BROADCAST NEWS

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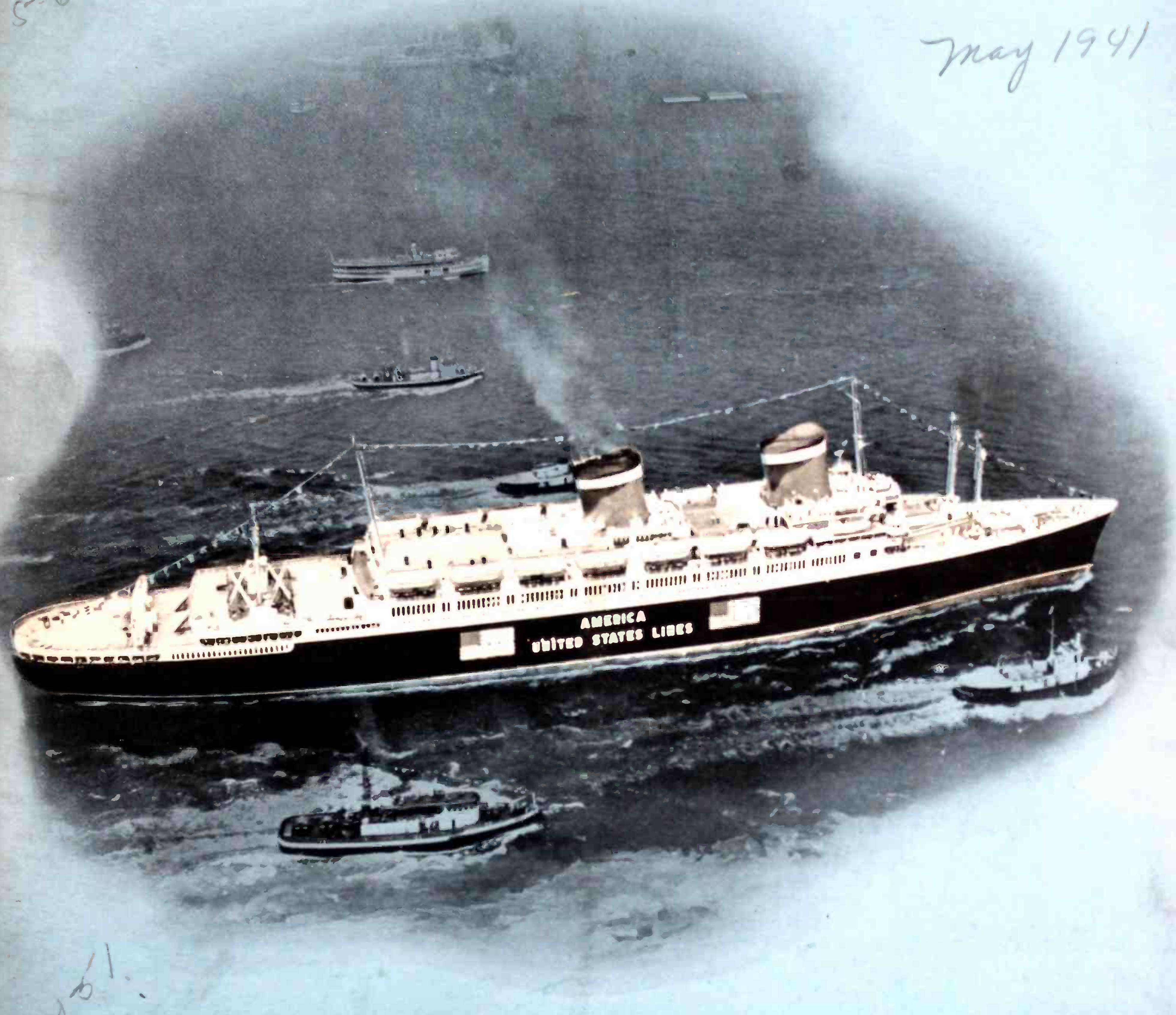
May 1941



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SIX WIRE TRANSMISSION LINE

SPEECH INPUT SYSTEMS

CHARACTERISTICS OF UNBALANCED OVERHEAD TRANSMISSION LINES

RCA MANUFACTURING COMPANY, INC., CAMDEN, N. J.

RCA Manufacturing Company, Inc.

A Service of Radio Corporation of America

Camden, N. J.

"RADIO HEADQUARTERS"

ENGINEERING PRODUCTS DIVISION

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BROADCAST STATION EQUIPMENT
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PAUL V. LUTZ, Editor

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SIX WIRE TRANSMISSION LINE

A Re-appraisal of the Relative Merits of Open Wire as Opposed to Gas Filled Concentric Lines

By J. C. WALTER & J. H. KEACHIE

RECENT developments in methods of construction have improved the efficiency of open wire transmission lines to such an extent that re-appraisal of the relative merits of open wire construction versus gas-filled concentric lines will be welcomed by all engineers interested in sound economy and trouble-free operation.

Factors governing the choice of r-f transmission lines may be briefly enumerated as follows:

1. Cost of completed installation.
2. Vulnerability of line to external faults, such as direct or indirect lightning strokes.
3. Breakdown voltage rating of the installation.
4. Power losses (including radiation).
5. Choice of characteristic impedance and its effect on cost of phasing and terminating equipment.
6. Installation facilities.
7. Maintenance and operating problems.

Both types of line are in general use throughout the industry. When rationalized on the basis of economy, reliability and efficiency, each has its advantages. On the basis of minimum radiation losses there can be no question of the superiority of a properly designed concentric line. On the other hand, the open wire type has obvious advantages from the standpoint of reliability. Cost considerations are definitely in favor of the open wire construction.

Early types of open wire line permitted excessive losses through radiation. Even more recent types of the balanced field variety, consisting of two power conductors symmetrically disposed about a ground plane, suffered from ground return losses to a considerable degree, especially at the higher frequencies and over soil of poor conductivity. Naming names, this applies specifically to the balanced three-wire and balanced four-wire types. Principal advantages were low cost and a virtually trouble-free installation.

Concentric lines, while having the advantage of zero radiation loss because of their closed field, are certainly more expensive, even on a first-cost basis, and definitely inferior from the standpoint of vulnerability.

Since it is not economically feasible to construct a concentric line having the same trouble-free characteristics as the open wire type, the obvious solution is to utilize an open wire configuration that will have the closed field properties of the concentric type. *For a single-ended transmission system a single power conductor surrounded by concentrically disposed grounded conductors is a complete solution as far as radiation is concerned.* For all practical purposes, a five wire symmetrical configuration can be considered as having a closed field. In order to retain sufficient spacing for high surge voltages, however, the characteristic impedance must be considerably increased beyond the optimum range of 175-250 ohms.[1] This disadvantage can be conveniently overcome by increasing the effective field of the power conductor, and we find that by using two parallel power conductors spaced 2½ inches between centers we are able to locate these at

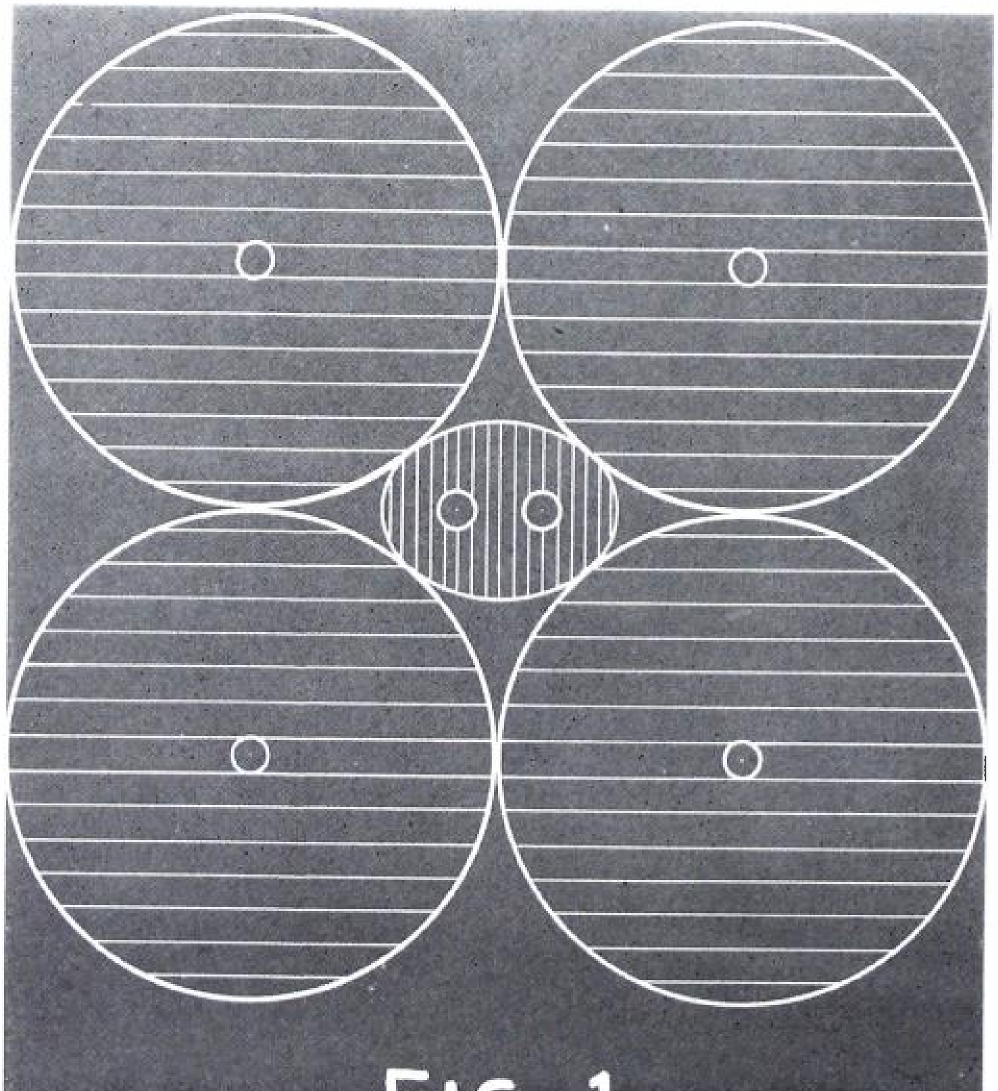
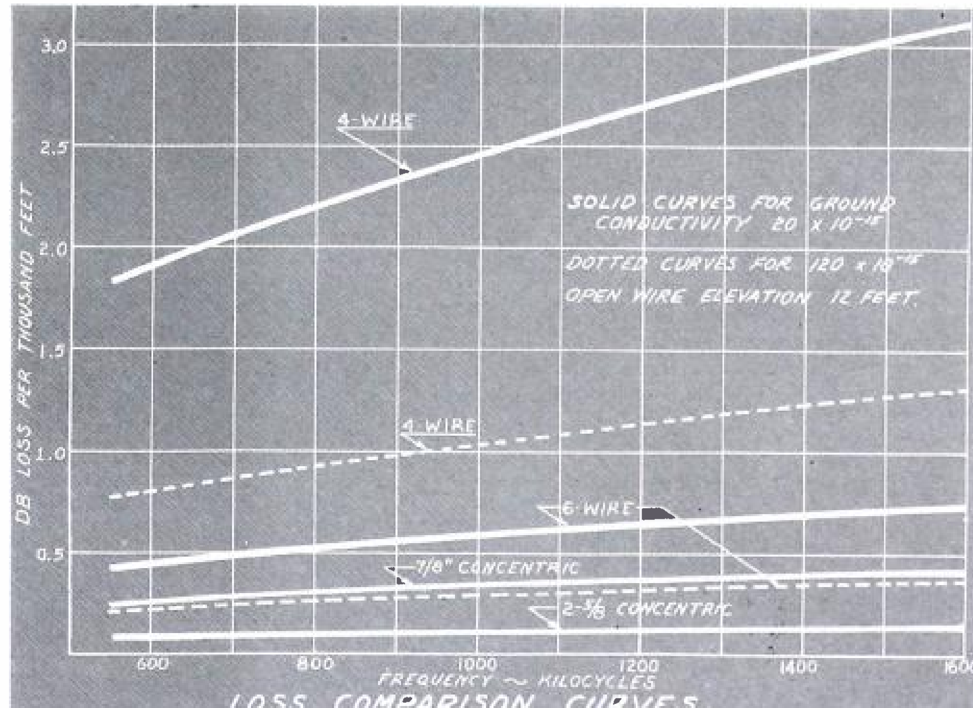


FIG. 1

[1] J. E. Eiselein, "Patterns Tailored to Fit," Broadcast News, No. 35, February, 1941.

the center of a 15 inch square of four ground wires and bring the characteristic impedance down to 230 ohms without sacrificing surge voltage rating and without using large conductors. A diagram of the resultant field is shown schematically in Fig. 1.

