplifier would be subjected to a heavy overload. One method of lowering the duty cycle of the audio oscillator to closer approximate speech conditions would be to modulate the oscillator with a low frequency.

An alternate method would be to use the continuous audio sine wave, making all adjustments at half voltages and half currents on the screen and plate, thus reducing the power to one quarter. The stand-by plate dissipation under these conditions should be set at about 10 watts. Following these adjustments, minor adjustments at full voltages and 50 watts of stand-by plate dissipation could then be made, but only allowing the full power to remain on for ten or fifteen-second intervals.

The first step is to loosely couple the 'scope to the output of the exciter unit. The final amplifier with its filament and bias voltages turned on should also be coupled to the exciter at this time. With the audio oscillator running, the exciter unit will have to be adjusted so that it delivers double sideband signals. Using a linear sweep on the 'scope, the double-sideband pattern will appear on the screen the same as that obtained from a 100% sine-wave modulated AM signal. The audio gain control should then be varied so that the exciter can be checked for linearity. When the peaks of the envelope start to flatten out, the upper limit of the exciter output will have been reached and the maximum gain setting should be noted. The coupling to the stage should be varied during this process and a point of optimum coupling determined by watching the 'scope pattern and the grid meter in the final stage.

Then the exciter can be adjusted for single sideband operation and if it is working properly, the pattern on the 'scope will resemble an unmodulated AM carrier. The phasing controls should be adjusted so as to make the envelope as smooth on the top and bottom as possible. If the above conditions are satisfied, the exciter unit can be assumed to be operating satisfactorily.

The 'scope link can then be loosely coupled to the output of the final amplifier and the exciter unit adjusted to give double sideband output.

4-65A FM and AM Applications

The 4-65A may be operated as a class-*C* FM or telegraph amplifier without neutralization up to 110 mc, if reasonable precautions are taken to prevent coupling between input and output circuits external to the tube. In single-ended circuits, plate, grid, filament and screen bypass capacitors must be returned through the shortest possible leads to the common chassis point. In push-pull applications the filament and screen terminals of each tube should be bypassed to a common chassis point by the shortest possible leads, and short, heavy leads used to interconnect the screens and filaments of the two tubes. Care must be taken to prevent leakage of *rf* energy to leads entering the amplifier, to minimize grid-plate coupling between these leads external to the amplifier.

Where shielding is adequate, the feedback at frequencies above 110 mc

(*Continued on page 36*)

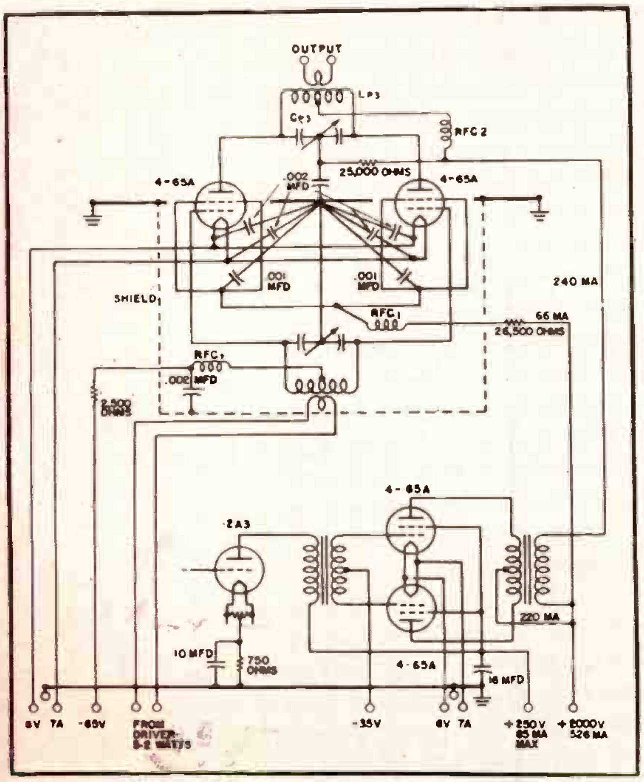
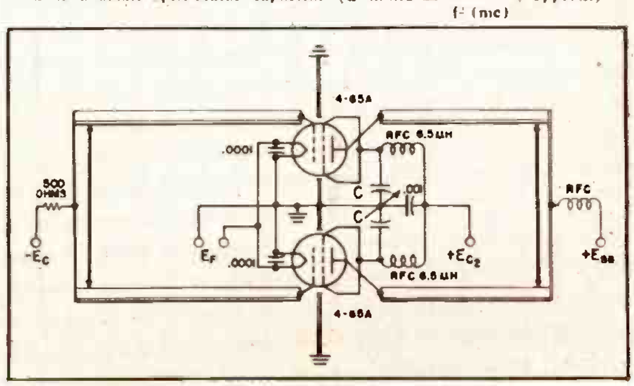


Figure 2
Typical high-level-modulated *rf* amplifier circuit with modulator and driver stages; 480 watts plate input. In this circuit L_{p3} and C_{p3} represent the tank circuit appropriate for the operating frequency where the *Q* equals *12* and the capacitor plate spacing equals .375". The .002-mfd capacitor in the output circuit is a 5,000-*v* mica type, while the .002-mfd capacitors in the filament circuits of the tube and in the RFC₁ circuit are 500-*v* mica types. The .001-mfd capacitors are 2,500-*v* mica types. The 16-mfd capacitor is a 450-*v* electrolytic type, and the 10-mfd capacitor is a 100-*v* electrolytic. The 26,500-ohm resistor is actually a 30,000-ohm adjustable carrying 200 watts. The 750 and 2,500-ohm resistors are each of 5 watt capacity. The 25,000-ohm resistor in the balanced output circuit is a 2-watt unit. The RFC₁ chokes are 2.5 mhy, 125-ma types and RFC₂ is a 1-mhy 500-ma unit. The driver transformer is a 5-watt type. The modulation transformer is a 300-watt unit: impedance ratio primary to secondary approximately 2.4:1. Primary impedance, 20,000 ohms; secondary impedance, 8,333 ohms.

Figure 1
Screen-tuning neutralization circuit for use above 100 mc, where *C* is a small split-stator capacitor ($C \text{ mmfd} = \frac{640{,}000}{f^2 \text{ (mc)}}$, approx.)



Commercial Single Sideband Radiotelephone Systems

by F. A. POLKINGHORN

Engineer, Transmission Development Dept.
Bell Telephone Laboratories, Inc.

The keen interest that has been shown recently both in professional and amateur circles in the single-sideband method of radio transmission has focused attention on the early developments in this field including the choice of means for generating and receiving the signals. The present interest no doubt stems from the splendid service which these systems gave during the war and from the reports of the numerous men who became acquainted with them, coupled with a better appreciation, since the 1947 International Radio Conference in Atlantic City, of the possibilities of single sideband in increasing the potential number of channels which can be crowded into the spectrum.

New Developments

Considerable impetus to the widespread use of single-sideband systems can reasonably be expected to result from the development of such complete low-power, single-sideband radiotelephone systems as the *LE* system. This apparatus was specially designed by Bell Telephone Laboratories for point-to-point medium-distance applications.

Carson's Pioneering Work

The single-sideband method of transmission was born in the mind of John R. Carson by pure analysis as a result of his mathematical investigations of the operation of vacuum tubes.[1] Almost simultaneously H. D. Arnold discovered the possibility in connection with tests of the Arlington transmitter in 1915. For a considerable period thereafter the physical reality of sidebands was vigorously argued by some engineers.