That the engineering logic behind this design is sound is conclusively shown in the curves of Fig. 2. The improvement in the loss and radiation characteristics beyond previous open wire types permits the use of the six-wire configuration in even the most complex directional systems without fear of pattern distortion.[2] The cardinal advantage of the concentric field is obtained without sacrificing the widely recognized features of open wire construction.



LOSS COMPARISON CURVES.
FIG. 2

While earlier types of open wire lines were easily erected on simple cross-arm structures, the Six-Wire system brings up new problems that are not easily solved by reference to standard catalogues of pole line hardware. It is a simple matter to design the correct hardware, but in such a restricted field of application the fabrication of special parts in small lots becomes expensive. In addition, deliveries are likely to be slow and many local jobbers are not equipped to fabricate specialty hardware of this nature.

In order to make correctly designed hardware available to the trade at reasonable prices RCA has assembled and stocked essential pole line items. Known as MI-19421 Double Bayonet, Insulator and Connectors, the assortment consists of the following material, sufficient for one pole:

1 Double bayonet bracket, consisting of formed steel angle, welded, drilled and hot-dip galvanized.

1 Special Fog Type low-loss double groove post insulator having no metal parts above the base. Overall height approximately 8¼ inches.

4 Cadmium plated bronze ground wire connectors.

All other hardware required for erection of a complete line is readily available as stock material from the manufacturers of standard pole line hardware. All six conductors are #6 stranded hard drawn copper, also obtainable from any manufacturer's stock.

The higher cost of conventional gas-filled concentric installations arises mostly from the cost of materials and the greater cost of installation labor. Where duplicate lines are required this cost is doubled. Complicated gas manifolding increases maintenance problems and breakdowns may result in serious outages. Trouble-shooting becomes something of a problem when internal faults develop, especially when lines are buried. In favor of the open wire line are such points as low cost materials, low cost of installation, minimum maintenance requirements and essentially trouble-free operation. A line crew of six or eight men borrowed from the local utility company can completely erect a thousand feet of six-wire line in two days, starting from scratch. Such faults as are likely to occur, under the worst possible operating conditions, can be quickly detected and repaired. A broken conductor may be tied clear or cut away without seriously upsetting transmitter loading. Broken insulators, unless completely shattered, will continue to function without interruption and are, in any event, quickly and easily replaced. Since the power conductors are surrounded by four grounded con-

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[2] G. H. Brown, "Characteristics of Unbalanced Overhead Transmission Lines" (Page 16).


Fig. 3.

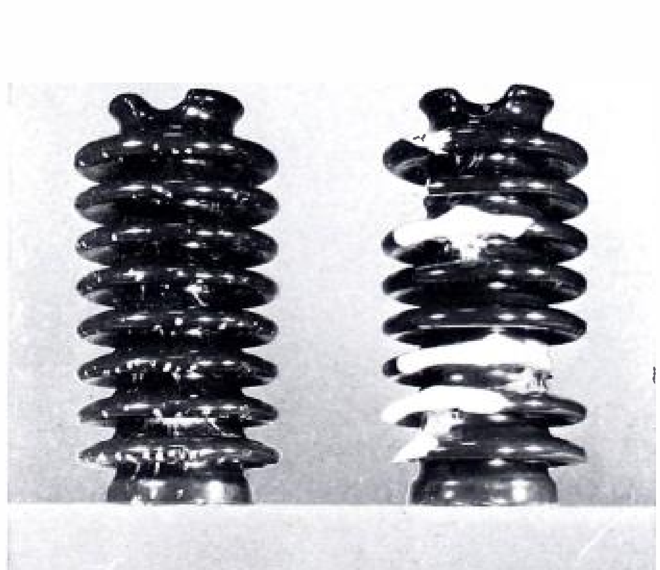


Fig. 4.

General view of the rig above decks.

A SEA-GOING INSTALLATION

Radiomarine Facilities on S.S. America Unequalled

COMPREHENSIVE and efficient to the highest degree, the radio installation on the S.S. *America* provides facilities for radio communication, navigation, and safety at sea unequalled by those of any other ship afloat. Eight transmitters, nine receivers, a direction finder, an automatic distress alarm, and thirteen antennas form a vital link between the *America* and other vessels, ports, and cities in any part of the world.

Custom Built Equipment

This impressive array of custom-built, expertly installed equipment, which makes available to ship's officers and passengers alike the full range of radio's telegraphic and telephonic services, is housed in quarters especially designed for it on the *America's* spacious sports deck. It lies aft of the wheel house and the chart room, where it is instantly available to the bridge and easily accessible to passengers.

The radio quarters are a show place in themselves. Outfitted in a modern functional style, they give the appearance of ship-shape compactness and efficiency without being cramped. The front office is equipped with writing table, radio telephone booth, and the chief radio officer's desk. A door leads from the office into the operations room, where are located the transmitters, receivers, and controls.

Maintain Continuous Service

Operations are conducted by a complement of five radio officers, who maintain a continuous radiotelegraph and radiotelephone service while the *America* is at sea.

Five transmitters, together with associated receivers and other equipment, are installed in the operations room. Four of the transmitters are used for radiotelegraphy and one for radiotelephony. Control consoles run through the center of the room. An emergency station is set up in one corner, and adjacent to it is the automatic alarm.

Instantaneous Change Feature

The bulk of message traffic is carried by three main radiotelegraph transmitters, which operate in three frequency bands—intermediate, short wave, and long wave. The versatility of this equipment permits operations over any distance and under all conditions.

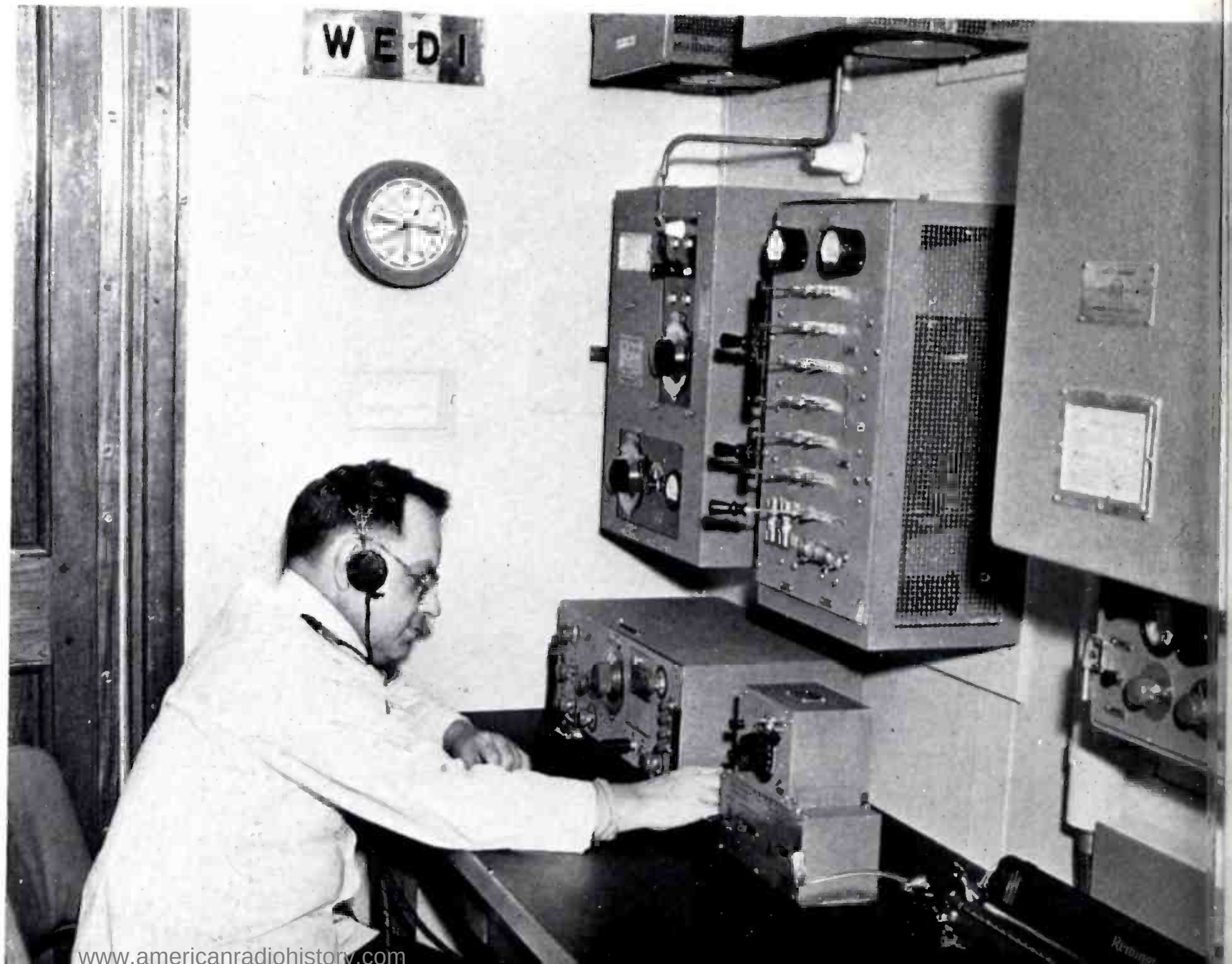
In the intermediate frequency band of 350 to 500 Kc, the *America* is equipped with a 1000-watt specially designed transmitter which provides 10 separate crystal-controlled frequencies, or communication channels. A feature of this set is provision for instantaneous change from the 500-kilocycle distress and calling wave to a working wave. The operator may make the shift by merely throwing a switch at his desk.

Long Distance Communication

A 1000-watt crystal controlled 20-frequency transmitter, which covers the range from 4 to 24 megacycles, provides long distance short wave communication. This transmitter makes it possible to maintain radiotelegraph communication over distances of 3,000 miles and more.

In the low frequency, or long wave, band of 110 to 160 kilocycles, there is another 1000-watt transmitter designed for 10 crystal-controlled frequencies. This unit is used chiefly on a vessel such as the *America* when short waves are subjected to magnetic

Emergency position including transmitter and receiver.



Radiotelephone control center.

Independent Emergency Facilities

The fifth transmitter in the room is the emergency station, set up apart from the main equipment. Its power is 50 watts and its frequency range is 375 — 500 kilocycles. This unit is for use in the rare event the main transmitters are unable to operate due to failure of the power supply. It is linked to an emergency generator and, for still greater protection, has its own set of storage batteries.

Two receivers are also installed in the emergency position. One of them, a vacuum tube unit, covers the frequencies from 15 kilocycles to 500 kilocycles, with the other—a type B crystal receiver—is one that operates without batteries or tubes.

storms or other phenomena that cause excessive fading.

Specially Designed Console

Operating controls for these three radiotelegraph transmitters are arranged in a compact, specially designed console 9½ feet long. Three receivers are housed in the console, together with stop-start switches for the motor generators and the frequency selector switches. Signal lights indicate when the equipment is functioning.

The console also has an antenna switching panel for selection of any of the five receiving doublets for either of the two high frequency receivers. Four loud speakers and switches permit combinations for monitoring by speaker or earphones. Any of the receivers may be switched to a loudspeaker on the bridge for time signals.

Powerful Radiotelephone

The radiotelephone transmitter, most powerful of its kind installed aboard an American vessel, is a 600-watt, 5 channel transmitter with crystal control on all channels. The set's design provides for adjustment to thirty different frequencies, thus permitting the addition of other transmitting channels in the future. Privacy for radiotelephone conversations is obtained through a speech inversion, or "scrambler," device, which makes the voice signals unintelligible to unauthorized listeners.

The control panel for the radiotelephone contains the subscriber switching bay, which enables the operator to put calls through to passengers' staterooms. Here, too, are all the controls for voice operation, circuit switching, simplex operation, and speech inversion. Also included are a microphone and special headphones, high frequency receiver, and pre-selector, and a noise-reducing electronic relay.

Automatic Distress Alarm

Although it is not required by law on a vessel that maintains a continuous radio watch, a radio automatic distress alarm is an integral part of the *America's* equipment. Mounted on a bulkhead next to the emergency position, the automatic alarm adds considerably to the measure of protection the ship is able to give to other vessels which happen to be in its vicinity.

This unit is responsive at all times to the emergency distress signals of other ships. When such signals are received, the unit auto-

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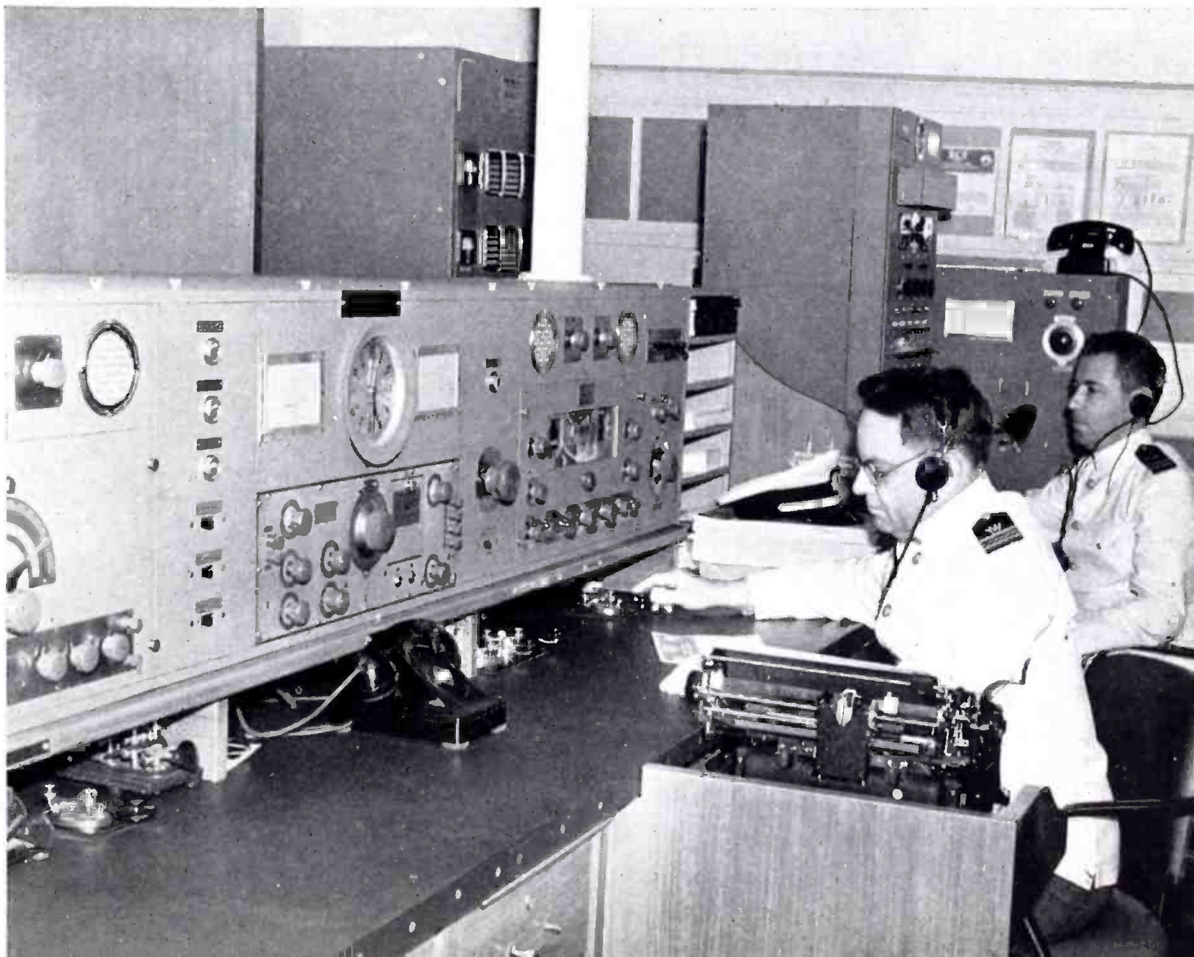
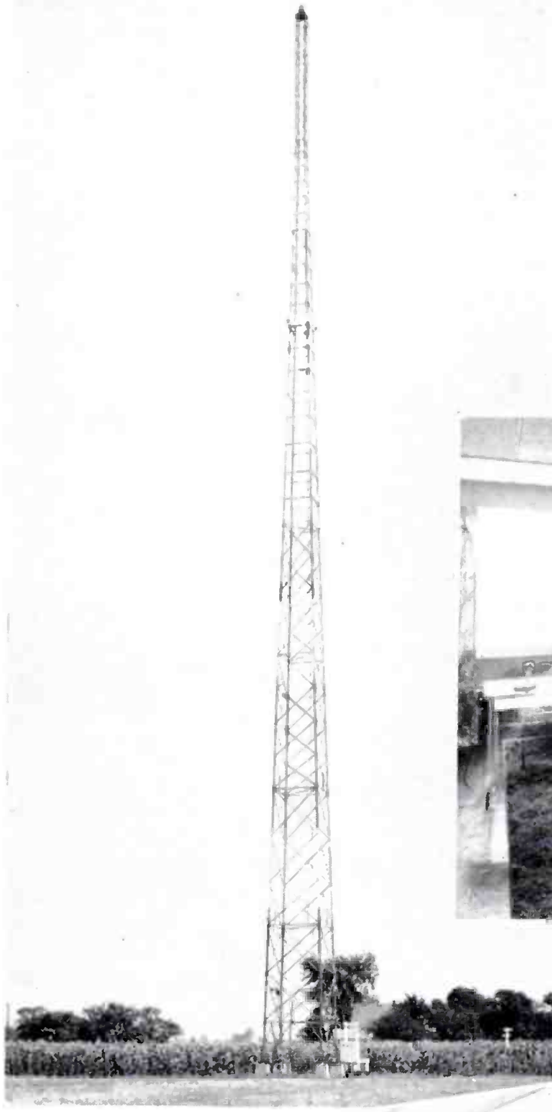
Control console for sending and receiving.



WSAM—"RCA ALL THE WAY"



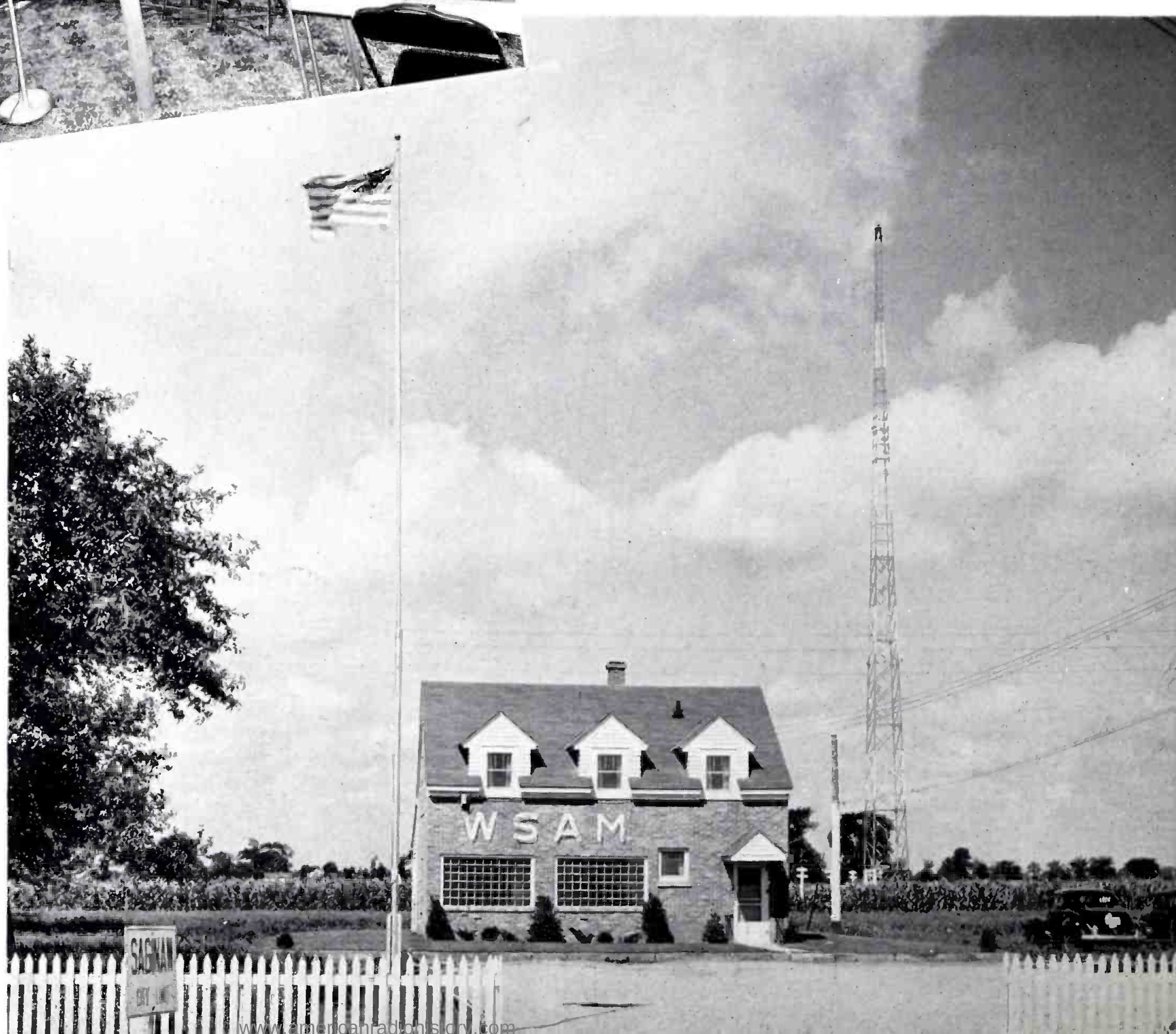
205 ft. tower that puts WSAM's signal on the air.

Studio view at the Saginaw station.

RCA 76 B Consolette, 70-C Turntables and 64-B Loudspeaker are combined to provide an efficient speech input system.

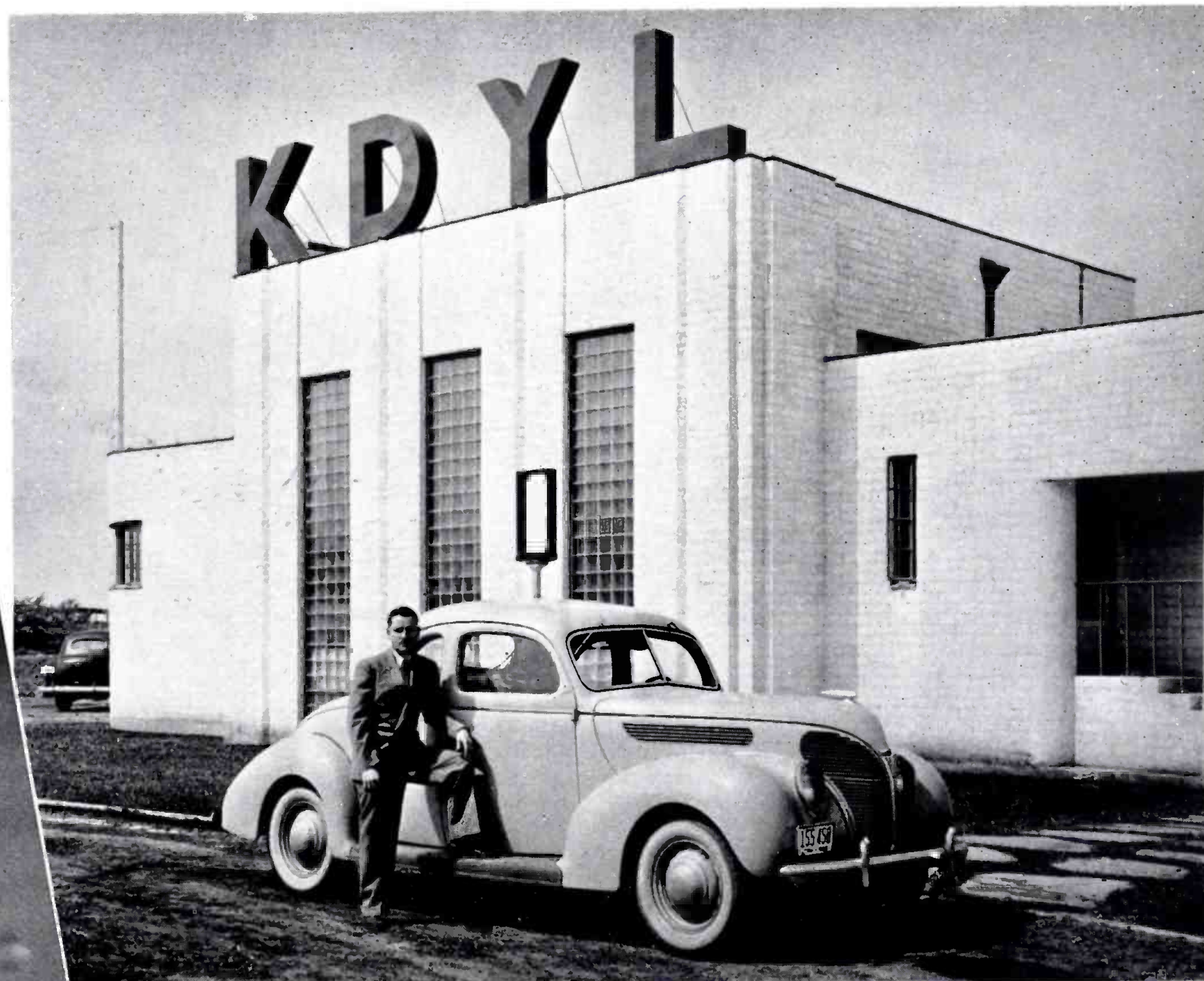
RCA microphones, stands and cue speakers are used in the attractive WSAM studios.