Experiments of Thirty Years Ago

The single-sideband method of transmission has been standard in Bell System carrier telephone equipment for nearly three decades.[2] The first published mention of the use of single sideband for radiotelephony, however, seems to have been made by Espenschied in 1922.[3] About 1922 an experimental single-sideband radio system was set up with a transmitter operating at about 60 kc located at Rocky Point, Long Island,[4] and publicly demonstrated on Jan. 5, 1923. This system was put into commercial service between New York and London in 1927 and is still in operation, being, as far as is known, the first single-sideband radio system to be used commercially. The large size of the antenna structure required for efficient radiation at such a low frequency made it difficult to obtain a broad

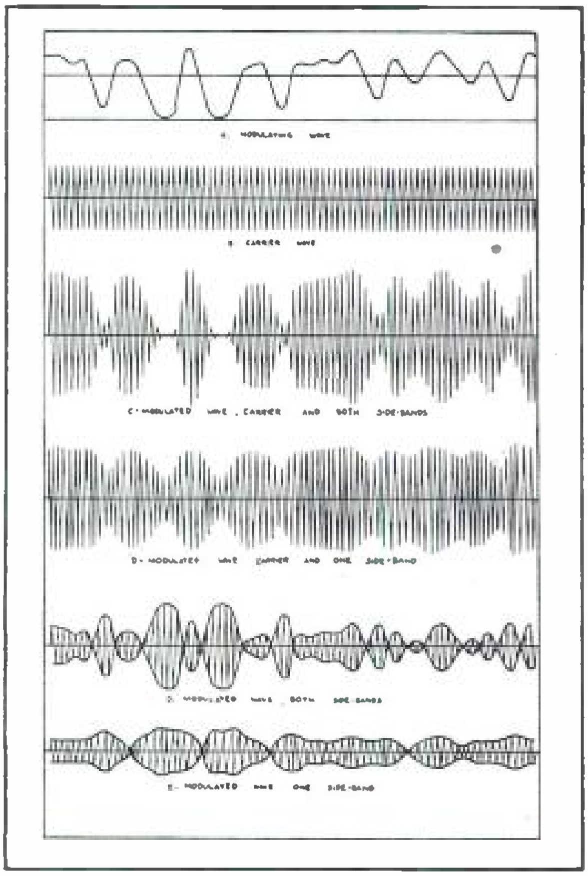
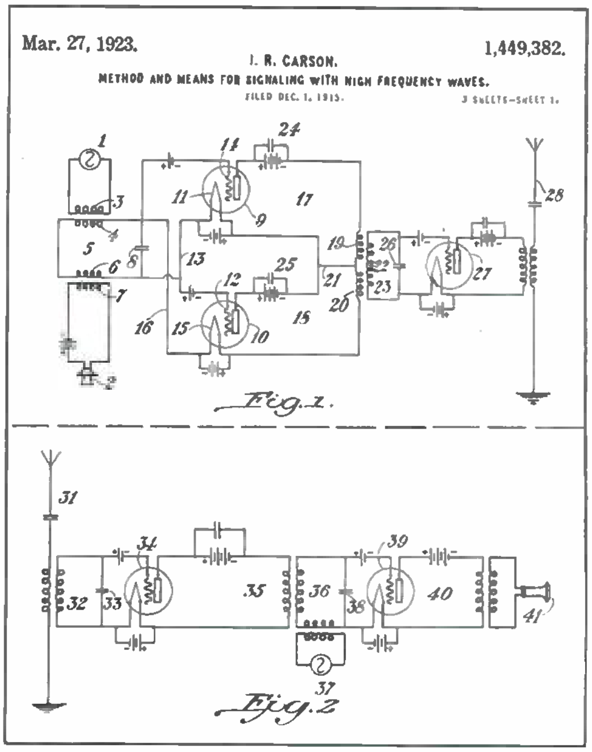


Figure 2
Carrier modulated by speech waves: at bottom, single-sideband pattern. (*Taken from the paper on carrier by Colpitts and Blackwell, A.I.E.E.; 1921.*

Figure 1
Portion of one of John R. Carson's original patents showing application of the combination of balanced modulation for suppressing the carrier, and output filter for stripping off one sideband.



enough band for a good telephone channel and the use of single sideband made the problem much simpler by permitting the required band to be halved. Efficient operation of the system was imperative since a power of 150 kw or more was involved.

The early Bell System work on high frequencies (it was short waves in those days) wash done in the 1920's on double sideband but it was not long before the theoretical advantages of single sideband resulted in experiments with the same arrangement of suppressed carrier and hand-synchronized receiver which has recently been taken up by the amateurs. This work was done by Raymond A. Heising, who, in 1915, worked on the Arlington transmitter, the forerunner of all modern radiotelephony, and who invented the constant current system of modulation now so widely used.

The hand adjustment of the heterodyne frequency was not very practical however, and a few years elapsed before active work on the commercialization of single-sideband radiotelephony was taken up in earnest. In those years, the high-frequency double-sideband circuits were put in operation to many parts of the world and ship-to-shore telephony became a permanent commercial service.

In the late 1920's an unusual receiver was constructed at the Bell Laboratories with which to investigate the characteristics of single-sideband reception. This receiver occupied seven bays and used the first crystal filters to go in equipment of this kind. It was capable of receiving double-sideband transmissions and separating the sidebands and carrier for experimental purposes. Reconditioned and local carrier and automatic frequency control were provided so that it was possible to simulate almost any kind of reception. The results obtained with this receiver were in accordance with expectations and consequently designs for a single-sideband transmitter and a receiver for a transoceanic trial were initiated. Upon the completion of the transmitter it was taken to England and, in cooperation with the British Post Office, set up in their transoceanic transmitting station at Rugby. There followed extensive tests which confirmed that the theoretical advantages could be achieved in practice.[5, 6]

Comparisons with double-sideband transmissions were made on a basis of signal-to-noise ratio, articulation, and judgment tests. The articulation tests consisted of transmitting meaningless syllables and determining the errors in interpretation by a number

Single Sideband Systems, Which Have Had an Unusually Interesting Developmental History Since 1915, When the Method Was Used in a Transmitter at Arlington by H. D. Arnold, Now Being Applied To Solve Many Current Transmission Problems. One Procedure, Designed for Point-To-Point Work in the 3.4 to 25 and 2.7 to 14 mc Bands, Provides 200 Watts Peak Envelope Power, With Ranges of 200 to 2500 Miles.

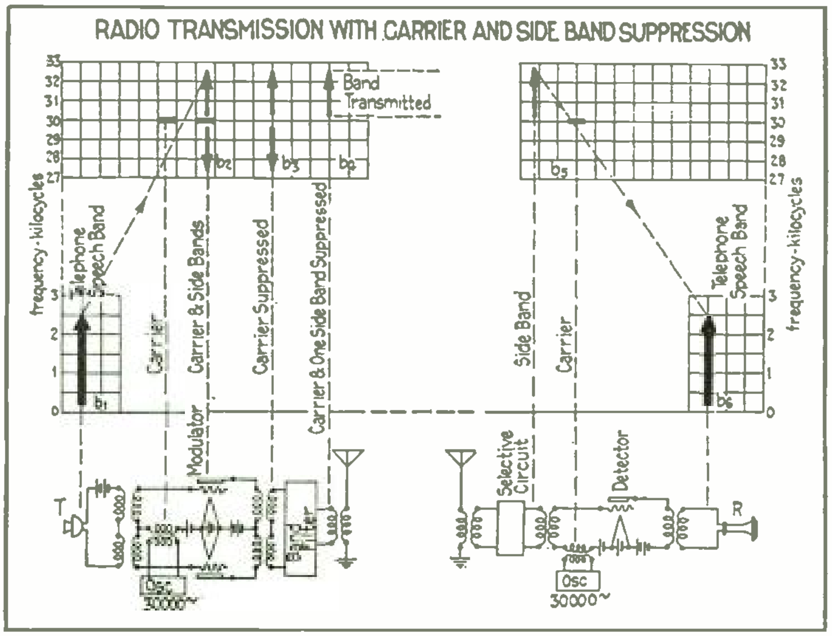
of observers. After making corrections for differences in bandwidth, the signal-to-noise improvement checked the theoretical 9 db very closely. The number of articulation errors obtained also showed that the field strength of a double-sideband signal had to be 8 or 9 db stronger than a single-sideband signal in order to get equivalent results. Finally, judgment, or so-called circuit merit, tests gave approximately the same results.

The original equipment was put into commercial operation and in '36 redesigns were started for commercial production.[7, 8, 9, 10] In the following decade over 50 single-sideband circuits were set up in all parts of the world using this equipment.

During World War II the single-sideband equipment did particularly valuable service in connecting continental United States with the armed forces all over the globe. Multi-channel teletype using two-tone operation with frequency diversity (4 tones total) was used in most cases with speech channels for special purposes.

The first commercial single-sideband equipment provided only a single speech channel, but it was soon determined that two channels could be obtained almost as easily as one by using two low-power modulators to place one channel on one side of the carrier and another on the other side of the carrier. Somewhat better performance was obtained by spreading one channel from the carrier so that modulation products generated by one channel would put less noise or crosstalk into the other. During the war years and shortly thereafter the need for more radiotelephone circuits caused

Figure 3
Early illustration of single-sideband transmission applied to radio, showing derivation of single band, and at receiver the reintroduction of the carrier.[3]



both channels to be spread from the carrier and a third divided the two sidebands; thus permitting three separate simultaneous conversations over the same equipment.

The 9-db transmission advantage of single sideband as compared with double sideband is explained entirely on the basis of amplitudes. It is assumed that the same *rf* power amplifier is used and the peak driving voltage is the same. This results in approximately the same distortion. Since the carrier represents half the peak amplitude of a fully modulated double-sideband transmission, reducing this to a negligible value permits doubling the amplitude of the sideband, an improvement of 6 db. The other 3 db comes from the reduction in noise at the receiver by reducing the received band to one-half, permitted by the elimination of one sideband at the transmitter.

In the commercial operation of single-sideband circuits the carrier is normally transmitted 26 db below the envelope peak amplitude. This permits the automatic tuning of the receiver, so that the receiver may remain in service hour after hour with little or no attention from the receiving-station operator, who may have a dozen or more receivers under his care. The reduced carrier is separated from the sidebands by a crystal filter which is only about 40 cycles wide. This filter reduces the noise to a point where automatic frequency control and automatic volume control can be obtained at as low signal strengths as the speech circuit remains commercial.

The *afc* device of the W. E. receiver* is frequency operated, i.e., it is operated by a beat note between the carrier at the final intermediate frequency and a local crystal oscillator. This beat frequency drives a motor connected to the beating oscillator frequency adjustment, either forward or backward, depending upon whether the carrier is too high or too low in frequency, until frequency of the beat note is reduced to zero. This system has the advantages that it is accurate, not sensitive to amplitude, and the absence of a carrier for a short period need not cause the oscillator frequency to move in one direction or the other.

Commercial single-sideband receivers are generally arranged so that either a carrier from a local oscillator or the transmitted carrier may be used for the final demodulation. Using the transmitted carrier has the advantage of insuring the proper frequency relationship between carrier and sideband, but requires an effective rapid-acting volume control or limiter to insure a constant amplitude of carrier. Using a local carrier insures an adequate amplitude at all times but requires a good *afc* system. Receivers can be built in which no difference can be detected between the two methods of demodulation.

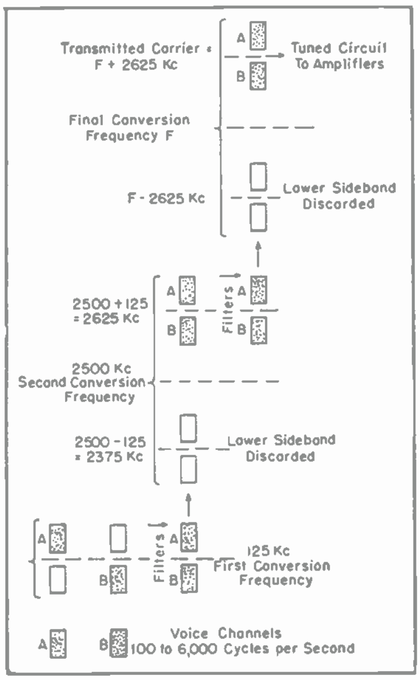
A single-sideband signal is generated by modulating a carrier with a sideband to produce a double-sideband signal and then either shaving off one sideband by a sharp filter or balancing out one sideband in a double modulator arrangement in which the carrier and sideband to one modulator are both shifted by 90°.

The basic idea of the balancing scheme was invented by R. V. L. Hartley** in 1928.[11] To this R. K. Potter** added the idea of obtaining separate speech channels on the two sides of the carrier[12] and E. I. Green** suggested the use for separating the two sidebands at the receiver.[13] Recently several companies have either used these methods or indicated their intention of doing so. The system is well suited for certain purposes. The suppression of the unwanted sideband depends upon phase and amplitude balances and may not be adequate for all purposes.

The telephone transmitters and receivers have used crystal filters for the purpose of eliminating the undesired sideband and interfering signals to a high degree. Crystal filters permit obtaining the desired selectivity

Figure 4.

Application of single-sideband to short-wave transoceanic radiotelephony, showing the manner of deriving two independent speech channels, each occupying one of the sideband positions with respect to the high-frequency suppressed carrier. (From *A Twin-Channel Single-Sideband Radio Transmitter* by K. L. King, Bell Laboratories Record; March 1941).



at frequencies as high as 100 to 125 kc or more. With crystal filters operating at these frequencies only one intermediate modulation is required, generally operating around 2,800 kc. Crystal filters have the same advantage when used in single-sideband receivers. Even at 100 kc the filters may give 80 or 90 db attenuation at the end of the first 1,000 cycles outside the transmitted band.

The Bell System was not alone in recognizing the merits of single-sideband radiotelephony. The British Post Office worked hand-in-hand in establishing the North Atlantic circuits. Among those who made important contributions, A. H. Reeves of International Standard Electric did some major pioneer work.[14] The Dutch were pioneer workers in the field and established a circuit between Holland and the Dutch East Indies at an early date.[15] The Japanese and Germans also constructed equipments.

At the present time a large proportion of the overseas telephone services operating from the United States use single-sideband equipment and the number of circuits is increasing yearly. With the production of simpler and cheaper equipment, it is expected that many of the services still using double-sideband transmission will be converted to single-sideband.

Typical of the modern trend to simpler, less expensive equipment is the *LE* system previously mentioned. This system was specifically designed to make available the important advantages of single-sideband techniques in an economical form for use in point-to-point radiotelephone services. It provides complete radio transmitting and receiving facilities, including the new *synchro-switched* speech privacy equipment which is built directly into the circuits of the radio units.

In addition to the transmitter and receiver, a versatile manually-operated telephone-control terminal is available as a part of the *LE* system. This control terminal includes all necessary control apparatus for connecting the transmitter and receiver to a conventional telephone system. Where a semi-automatic control terminal is desired to relieve the operator of constant monitoring during calls, a suitable control terminal may be substituted.

The *LE* system transmitter delivers 200 watts peak-envelop power and is ideally suited to the following applications:

(*1*) Satellite feeder circuits from remote points to higher pow-

* Model D-99945.
** Bell Labs.

ered transoceanic radiotelephone stations,

(2) Radio circuit extension of telephone land lines, and

(3) Intercity or point-to-point radiotelephone circuits.

The ranges which can be covered by the *LE* System depend, as with all *hf* radio systems, on a number of factors which affect the signal-to-noise ratio. Atmosphere static varies with frequency, geographical location, season, and time of day. The radio fields received in sky-wave transmission depend upon power, antenna characteristics, frequency, distance, geographical region, direction of path, and ionosphere conditions.

Representative figures for the *LE* service ranges, with suitable antennas and appropriate frequencies, are estimated to be: In the tropics, night ranges up to 200-600 miles, day ranges up to 700-2,000 miles; in temperate latitudes, night ranges up to 400-1,000 miles, day ranges up to 1,000-2,500 miles.