An unusually fine building houses the RCA Transmitter at WSAM.



KDYL—A Busy Station in the Beehive State

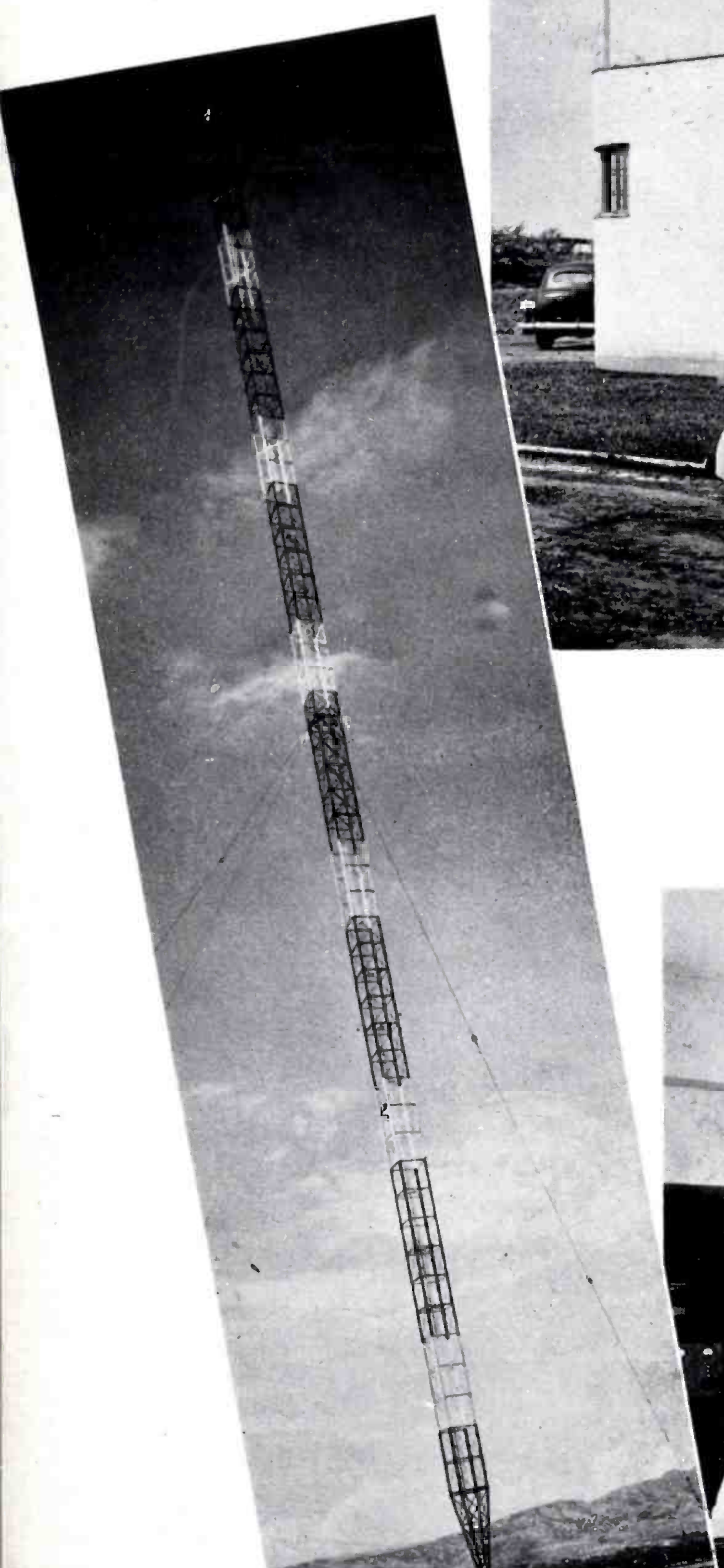
Most Populous Section of Utah is in KDYL's range.



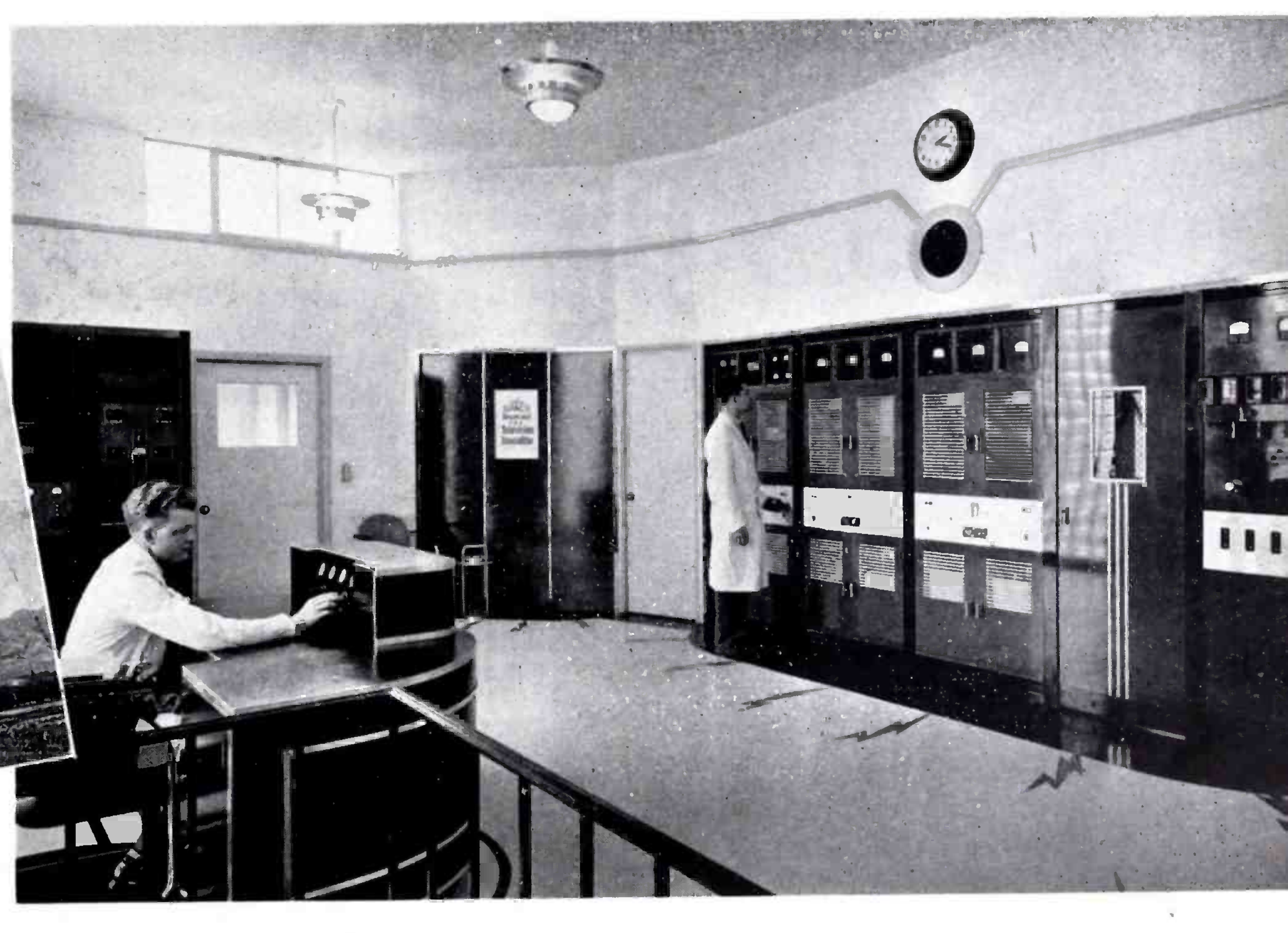
▲ A modern, light transmitter house, designed for efficient and compact arrangement of units, is the home of KDYL's RCA transmitter.

Towering over 400 feet above the immediate terrain, KDYL's antenna sends out a powerful signal to Salt Lake City and surrounding territory.

▼



▼ The RCA 5-D1, predecessor of the 5-DX, has given excellent service at KDYL.



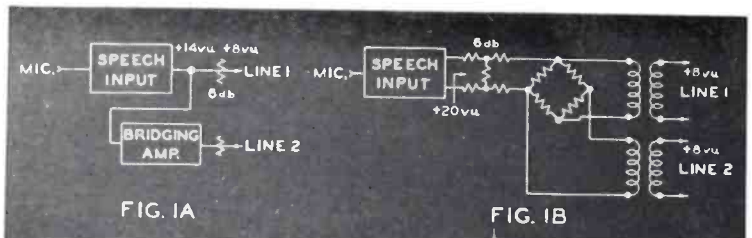


FIG. 1A FIG. 1B

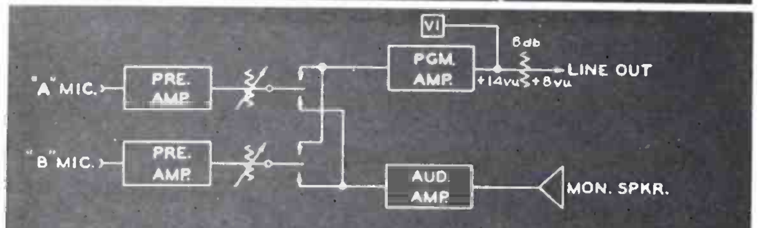


FIG. 2A

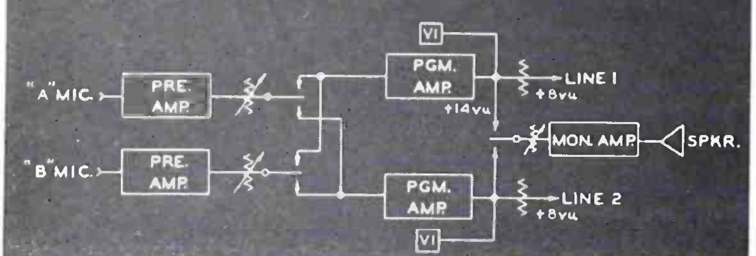


FIG. 2B

SPEECH INPUT SYSTEMS

A Thorough Discussion of the Practical and Theoretical Aspects of Various Systems

By

C. M. LEWIS, Speech Input Sales Manager

J. D. COLVIN, Design Engineer

Presented Before the Fourth Annual Broadcast Engineering Conference, Ohio State University, Columbus, Ohio.

BROADCAST engineers, like the proverbial postman who takes a long walk on his day off, are often found visiting other broadcast stations. We are all interested in knowing how our colleagues meet their particular problems because we learn unusual methods which can benefit our own stations. It is practically impossible for an operating engineer to visit every new installation. For this reason we have prepared an outline describing the major type of speech input systems in use today. Few speech input systems are alike in every respect. Each varies in the number of studios, network connections and programming requirements.

This paper is divided into two parts. The first describes practical schemes for switching output channels, remote inputs and monitoring systems. The second part deals with actual installations which are successfully performing their required functions. In order to make the paper as comprehensive as possible, systems are described which vary from the relatively simple one transmitter installation to the comparatively complex multiple studio and multiple output layout.