The transmitter and receiver of the system can be furnished for operation in either the frequency range from 3.4 to 25 mc or from 2.7 to 14 mc.

The transmitter and receiver are designed to permit the selection of any one of ten crystal-controlled preselected frequencies.

In making a change from one to another frequency, the operator is guided by a *control-position indicator* which provides information for setting all controls for any of the ten preselected frequencies. The indicator is located at eye level on the front panel of both transmitter and receiver. When rotated to the chosen frequency, the necessary control settings pertaining only to that frequency are shown on a dial. A change in operating frequency is then accomplished by use of selector switches and tuning controls readily accessible on the front panel of each cabinet. The time required to make a frequency change is about three minutes.

The *rf* emission consists of *(a)* two pilot frequencies which are spaced 3,625 cycles apart, and *(b)* signal frequencies radiated between these two pilot frequencies in a band 3,000 cycles wide. The signal frequencies correspond to voice frequencies in the band 250-3,250 cycles.

The system provides an electronic privacy equipment of the *synchro-switched* type which will prevent a casual listener from eavesdropping. It is obtained by alternately transmitting one or the other of the two pilot frequencies in inverted relation to the signal, and is directly incorporated in the circuits of the transmitter and receiver. This switching feature can be turned off for testing purposes or to permit transmission of a normal or inverted sideband.

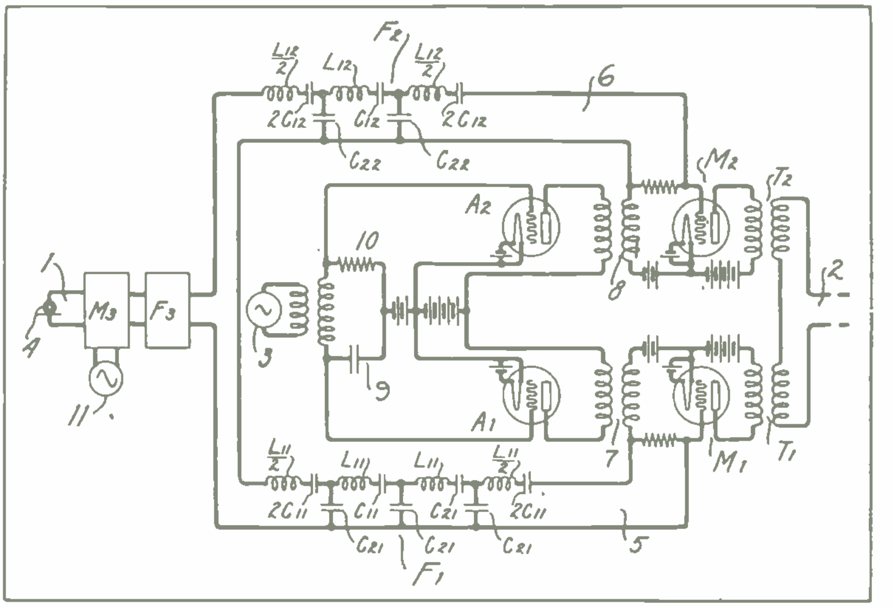


Figure 5

Circuit diagram illustrating another method of deriving single-sideband, which was invented by R. V. L. Hartley in 1928. This method uses a double modulator arrangement and balances out one sideband instead of eliminating it by filter. This method was later further developed by R. K. Potter and E. I. Green. (*Figure from Hartley patent No. 1,666,206.*)

Special attention has been given to providing unusually complete testing and metering facilities, which have been built directly into both the transmitter and receiver, providing observation of operating conditions in the vacuum tube circuits. An alarm circuit is also provided in the receiver to indicate loss of signal, and relay contacts are available to permit extension of this alarm to remote positions.

The receiver is a triple detection receiver having a crystal-controlled first beating oscillator and automatic frequency control acting on the second beating oscillator. The first *if* operates at about 2,800 kc, and the second *if* at about 100 kc. A crystal filter at the second *if* is used to obtain high selectivity and high fidelity in the band. Both *avc* and *afc* operate from both pilots, thus taking advantage of the frequency diversity to obtain improved performance. The alternate transmission of the pilots is used to synchronize the privacy switching.

The control terminal has been specificially designed to achieve the full transmission capabilities of the radiotelephone links, in addition to the effective handling of telephone traffic. The adjustment of received volume which, until the new model*** has been the most difficult of manual adjustments, is now effected by mechanical coupling to the other controls so that it does not require any attention. Built-in transmission testing equipment essential to maintaining the terminal at peak efficiency is provided.

For maximum transmission results, the highly directional rhombic-type antenna can be used for longer transmission paths. Other types of antennas possessing desirable transmission and directional characteristics may be used over shorter circuits.

*** B4.

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[2]E. H. Colpitts and O. B. Blackwell, *Carrier Current Telephony and Telegraphy*, *A.I.E.E.*; April 1921.

[3]Lloyd Espenschied, *Application to Radio of Wire Transmission Engineering*, Proc. IRE; Oct. 1922, and BSTJ; Nov. 1922.

[4]R. A. Heising, *Production of Single Sideband for Transatlantic Radio Telephony*, Proc. IRE; June 1925.

[5]F. A. Polkinghorn and N. F. Schlaack, *A Single-Sideband Short-Wave System for Transatlantic Telephony*, BSTJ; July 1935 and Proc. IRE; July 1935.

[6]G. Rodwin, *Single-Sideband Short-Wave Receiver*, Bell Laboratories Record; Aug. 1936.

[7]A. A. Roetken, *A Single Sideband Receiver for Short-Wave Telephone Service*, Proc. IRE; Dec. 1938.

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[9]J. C. Gabriel, *Single-Sideband Short-Wave Receiver*, Bell Laboratories Record; Nov. 1939.

[10]K. L. King, *A Twin-Channel Single-Sideband Radio Transmitter*, Bell Laboratories Record; March 1941.

[11]Patent 1,666,206.

[12]Patent 1,773,116.

[13]Patent 2,020,409.

[14]A. H. Reeves, *The Single-Sideband System Applied to Short-Wave Telephone Links*, JIEE; Sept. 1933.

[15]N. Koomans, *Single-Sideband Telephony Applied to the Radio Link between the Netherlands and the Netherlands East Indies*, Proc. IRE; Feb. 1938.

Aircraft Antennas

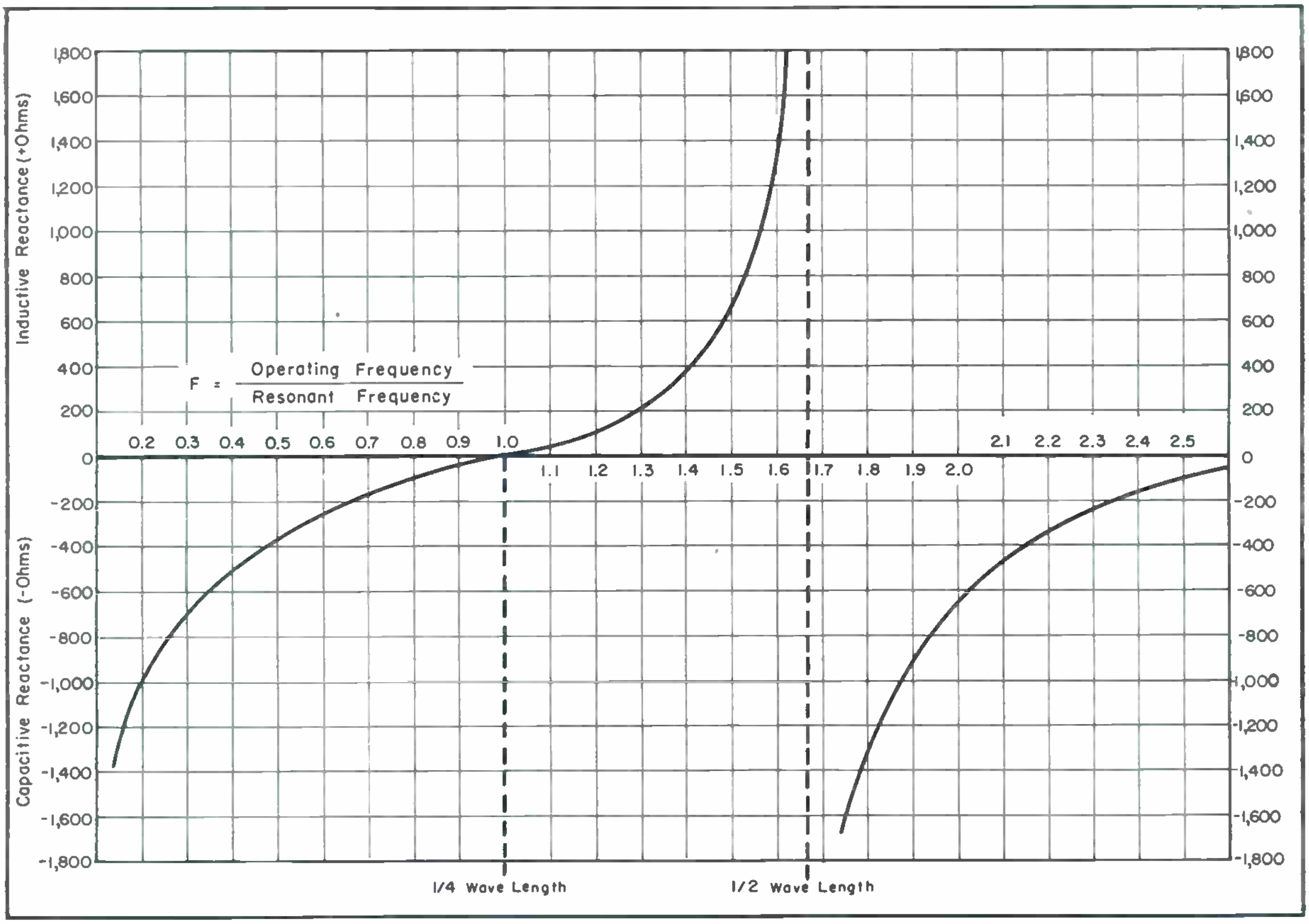

Table 1 (below)
Examples of use of antenna charts.

Figure 7 (above)
Chart to be used to find the reactance of aircraft antennas.

Example No.	1	2	3	4	5	6	7	8
Antenna type	*Fore and Aft*	*Fore and Aft*	*Trailing*	*Vertical*	*Center Fed V*	*Off-Center Fed V*	*Center-Fed V*	*Center-Fed V*
Antenna length	22′	22′	24′(**)	15′	30′	40′	20′	20′
Refer to chart	2	2	2	3	1	1	1	1
Quarter-wave resonant frequency	10 mc	10 mc	7.5 mc	18 mc	7.0 mc	5.0 mc	9.8 mc	9.8 mc
Operating frequency	3 mc	12 mc	7.5 mc	13 mc	6.1 mc	3.0 mc	8.0 mc	9.2 mc
¼ wave res. freq. / operating freq. = F	0.30	1.2	1.0	0.70	0.87	0.60	0.82	0.94
Next, refer to chart	7	7	7	7	7	7	7	7
Find: Antenna reactance	—700 ohms	+ 110 ohms	0 ohms	—150 ohms	—50 ohm	— 260 ohms	—96 ohms	—20 ohms
Then, refer to chart	6	6	5	6	4	4	4	4
Find: Antenna resistance	1.6 ohms	60 ohms	19.6 ohms	14.8 ohms	3.25 ohms	2.0 ohms	2.9 ohms	3.9 ohms

*Figures 1, 2, 3, 4, 5 and 6 appeared in Part 1, November. **Trailing wire antennas generally are unreeled to such a length that the quarter-wave resonant frequency is the same as the operating frequency (i.e., F=1.0). The correct length to be unreeled may be determined from the chart, Figure 2.

Part II . . . How to Use Charts to Find Reactance and Resistance of Fore and Aft, Trailing, Vertical, Center-Fed *V* and Off-Center-Fed *V* Aircraft Antennas. Eight Examples Offered.

by SIDNEY WALD

Aviation Equipment Engineering
Engineering Products Dept., RCA

Continuing with our analysis of measurement plots for aircraft antennas, to find the antenna reactance, we use the number obtained when the operating frequency was divided by the resonant frequency; Figure 7.

In applying this chart, from the point on the *F* scale corresponding to the number just found, we follow a vertical path until it intersects the curve. From there, the horizontal path is followed to the *H* scale. The number indicated on the *H* scale (where it is intersected by the horizontal path) is the value of antenna reactance.

Example

As an example, imagine a center-fed *V* antenna having a length of 50′. Frof Figure 1* we find that the quarter-wave resonant frequency is 4.55 mc.

Let us assume that the transmitter operating frequency is to be 4.09 mc. Then the number to use for the *F* scale is

$$F = \frac{\text{operating frequency}}{\text{resonant frequency}} = \frac{4.09\text{ mc}}{4.55\text{ mc}} = 0.90$$

Locating the *V* antenna curve on the *antenna resistance chart;* Figure 4*, we find an antenna resistance value, on the *G* scale, of 3.5 ohms.

Going to Figure 7 and following through from an *F* scale value of 0.90, the value of antenna reactance is found to be −40 ohms (i.e., 40 ohms of capacitive reactance).

Other examples, which may aid in the use of the antenna curves are presented in Table 1.

*Communications; November, 1948.

Index, COMMUNICATIONS, 1948

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Alphabetically Arranged For Authors and Subjects

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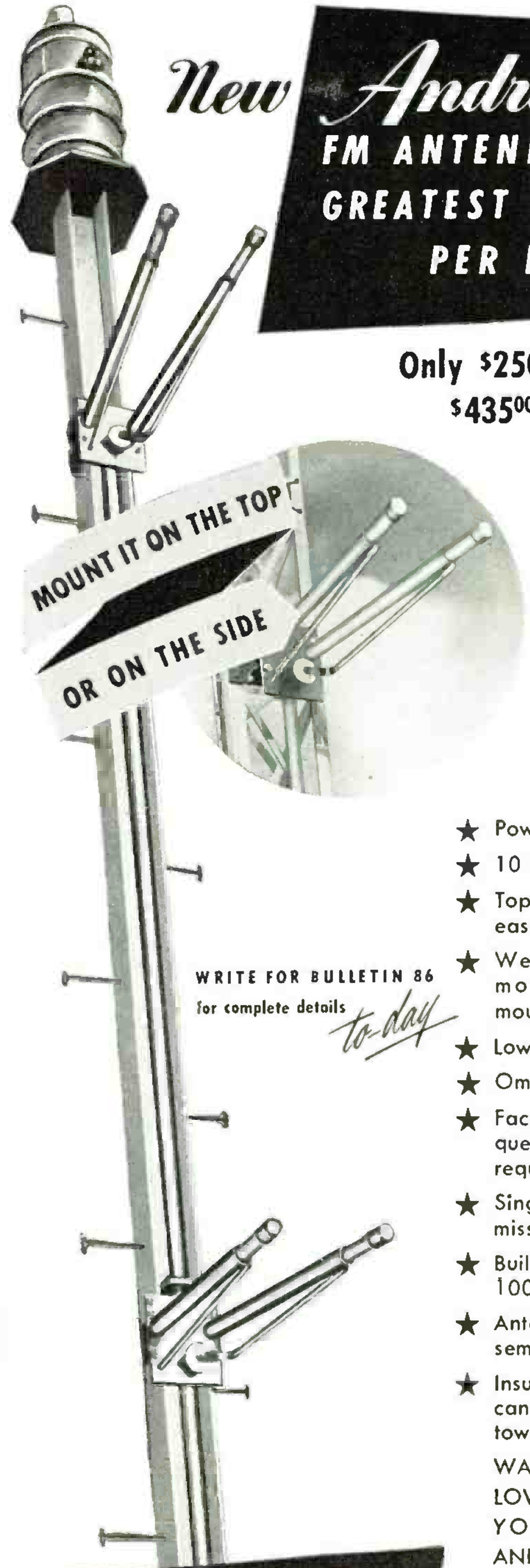

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WBZ TV

(*Continued from page 11*)

The other racks house video equipment and its associated power supplies. One rack has a master monitor and a rack-mounted switching panel that permits previewing any one of six video feeds on the master monitor, and still another row of buttons with tally lights that are used to feed the transmitter the desired signal. This rack also contains a video patch panel, thereby lending complete flexibility in the event of trouble in any one of the line amplifiers, isolation circuits, etc.