PART I

Multiple Output Systems

The simplest system is the one consisting of an assembly of amplifiers and mixers by means of which one or more microphones are fed to one transmitter or outgoing line. An expansion of this circuit is required whenever it becomes necessary to feed more than one output as, for example, the transmitter and a network or two transmitters. The two outputs should not be multiplied directly or connected together in a simple mixer because insufficient isolation is obtained with the result that any objectionable noise originating on either of the lines will also interfere with the other. Two successful methods are used, and are shown in Fig. 1. The first employs a bridging line amplifier (Fig. 1A). The input of the amplifier has a high impedance (usually 20,000 ohms) and may be connected across the main program bus without affecting its level or characteristics. Sufficient gain is provided in the amplifier to overcome the bridging loss and to furnish an output level which is the same or greater than the input. Since the amplifier is a one-way device, perfect protection is afforded the main bus. If two amplifiers are used, one in each output, complete isolation is obtained between the two lines. The second method utilizes a bridge circuit and is less expensive but has a few disadvantages. As shown in Fig. 1B, the output of the program amplifier is fed into one leg of a Wheatstone bridge and the two output lines are connected across opposite corners of the bridge. Any undesirable voltage generated on either line will be attenuated approximately 40 db before getting on the other line, but the program is attenuated only 6 db to each line. In actual practice, we have found that high quality line coils are usually required between the bridge and the lines to insure correct balance. A 6 db impedance isolation pad is also desirable between the amplifier and the bridge. The disadvantages of the bridge circuit are the high loss of 12 db in the amplifier's output, the limited attenuation between lines and the fact that both outputs must be operated at the same level.

When more than one studio is involved, some arrangement for selection of the proper studio is required. Simultaneous broadcasting and auditioning is of great importance to the programming and sales departments. When only two studios are to be fed to one output and a minimum of equipment is desired, the simple arrangement shown in Fig 2A may be employed. By inserting key switches in the outputs of the respective mixers, each studio

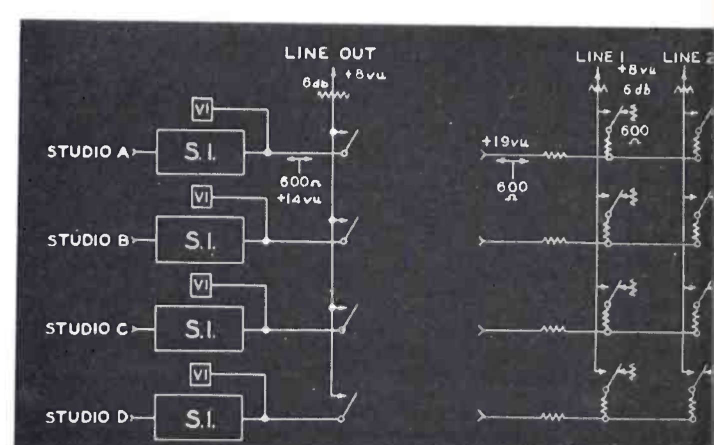
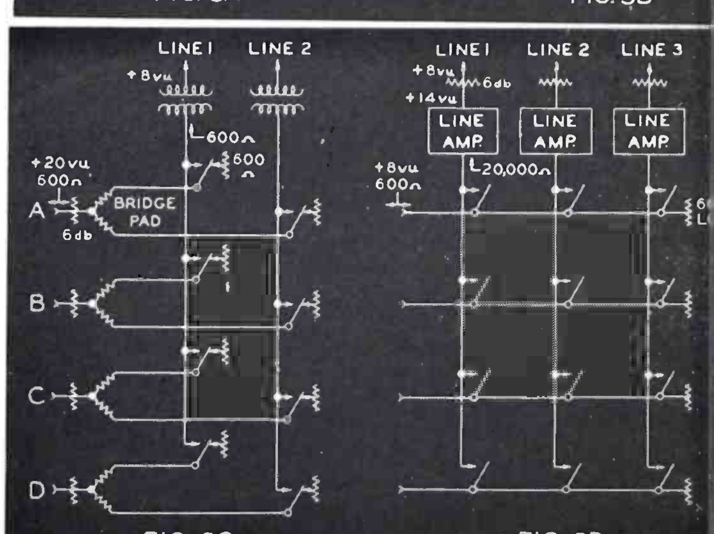


FIG. 3A FIG. 3B



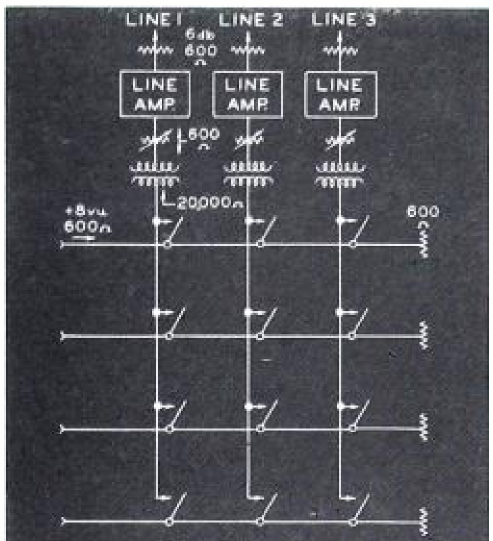


FIG. 3E

can be connected to either the program amplifier or the audition amplifier. Thus it is possible to be broadcasting from one studio while auditioning from the other. An alternative and more flexible version of this arrangement is indicated in Fig. 2B. By making the audition amplifier a duplicate of the program amplifier, it can be used to feed a second output. A separate monitoring amplifier with a selector switch will then be required.

As the number of studios is increased, it becomes desirable to have separate and independent amplifiers and controls for each studio. With independent systems for each studio, it is possible to use more than one operator at a time which permits simultaneous broadcasting or rehearsing from any combination of studios. Fig. 3A shows a basic circuit for connecting one output to any one of several studios. Some means should be provided to interlock the studio outputs so only one can be fed to the output at a time. If it were possible to connect two or more studios to the output, a serious impedance mismatch and possibility of accidently interfering with the program would result. If the output switching can always be done from the same location, as in the case of a central control room operating several studios from one control desk, the output selector may be a mechanically interlocked pushbutton switch. However, if the switching is to be operated from various locations, relays should be used for the master selectors. The relays can be made to operate from output keys at each studio control and interlocked so that only one relay will close at a time. A convenient interlocking system is one in which the circuit is so connected that, if all the studio keys are "off," any one key can close its respective relay. The succeeding studio operator would then close his key when ready but would not get the output line until the preceding studio's key had been released. Suitable indicating lamps, operated from contacts on the relays, may be used to inform each operator when the output line has been transferred to him.

Should it become necessary to simultaneously feed the outputs of two or more studios into one outgoing line, one of the studio controls should be designated as the master. The outputs from the other studios should then be routed through the master in the same manner as for remote pickups. This is the only sure method of insuring correct output level and proper balance.

Fig. 3B is a simple arrangement for selecting between two outgoing lines. Double rows of pushkeys or relays are provided and connect to loading resistors, when normal. Since the selectors are interlocked only in the vertical rows, it is possible to feed any one studio to either or both of the outgoing lines. Like Fig. 3A, these selectors can be pushkeys or relays. Although inexpensive, this system has the disadvantage of practically no attenuation between outgoing lines when they are being fed from the same studio. Also, the mixer loss must be overridden by operating the studio equipment at a higher output level. Considerable improvement in line isolation may be obtained by using the Wheatstone bridge circuit as shown in Fig. 3C. The isolation between outputs is greatly improved over the arrangement in Fig. 3B but the disadvantages of program level attenuation and the necessity of operating both outputs at the same level are still present.

A worthwhile improvement in operating performance is obtained with the arrangement shown in Fig. 3D. Here only a +8 vu output level is necessary for each studio. The studio's output is loaded with a 600 ohm resistor. Line amplifiers with high impedance (bridging) inputs are used in each outgoing line. This method has the advantage that either one or all of the outgoing lines are fed from any studio without affecting the program level or characteristics. Complete isolation is obtained between channels and different levels may be fed to each outgoing line if necessary.

Relays may be used instead of pushbuttons to permit operating the master selectors from any desired remote position. Each studio control can be provided with a remote control station from which

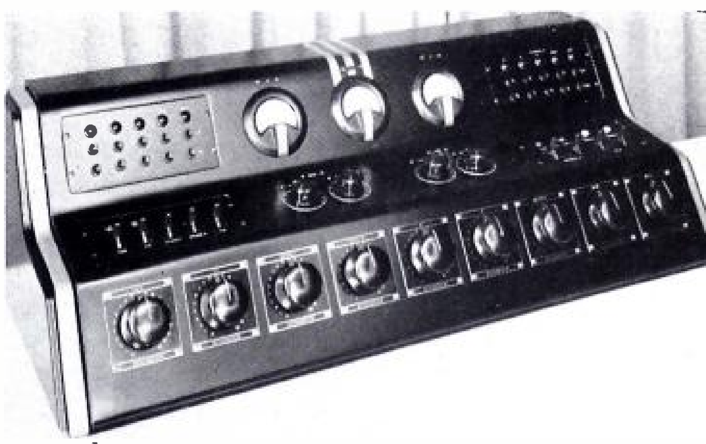


Fig. 4—Master Control Console at WHBC, Canton, Oh

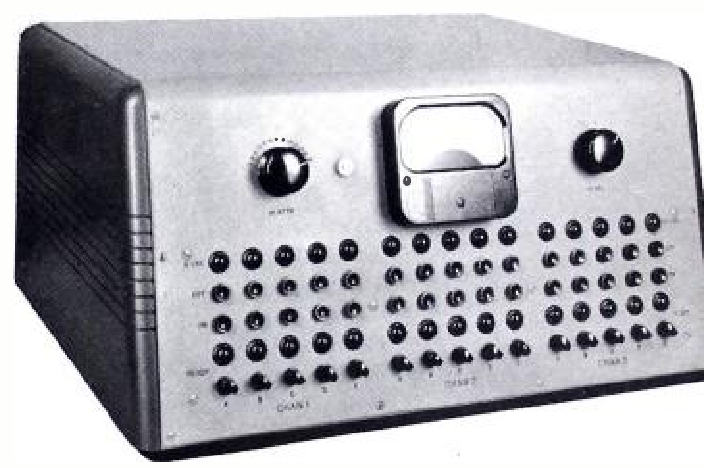
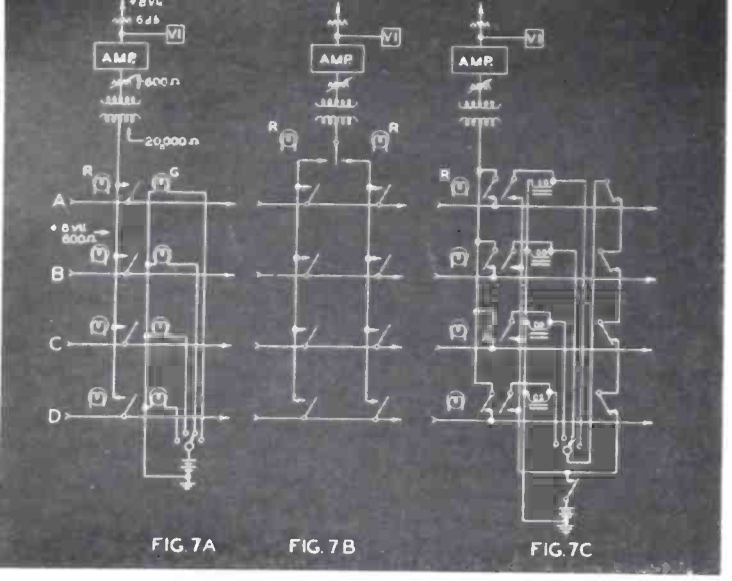


Fig. 5—Master Switching at WOV, New York.

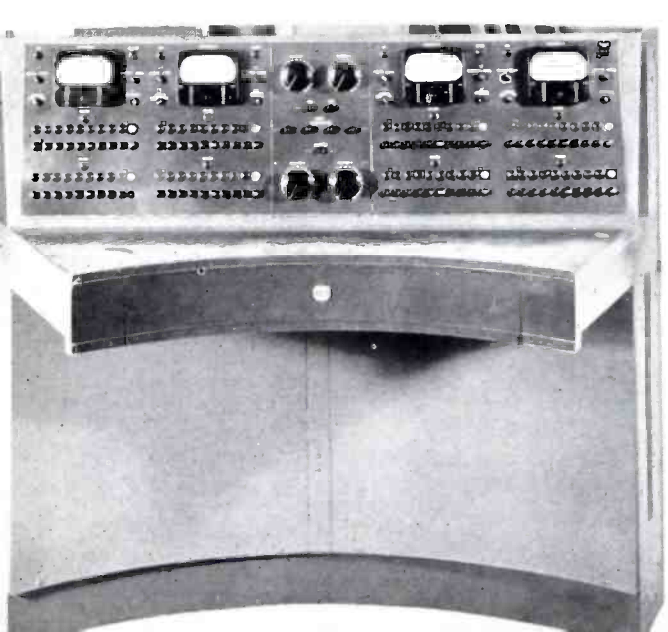
Fig. 6—Master Control Panel at WIRE, Indianapolis



the complete master control can be operated. A typical control of this type is shown in Fig. 4. The studio mixer console is equipped with two panels of master control selector keys. A panel is used for each of the two outgoing channels. From this console, any of the three studios, the remote pickup input, and the incoming network may be dispatched to either outgoing channel. Another example is shown in Fig. 5 which consists of a remote master control console. One of these consoles is located in each studio control room and provides switching facilities for five studios and three outgoing channels. Indicator lamps show the circuits in use and a standard vu meter may be switched across the output of each of the three channels. The "READY" lamps and keys are for simplified "present" as described in Figure 7A.

Whenever a master control position is utilized, it is desirable to have master gain controls in each outgoing line. These controls are usually operated at a normal attenuation of 10 or 15 db and can be increased or decreased as required. They also permit the operator to fade an outgoing channel and thereby avoid a sudden break. The master gain control should not be connected in the output of the line amplifier because its attenuation will necessitate the operation of the amplifier at a high output level resulting in increased distortion. The preferred method is to connect the master gain control in the input to the line amplifier and use bridging coils between the selectors and the variable attenuators as shown in Fig. 3E. This system is ideal because it has advantages of all the others. The program may be easily and quickly dispatched to six or more outgoing lines from any number of studios. The actual switching is accomplished without affecting the level or load impedance of the circuits involved. A typical panel layout of a system of this type is shown in Fig. 6.

Fig. 8—Master Control Panel at WFBR, Baltimore.



Pre-set Systems

The primary purpose of a master control selector system is to permit the operator to execute comparatively complicated dispatching with a minimum of mistakes and time. In the average installation utilizing a number of studios it is usually necessary to switch several studios in the space of a few seconds at the quarter-hour station break interval. It would be impossible for a single operator to attempt to make the required switching with patch cords and the possibilities of making mistakes would be numerous. With convenient switching arrangements such as those described above, the dispatching operation is greatly expedited but the chance for errors has not been eliminated. It is difficult for the operator to refer to his schedule sheet and operate the many switching functions in the alloted time. A reduction of errors and an increase in efficiency result when a "pre-set" arrangement is used. A "pre-set" system permits the operator to set up the succeeding dispatching circuits ahead of time, thus simplifying the actual selector switching. A number of "preset" circuits have been devised and they all have certain advantages.

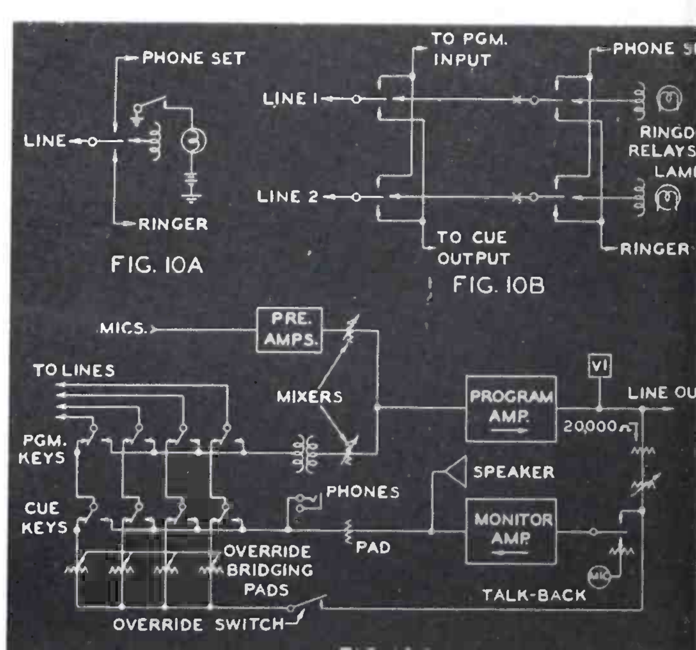
One of the simplest "preset" circuits is that shown in Fig. 7A. Pushbutton selector switches are used in the audio circuits and

Fig. 9—Master Control Panel at WFAA, Dallas.

only the indicator lamps are utilized in the presetting arrangement. The operator can rotate the preset switch and light a green lamp located next to the pushbutton associated with the studio in which the succeeding broadcast is to originate. This procedure is followed for each of the outgoing channels and, at the time of making the actual switch, it is only necessary for the operator to push the buttons beside the green lights. As an added convenience, red lamps are lighted through contacts on the selector switches and give a quick indication of the studio in use. Although simple, this circuit has one disadvantage. The particular studio pushkey associated with each channel must be depressed at the time of actual transfer because the audio circuit has not been preset. Also, its use is restricted to the master control room and the switching operation cannot be made from the studio nor can all channels be operated simultaneously.

Another version of pushbutton selector switching systems with "preset" is shown in Fig. 7B. In this circuit two rows of pushbuttons are used for each outgoing channel.* Only one row is

* Mechanically interlocked push keys must be used with the interlocking arranged vertically in Fig. 7B. This is necessary to prevent cross connecting the "on-air" and "pre-set" studios in the key banks should two keys be accidentally depressed.



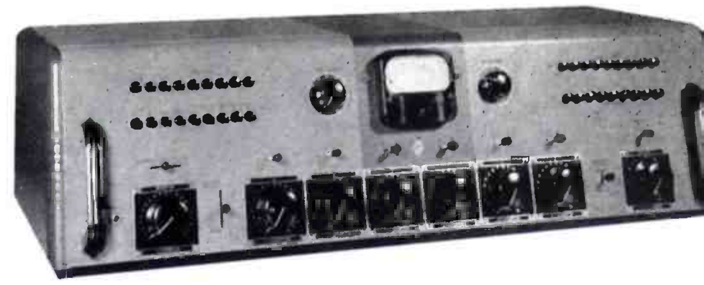


Fig. 13—RCA Type 76B-2 Consolette.

used at a time thereby leaving the other row free for the "preset." Red indicator lamps show which row of pushbuttons is in use. The outgoing line is switched between the two rows of pushbuttons by means of a key-switch on relays. The use of relays is preferred because they can be operated from a single non-locking pushkey and, since the same key is pressed every time, the operating routine is easily maintained. Relays also permit ganged operation from a single "MASTER OPERATE" pushkey so that all the channels can be switched simultaneously from a single key. A typical master control panel of this type is shown in Fig. 8. A total of nine studios may be dispatched to four outgoing channels. Two rows of pushbuttons are provided for each channel as is a vu meter and a master gain control. Lamps associated with each row of pushkeys give ready indication of the circuits in use. The transfer between key banks is made by relays which are controlled from the "OPERATE" pushbutton located at the lower right corner of each vu meter. By means of the turnkeys located at the right and left center of each meter, the operating control is transferred to the studio control room or to the "MASTER OPERATE" key in the center panel. This system has two minor disadvantages. The first is the ever-present possibility that the operator may try to preset on the key bank which is in use and interrupt the broadcast and the second is the comparatively large amount of panel space required. Some may object to having the audio circuits connected to so many switches and carried through the flexible cables on the control panels. However, stations using this system over a considerable length of time report very satisfactory service.

Fig. 7C shows a basic circuit for the ultimate in master control switching systems. It is the type used by most of the larger stations and network control rooms. The audio switching is handled by relays which can be "preset" and operated from the control desk. The operation can also be made from the studio control rooms and the "MASTER OPERATE" key can be made to trip any combination or all of the channels. The circuit is particularly fool-proof because the same rotary switch is always used for presetting and no interruptions can result from turning it during a broadcast. As soon as each relay has operated, its self-locking contacts hold it in place and additional contacts prevent the other relays from closing. The transfer is made by operating a non-locking, normally closed push or lever key. When the relay power is momentarily broken, all relays drop open. The instant the "OPERATE" key is released to normal, the relay, whose coil circuit has been completed through the "preset" switch, immediately closes and locks in. The "preset" switch is then free and can be set for the next transfer. A typical master control board using this circuit is shown in Fig. 9. Ten studios may be dispatched to six outgoing channels. Two rows of lamps are provided for each channel, one to indicate the studio feeding the channel and the other to indicate the studio that has been preset. The "OPERATE" lever-key is located in the center below the "PRESET" and "MASTER" gain control knobs. This key is non-locking in the right "OPERATE" position and locking in the left "MASTER" position. The "MASTER OPERATE" key in the center of the entire panel will trip all channels having keys thrown to "MASTER." Each channel is equipped with a power "OFF-ON" switch located in the lower left corner of each panel. A "STUDIO ON AIR" lamp under each vu meter indicates when the studio operator has thrown his output key. Many of these installations have been in continuous use for several years and relay troubles have been negligible. Although the original cost is higher than the other systems we have described, the improved performance and lessened possibility for operating mistakes make it a sound investment.

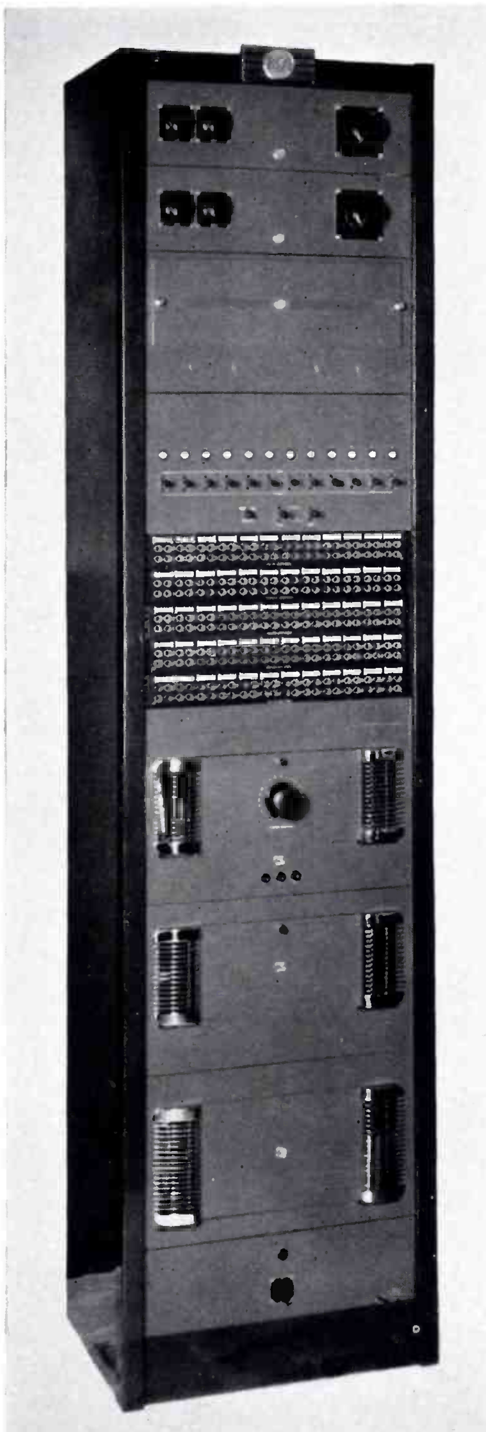
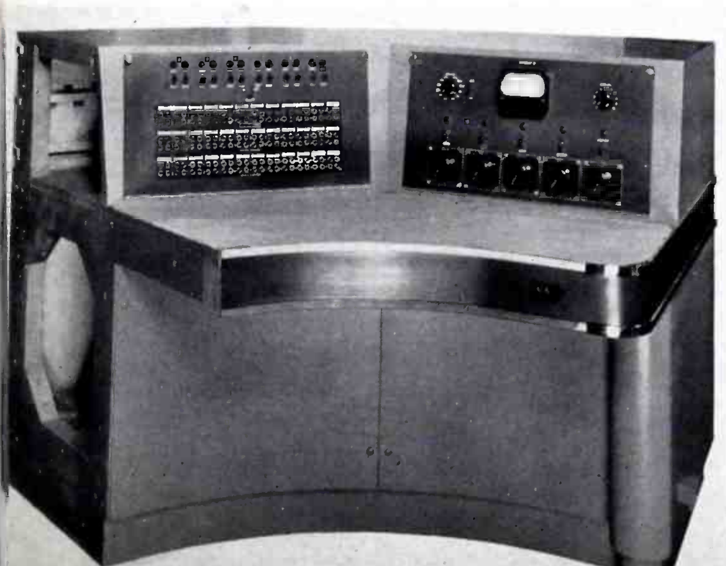


Fig. 11—Remote Line Termination Rack at WHBC, Canton, Ohio.