Another rack contains the microwave receiver control unit, isolation amplifiers, a stabilizing amplifier and their power supplies. The microwave receiver operates in the 6,900-mc region. It employs a four-foot parabolic dish and *garbage can*[18] that is mounted up on the tower. This unit is orientated on remotes being picked up by the *televan*.

The next rack contains still more isolation amplifiers. They consist of five individual amplifiers, each of which can deliver the same signal level and polarity it receives from a coaxial line (nominally 75 ohms). The inputs are of relatively high impedance so that several can be bridged without disturbing the driving circuit. They are designed to have a band pass from 30 cycles to 8 mc.

Besides acting as isolation amplifiers, they can be used to mix signals whereby the sync pulses are fed into one amplifier, the video with blanking, into another, and the outputs paralleled, with the end result, a complex video signal, complete with sync signals.

A monoscope camera is used to generate the test pattern. At first, we used the standard RMA test pattern embossed on the type 2F21 tubes, but since then have replaced the 2F21 with a tube[19] which has a gridded pattern of horizontal and vertical lines as well as the horizontal and vertical resolution wedges and the call letters WBZ-TV, Boston. *Channel 4.*

---

[18]The word *garbage can* is well meaning, because it resembles just that form of a disposal can. It is mounted on the rear of the parabolic dish and houses the head end of the microwave receiver. The *rf* input comes in via a section of wave guide and fed into a crystal mixer. A type 2K26 reflex klystron is used as a local oscillator and beats with the incoming signal to produce an *if* frequency of 118 mc. This is amplified in a four-stage *rf* preamplifier and then fed down to the receiver control unit via RG-8U where it is again amplified and the video component demodulated.

[19]Tube made by Lansdale Tube Co., Lansdale, Pa.

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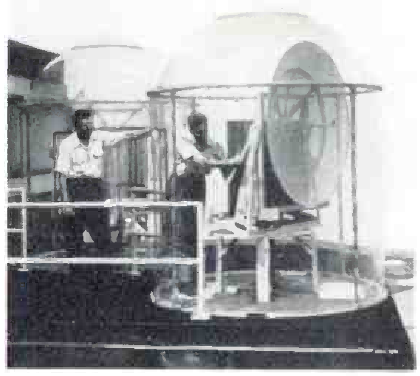
TV ANTENNA PLASTIC HOUSINGS



Plexiglas domes covering NBC parabolic relay antennas mounted atop the Empire State Building in New York City. Housing, of ½" thick acrylic plastic, is said to be shatter-resistant. To prevent development of excessive heat or freezing condensation each housing has its own *air-conditioning* system.

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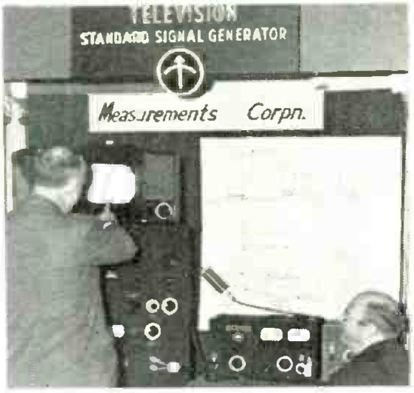
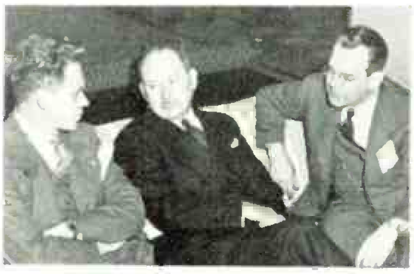
AT THE RMA FALL MEETING



Above: E. M. Weed of Measurements Corp. demonstrating their TV signal generator to L. C. F. Horle, chief engineer of the RMA engineering department at the recent Rochester Fall Meeting. (See November editorial for further data on signal generator). Below: D. B. Sinclair, General Radio; B. E. Shackelford, IRE president and S. L. Bailey, 1949 president-elect, discussing the forthcoming IRE national meeting at the recent Fall Meeting.



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SYRACUSE TV

Capt. Bill Eddy, director of operations for the Meredith-Syracuse Television Corp. (seated right), discussing the G.E. TV transmitter to be installed at Syracuse, N. Y., with T. F. Bost, G.E. TV sales and P. L. Chamberlain, manager of the G.E. transmitter division. Standing in the rear is Gene Crow, chief engineer for the Meredith-Syracuse Television Corp.

Tube Engineering News

(*Continued from page 23*)

is due principally to screen-lead-inductance effects, and it becomes necessary to introduce in-phase voltage from the plate circuit into the grid circuit. This can be done by adding capacitance between plate and grid external to the tube. Ordinarily, a small metal tab approximately ¾" square and located adjacent to the envelope opposite the plate will suffice for neutralization. Means should be provided for adjusting the spacing between the neutralizing capacitor plate and the envelope. An alternate neutralization method for use above 110 mc is illustrated in Figure 1. In this circuit, feedback is eliminated by series-tuning the screen to ground with a small capacitor. The socket screen terminals should be strapped together as shown on the diagram, by the shortest possible lead, and the lead from the mid point of this screen strap to the capacitor, *C*, and from the capacitor to ground should be made as short as possible.

Driver output power should exceed the driving power requirements by a sufficient margin to allow for coupling-circuit losses. The use of silver-plated linear tank-circuit elements is recommended for all frequencies above 75 mc.

The *rf* circuit considerations discussed under Class-*C* FM or telegraphy also apply to amplitude-modulated operation of the 4-65A. When the tube is used as a class-*C* high-level-modulated amplifier, both the plate and screen should be modulated. Modulation voltage for the screen is easily obtained by supplying the screen voltage via a series dropping resistor from the unmodulated plate supply, or by the use of an *af* reactor in the positive screen-supply lead, or from a separate winding on the modulation transformer. When screen modulation is obtained by either the series resistor or the audio reactor methods, the *af* variations in screen current which result from variations in plate voltage as plate is modulated automatically give the required screen modulation. Where a reactor is used, it should have a rated inductance of not less than 10 henries divided by the number of tubes in the modulated amplified and a maximum current rating of two to three times the operating *dc* screen current. To prevent phase-shift between the screen and plate modulation voltages at high audio frequencies the screen bypass capacitor should be no larger than necessary for adequate *rf* bypassing.

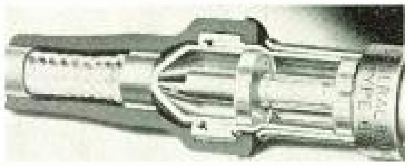
The Industry Offers

G-R UNIVERSAL COAXIAL CONNECTOR

A coaxial connector, type 874, featuring two identical connectors which plug into each other without any intermediate elements, has been developed by General Radio Company, 275 Massachusetts Ave., Cambridge 39, Mass.

The basic elements of the connector are an inner conductor, an outer conductor, and a supporting polystyrene bead. The inner and outer conductors are similar in principle; each is essentially a tube with four longitudinal slots in the end and with two opposite quadrants displaced inward. To make a joint, two connectors are plugged together so that the undisplaced quadrants of one connector overlap the displaced quadrants of the other. A strong friction grip is made by multiple, spring-loaded contacts, so that no locking means is required, and connections can be made and broken quickly.

The characteristic impedance is 50 ohms throughout the connector. The standing-wave ratio of an average coax connector is less than 0.3 db at all frequencies below 4500 megacycles.



* * *

ANDREW AUTOMATIC DEHYDRATOR

An automatic dehydrator, type 1900, designed for pressurizing coaxial transmission line systems with dry air has been developed by Andrew Corp., 363 East 75th Street, Chicago 19. Dehydrator is motor driven, fully automatic and self-reactivating. Operates on a six-hour cycle. The first four hours are of an intermittent nature since the unit delivers dry air to the load as needed. The last two hours are spent reactivating a silica gel desiccant and cooling. During reactivation, no further dry air is supplied to the load.

Capacity is 1¼ cubic feet per minute and operation is from a 115 volt, 60 cycle source. Entire system operates at the line pressure rather than through an intermediate high pressure stage.

Bulletin 85 contains complete details.

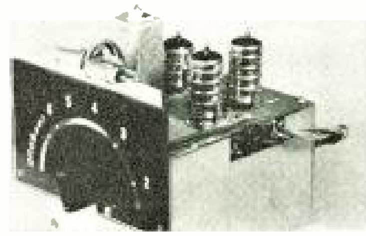
* * *

VISION RESEARCH FRONT END TUNER

A front end tuner, model TF 701, has been developed by Vision Research Laboratories, Inc., 87-50 Lefferts Blvd., Richmond Hill 18, New York.

Frequency gaps between channels, as from 6 to 7, are said to be bridged in one smooth motion, so that a 180° rotation of the tuning device covers all channels.

Measures 3" x 4" x 4½". Contains *rf* am-amplifier, oscillator and mixer circuits.



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IRC INSULATED FIXED RESISTORS

An insulated fixed composition small-type resistor, *Advanced type BT*, produced in 1/3, ½, 1 and 2 watt ratings equivalent to JAN types RC10, RC20, RC30 and RC41, has been announced by International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa. Meets joint Army-Navy requirements under JAN-R-11 specifications.

Family of resistors (type BTR resistor body measures 3/32" x 13/32") is furnished in ± 5%, 10% and 20% tolerances, in RMA resistance ranges. Temperature coefficient varies from 0.02% per °C for low ranges to 0.14% per °C for high ranges. Depending on the size of the resistor, voltage varies between 0.0% and 0.27% per volt. Element, constructed to IRC's filament principle, is housed in phenolic resin. High pressure molding of the housing provides security against humidity damage and moisture penetration.

Data in technical bulletin B-1.

News Briefs

INDUSTRY ACTIVITIES

The Sprague Electric Company, North Adams. Mass. has acquired the Herlec Corporation. Milwaukee, Wis.. manufacturers of ceramic capacitors and *Bulplate* printed circuits.

A plant for manufacturing ceramic assemblies is being established at Nashua, N. H. Milwaukee operations will be under the continued direction of Herlec executives including **Milton Ehlers,** president; **Harry Rubenstein,** vice-president and chief engineer; and **Thomas Hunter,** vice-president in charge of sales.

National Union Radio Corp. Orange, N. J., has purchased a plant in Hatboro, Pa., for the production of all types of picture tubes up to and including 20″ in diameter.

National Union will use straight-line exhaust methods for production of all its tubes, including 10″, 12″ and 16″ sizes.

James B. Lausing Sound, Inc., has moved to a new plant at 7801 Hayvenhurst Avenue, Van Nuys, Calif.

Cornell-Dubilier Electric Corp., South Plainfield, N. J.. has purchased the Faradon Capacitor Division of RCA.

All types and designs of Faradon capacitors previously manufactured by RCA will be continued and sold by Cornell-Dubilier.

WASH-FM, Washington, D. C. (key station of the Continental FM Network) has completed the installation of multiple unit Rangertone tape recording equipment.

Continental reported that it selected tape transcription recording because its "high fidelity characteristics (wide frequency range. low noise level and harmonic content, and greater dynamic volume range) could provide FM stations with the nearest technical approach by transcription to locally produced live shows."

Machlett Laboratories, Inc., will manufacture W. E. high power tubes for broadcast transmitters and allied applications.

Machlett will manufacture the tubes to Bell Telephone Lab. designs with the full use of the productions techniques developed by Western Electric.

Among the tubes to be manufactured by Machlett Laboratories are 300 to 1200-watt air-cooled amplifier tubes. types 212E. 214B, 251A. 270A, 279A, 308B, 357B. 363A. 379A: mercury vapor rectifiers. types 255B. 266B. 266C: water-cooled high vacuum rectifiers. types 222A, 233A: 10 to 100-kw water cooled triodes. types 220C, 232B. 236A. 240B. 298A. 298B. 340A. 342A. 343A; 5 to 25-kw forced air-cooled triodes. types 220CA. 232BA. 341AA. 343AA; and 3 and 10 kw uhf (to 110 mc) forced-air cooled triodes, types 5530 and 5541.

WBAP, the Star-Telegram's Fort Worth-Dallas broadcasting and telecasting station. will soon install an RCA audio setup with a master control switching system built into four racks. flanked by sixteen racks of equipment. eight on each side of the center section.

The switching system will provide an electrically interlocked circuit whereby sixteen inputs can be switched to ten outputs.

Six special studio control desks. all identical. will be furnished for six station studios. The desk has seven mixer inputs to a two-channel system.

The Refco Corp., 4509 White Plains Rd.. New York 66. New York was formed recently to do contract and sub contract work.

M. J. Simons is president and general manager: **Elias A. Smyrnakis,** vice president and production supervisor: **Richard L. Crandall,** secretary and treasurer.

FM Association is now located at 526 Dupont Circle Building. Washington 6. D. C.

PERSONALS

K. R. Smith, has purchased the manufacturing facilities of the World Broadcasting System and formed a new transcription company. which will be known as the K. R. Smith Company, Inc.. 619 West Fifty-fourth Street. New York City.

Dr. Harold A. Zahl, has been named director of research at the Signal Corps labs located in the Fort Monmouth, New Jersey area.

A. H. Brolly, has resigned from WBKB to become chief engineer of Television Associates, Inc., 190 North State St. Chicago 1, Ill.

Charles E. Rynd has resigned as vice president and assistant secretary of ABC to become president and general manager of Audio and Video Products Corp., 681 Fifth Avenue, New York. One of the principal products represented by the company is the Ampex magnetic tape recorder.

F. P. Barnes has been appointed sales manager of broadcast equipment for the transmitter division of G. E.

H. S. Morris has been named products sales-manager of Altec Service Corporation.

Paul V. Galvin, president of Motorola Inc., has named his son, **Robert W. Galvin** to the post of executive vice president.

The Muter Company has acquired all of the common stock of the Jensen Manufacturing Company. **Thomas A. White,** president of Jensen, **Hugh S. Knowles,** vice president and **Ralph T. Sullivan,** Jensen district sales manager, have acquired a substantial block of stock in the The Muter Company.

The new board of directors of Jensen Manufacturing Company will be: **Thos. A. White, Leslie F. Muter, Hugh S. Knowles, Karl E. Rollefson and A. A. Dailey.**

Leonard Mautner has been elected vice president of the Television Equipment Corp., 238 William Street, New York. The new company will engage in development and manufacture in the fields of TV pickup and transmission, and plans to market a low cost television camera for industrial and studio use.

Mautner formerly manager and chief engineer of the television transmitter division of Allan B. DuMont Laboratories, Inc.

WEST COAST TV INSPECTION

At the Mutual Don Lee TV studio during the recent West Coast IRE convention: Fred E. Terman, Dean of Electrical Engineering, Stanford University; Loyd C. Sigmon, KMPC chief engineer and general chairman of the convention; Benjamin E. Schackelford, IRE president; Walter Kenworth, chairman, Los Angeles IRE Section; and Harry Lubcke, Don Lee director of television.