Fig. 12—Remote Line Termination Panel at WIRE, Indianapolis.



Remote Pickup Circuits

The handling of incoming circuits from remote pickups involves two considerations. The

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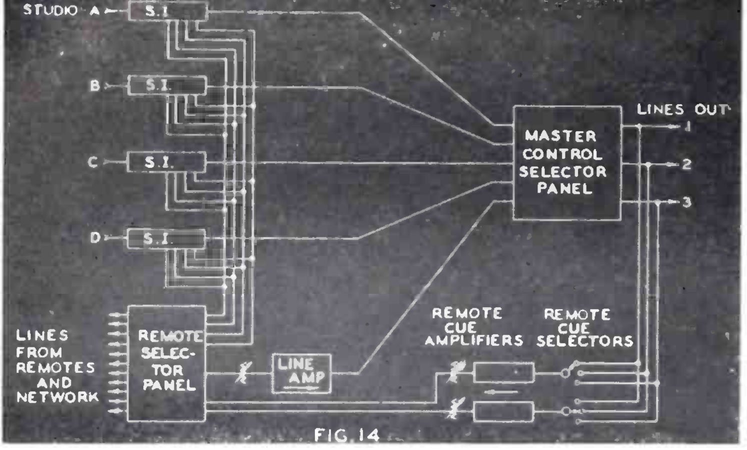

FIG. 14

SPEECH INPUT SYSTEMS

(Continued from Page 11)

first is the method of routing the incoming program and the second is the method of maintaining communication with the operator or announcer at remote locations. The safest system and the one used by networks and most stations for important programs is the use of two lines; one for the program and the other for the talking circuit. The order wire (talking circuit) is usually terminated on a ringdown panel at the studios. A lever key, in its normal position, connects the line to a relay which closes, locks in and lights an indictaing lamp when ringing current is sent in. As shown in Fig. 10A, the two operating positions of the leverkey connect the line to a telephone hand-set or to the source of ringing current for calling out. A typical rack-mounted ringdown panel is shown in Fig. 11.

For reasons of economy, many stations desire to use just one line on less important pickups. Successful operation can be accomplished with one line by utilizing the line for communication until the actual broadcasting begins. Once the program is on the air, however, no communication facilities are available which may prove embarrassing in case of trouble on important pickups. The scheme shown in Fig. 10B provides an installaiton which is readily adapted to both one and two line remote. If only one line is to be used, it is connected to a lever-key which connects the line to the input of the speech input equipment or to the "cue" output. When the first lever-key is in its normal position, the line is connected through a second lever-key which is in the usual order-wire ringdown circuit. This arrangement permits the remote operator to ring-in and talk with the studio upon arrival at location. The studio operator can then feed the cueing program to the line until the remote is to go on the air, at which time the lever-key is thrown to the program position. Attention is called to the fact that when the circuit is set up for broadcasting, it is impossible for the cueing and talking circuits to interfere with the program. By inserting jacks or accessible terminals into the circuit between the two keys (as indicated by "x" in Fig. 10B) the arrangement is readily converted to a two-line system for commercial and more important pickups. A remote switching panel utilizing this system is shown in Fig. 12. Switching facilities are provided for six remote lines.

Another one-line circuit which has become popular in the lower-powered stations, is shown in Fig. 10C. Two banks of pushkeys are used. The first bank permits the incoming remote lines to be switched into the speech input equipment. When the keys of the first bank are normal, the line is connected through to the second bank. The keys of the second bank are normal, the line is connected to "override bridging pads" the combined outputs of which are connected to the input of the monitoring amplifier through an off-on switch. When this switch is on, a remote operator can talk into his microphone and be heard by the studio operator over the program being monitored on the control room loudspeaker. The studio operator can then talk to the remote operator by closing the proper "cue" key and speaking into the talkback microphone. After the "cue" key has been closed, it becomes necessary for the studio operator to listen to the remotes by means of headphones plugged into the jack shown on Fig. 10C. Sufficient attenuation is provided in the monitor bridging pad to keep the override signal from cross-talking onto the program line above a level equivalent to that of the hum and noise in the system. Thus it is possible to handle the program, "cue" and two-way communication over one line without the use of hand-sets or ringers. A commercial speech input equipment successfully utilizing this type of circuit is shown in Fig. 13. Switching facilites are provded for six remote lines. Two banks of program keys are used to permit the handling of two pickups simultaneously. One pickup can be on the air while "cue" or two-way communication is being conducted on another.

The larger multi-studio installations require special consideration with regard to remote input switching. Because it is often necessary to mix a studio announcement or another program with the incoming remote program, special facilities must be provided to permit the master operator to route the remote through a studio control. This is usually accomplished by having one or two mixers reserved for outside programs in each studio control equipment. Lines connect these mixers to jacks in the master control room and the master operator can patch the remote into the studio. For those cases where no mixing is necessary in a studio control, the master operator may wish to route the remote directly into the master selector system. Facilities for both methods are usually included. Fig. 15 shows the circuit of a typical installation. The remote lines and incoming networks terminate in the master control room from which they are dispatched to the studio controls or directly into the master selectors. An amplifier is provided in the direct circuit to bring the remote program to the same level as the studio outputs. The lines to the studio controls are shown multipled. Such an arrangement is often used, especially for the incoming networks, because it permits the outside programs to be taken in any or all of the studios. The multipled lines are bridged in the studio controls. Cueing amplifiers,

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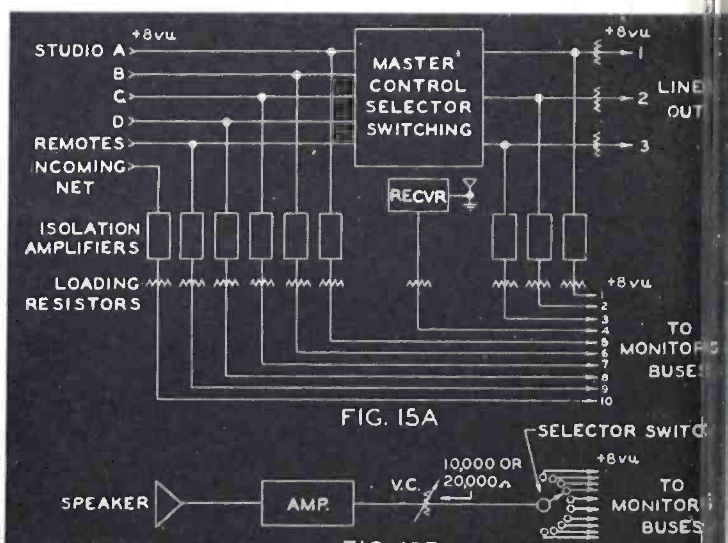


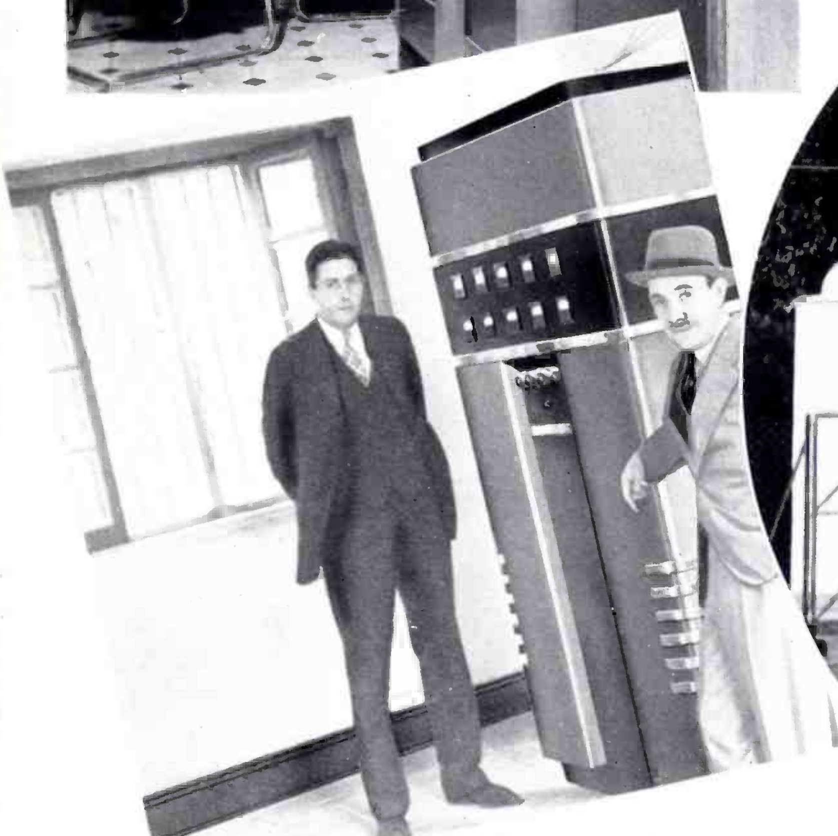
FIG. 15A

FIG. 15B

◄A corner of the control room at this leading Mexican station showing RCA turntables and consolette.

In Monterrey It's RCA

An excellent modern transmitter plant for XEH. ▼



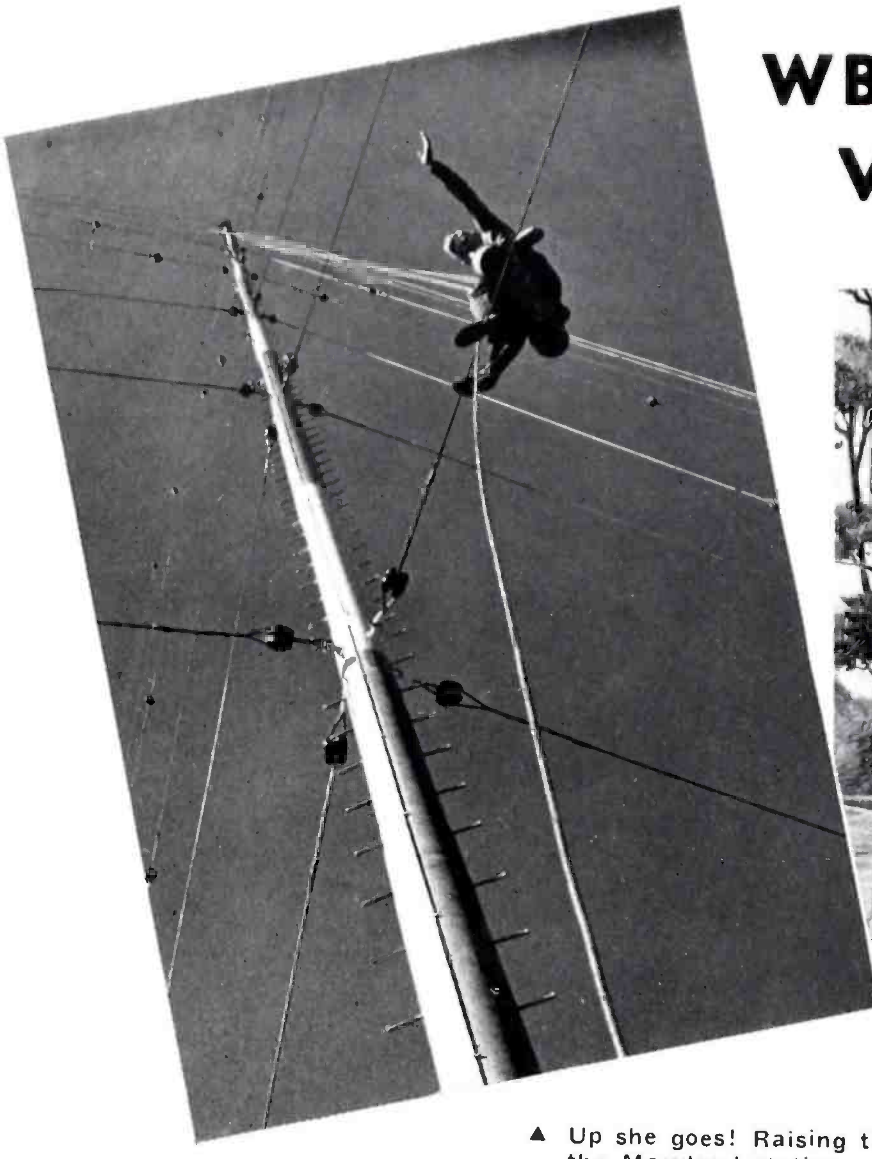
Another example of the trend to the RCA 250-K among broadcasters domestic and foreign.