ADVERTISERS IN THIS ISSUE

COMMUNICATIONS INDEX

DECEMBER, 1948

The EASIEST Way To Measure

INDUCTANCE • RESISTANCE • CAPACITANCE

- Completely self-contained, portable and always set up for immediate use, this impedance bridge is indispensable in any laboratory where electrical equipment is used. No hastily putting together a circuit, finding an oscillator, detector and power supply . . . they are all here permanently assembled in an accurate instrument . . . always ready for use at any time.

Over the major portion of its ranges this bridge is accurate for the majority of routine measurements in any laboratory. Its ranges are:

INDUCTANCE: 1 microhenry to 100 henrys
RESISTANCE: 1 milliohm to 1 megohm
CAPACITANCE: 1 micromicrofarad to 100 microfarads
STORAGE FACTOR (X/R): 0.02 to 1000
DISSIPATION FACTOR (R/X): 0.002 to 1

Included in the walnut cabinet are built-in standards, batteries, a 1000-cycle tone source for a-c measurements, a zero-center d-c galvanometer null detector and terminals for a headset for 1,000-cycle detection. Terminals are provided for an external generator for measurements from a few cycles to 10 k.c. Direct-reading dials add greatly to the ease and rapidity with which measurements can be made.

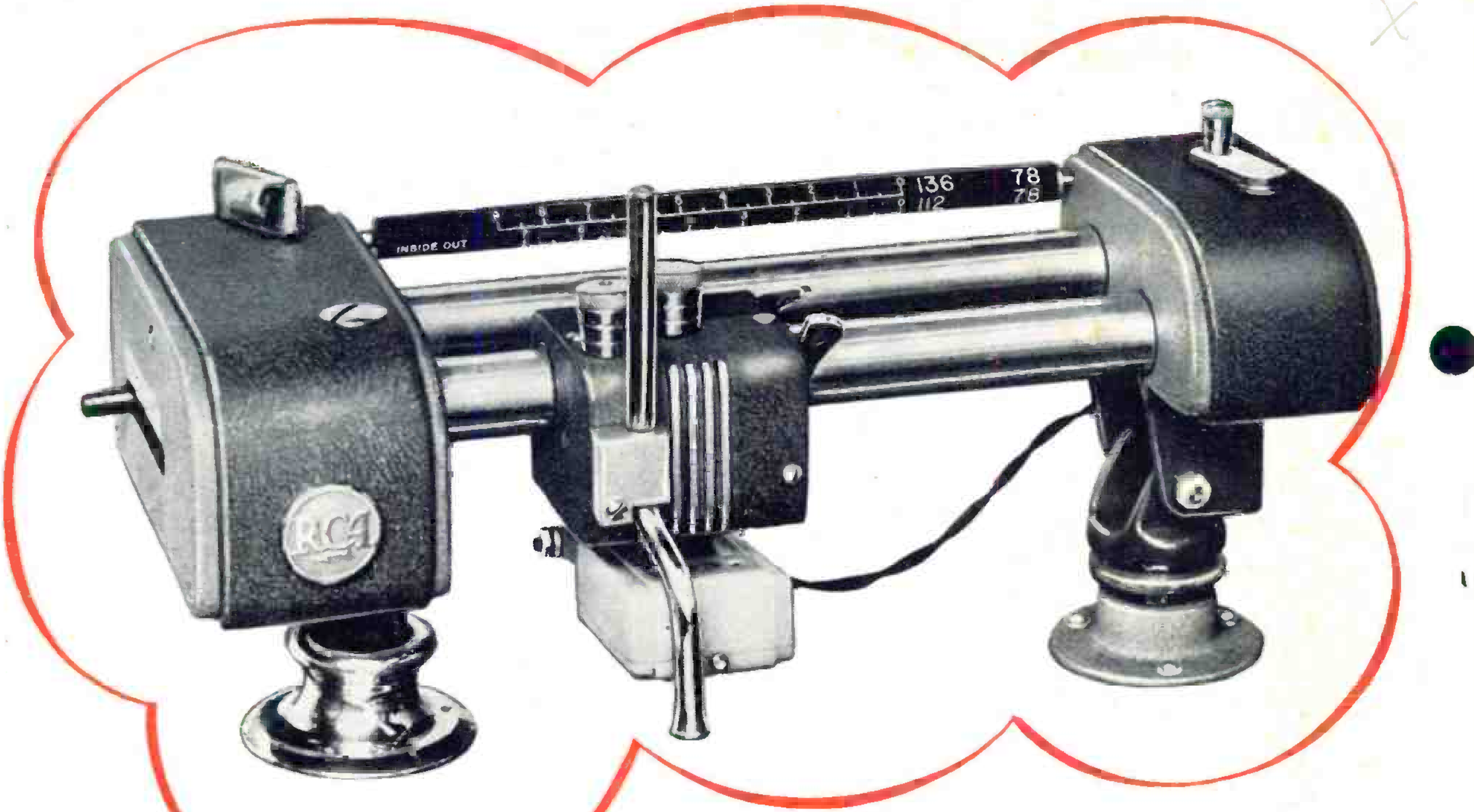
TYPE 650-A IMPEDANCE BRIDGE . . . $240

WRITE FOR COMPLETE INFORMATION

GENERAL RADIO COMPANY

Cambridge 39, Massachusetts

90 West St., New York 6 — 920 S. Michigan Ave., Chicago 5 — 950 N. Highland Ave., Los Angeles 38



The RCA Recorder mounted on a Type 70-D1 turntable

...makes your RCA turntable a high-fidelity recorder

—inexpensively

THIS IS THE NEW improved-type studio cutter. It is designed specifically to give you instantaneous high-quality recordings with your present "70 Series" turntable—at surprisingly low equipment cost to you.

It's uniquely flexible—With this professional attachment you can record at 96, 112, or 136 lines per inch—and at speeds of 33⅓ or 78 rpm. You can record outside-in or inside-out—without changing gears or lead screw. You can adjust the stylus cutting angle and cutting depth during recording.

It's simple to operate—A new improved cam-operated lowering device helps you lower the cutter gently to the record . . . eliminates stylus damage and deep cuts caused by sudden dropping. A spiralling hand crank enables you to insert space between recordings without breaking groove continuity. Plenty convenient, too, for making starting and finishing spirals.

It's dependable—No driver slippage or "knocks" . . . because power coupling is made to the center of your turntable through a vertical shaft spiral gear and a three-pin driving flange. No cutter carriage riding on the feedscrew . . . because the carriage is supported on a metal tube that encloses and protects the feedscrew. No groove grouping . . . because the head rides smoothly along a tubular enclosure that protects the feedscrew.

Here, we believe, is the finest cutter yet designed for high-quality studio recording . . . at modest cost. Type 72-D is complete with a standard head, mounting base, rest-post, and suction nozzle. Type 72-DX is complete with high-fidelity recording head, mounting base, rest-post, suction nozzle, and compensator.

For prices and details, see your RCA Broadcast Sales Engineer, or write Dept. 23L, RCA Engineering Products, Camden, N. J.

SPECIFICATIONS

Input Impedance to Cutter . . 15 ohms, nominal

Frequency Response:
- type 72-D . . . . ±3 db, 50 - 7,500 cps
- type 72-DX . . . . ±2 db, 50-10,000 cps

Sensitivity (groove velocity 6.3 cm/sec. 0.00079"—peak to peak) at 1,000 cps:
- type 72-D . . . . +30 dbm (1.0 watt)
- type 72-DX . . . . +30 dbm (1.0 watt)

BROADCAST EQUIPMENT

RADIO CORPORATION of AMERICA

ENGINEERING PRODUCTS DEPARTMENT, CAMDEN, N.J.

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