At KYCA It's RCA

A swivel chair brings everything within reach in this compact arrangement at Prescott, Arizona.

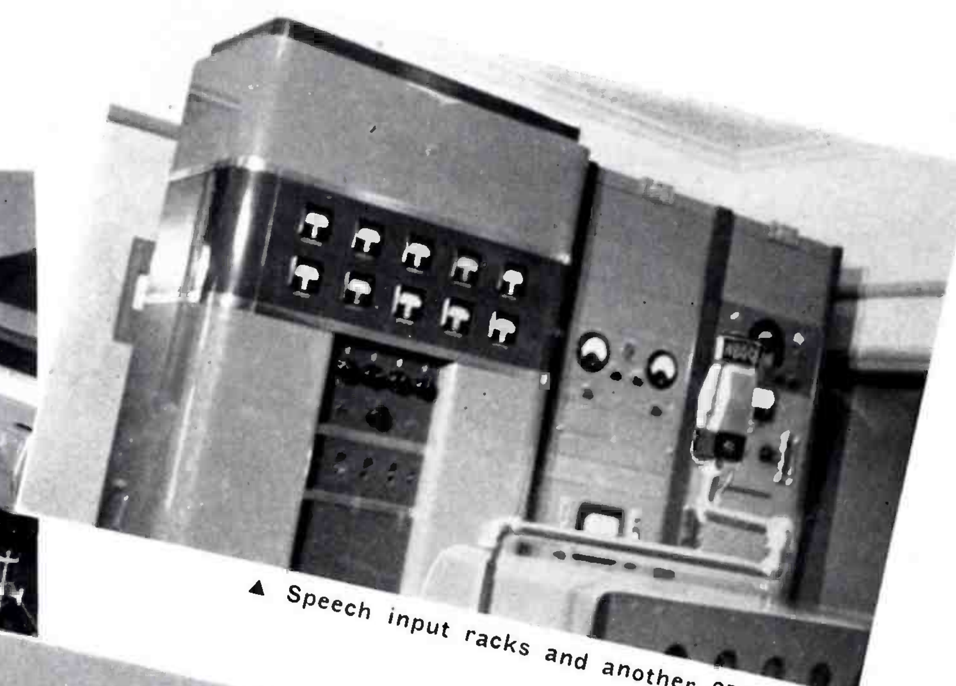
The 250-K must have something—there's another one in case you missed it.

WBOC, SALISBURY, MD.
Voice of the Eastern Shore



▲ Architect's sketch of the transmitter house for WBOC.

▲ Up she goes! Raising the antenna for the Maryland station.

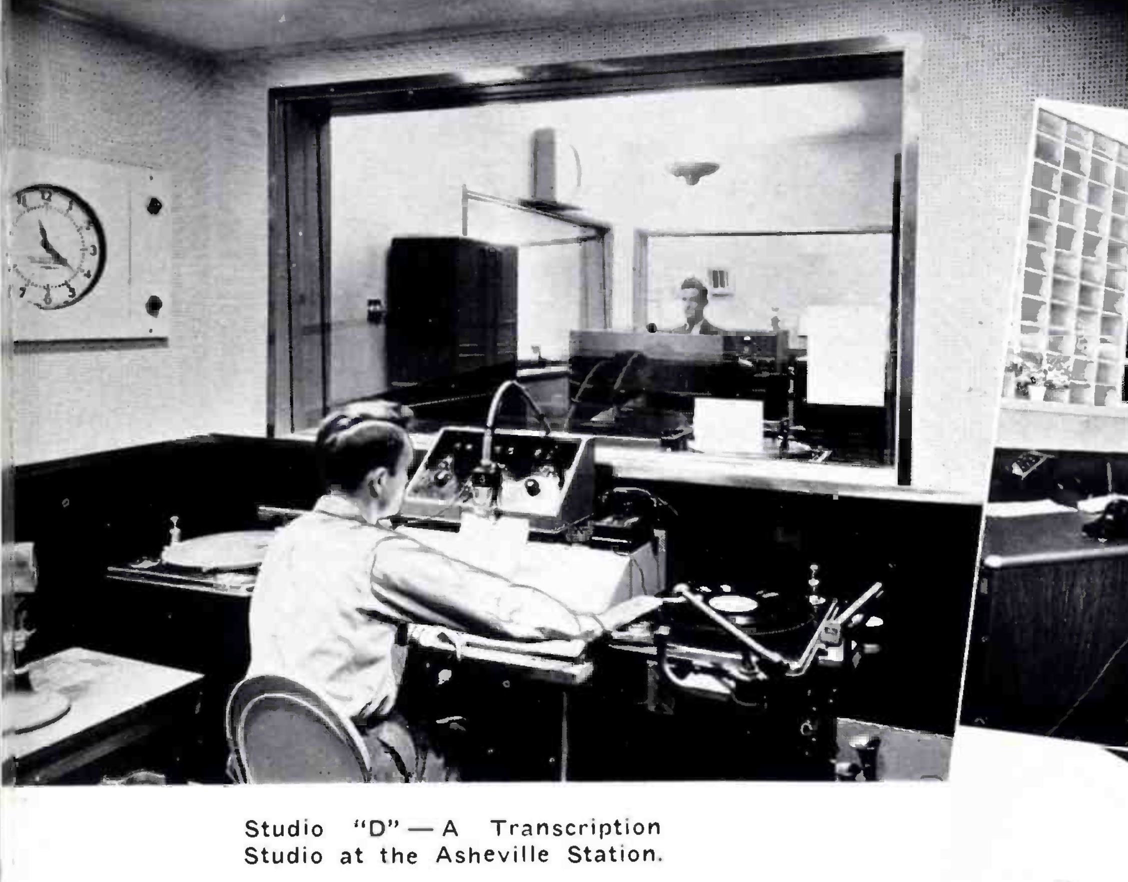


▲ Speech input racks and another 250-K.

▲ RCA consolette and turntables in action at the Salisbury station.

A program on the air with a ▶ 74-B and a 77-C1 mike in action.

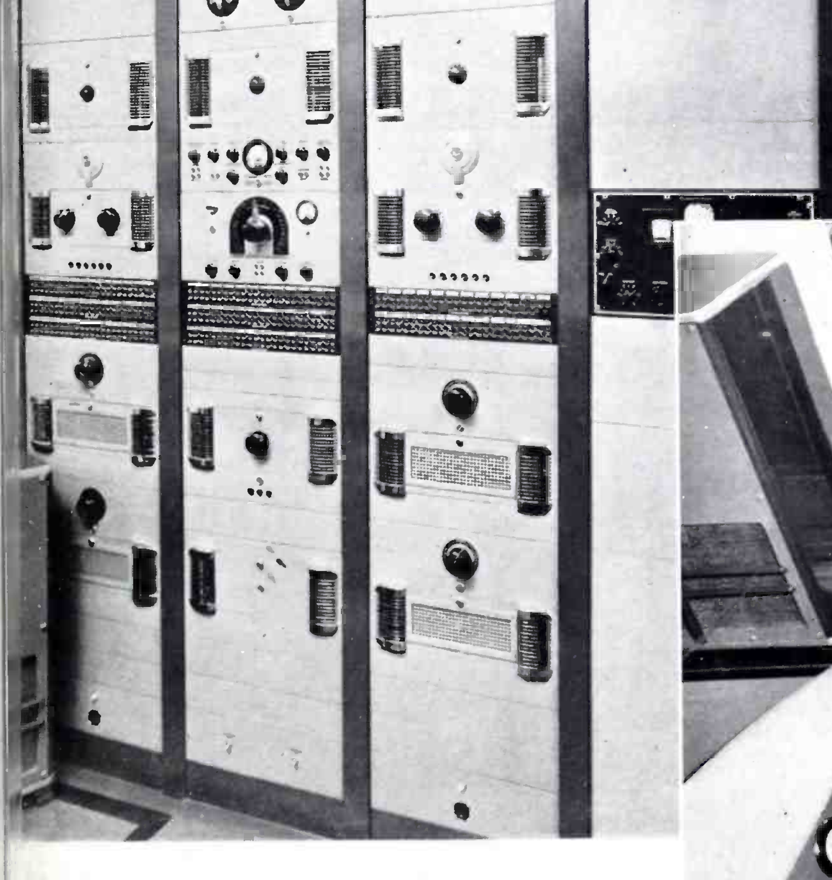
WWNC—One of North Carolina's Progressive Stations



Studio "D" — A Transcription Studio at the Asheville Station.

The reception room at WWNC with a 64-B Speaker in the Background. ▼

Studio "A." Note the Plentiful Supply of RCA "Mikes" for Every Purpose. ▶



▲ Speech Input Racks in the Control Room.

Cecil B. Hoskins, Chief Engineer, at the Control Console. ▶

CHARACTERISTICS OF UNBALANCED OVERHEAD TRANSMISSION LINES

By DR. G. H. BROWN
RCA Manufacturing Co., Inc.

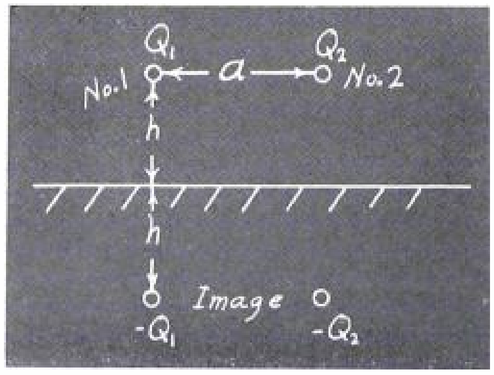


Fig. 1.

I. Introduction

IN broadcast practice, overhead transmission lines made up of a number of conductors have been used for several years. The usual custom has been to tie several conductors together and operate them at high potential with respect to the ground. The remaining conductors are then tied together and grounded. It is the purpose of this paper to consider the physical constants of this type of line which are of engineering interest. A study of these constants includes a consideration of the characteristic impedance of the transmission line, as well as the transmission loss.

II. Method of Computing the Characteristic Impedance

The characteristic impedance of a low loss transmission line is given by

$$Z_c = \sqrt{\frac{L}{C}} \text{ (ohms)} \qquad (1)$$

where L is the inductance per unit length (henries per centimeter) while C is the capacitance per unit length (farads per centimeter). Again, in a low loss line, the velocity of propagation is

$$v = \frac{1}{\sqrt{LC}} \qquad (2)$$

where $v = 3 \times 10^{10}$ centimeters per second. If we substitute (2) in (1), we find that

$$Z_c = \frac{1}{vC} \qquad (3)$$

From equation (3), we see that we may readily compute Z_c if the capacity per unit length is known.

To illustrate the method of computation of the capacity per unit length, let us refer to Fig. 1. Here two conductors, each of radius ρ, are placed at equal heights above a conducting plane. These conductors are semi-infinite in length and run normal to the surface of the page. Each conductor is raised to some arbitrary voltage. The choice of these voltages will determine the charge distribution. Let us suppose that Conductor No. 1 has a charge of Q_1 coulombs per unit length, while Conductor No. 2 bears a charge of Q_2 coulombs per unit length. Making use of the system of logarithmic potentials, the voltage above ground of Conductor No. 1 is*

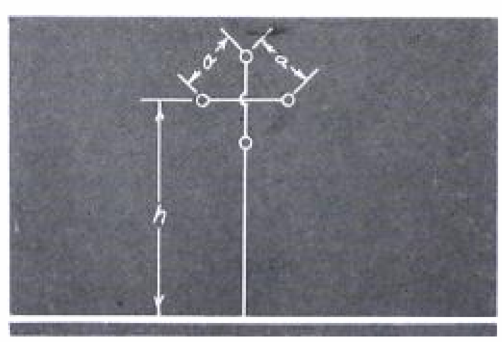


Fig. 2.

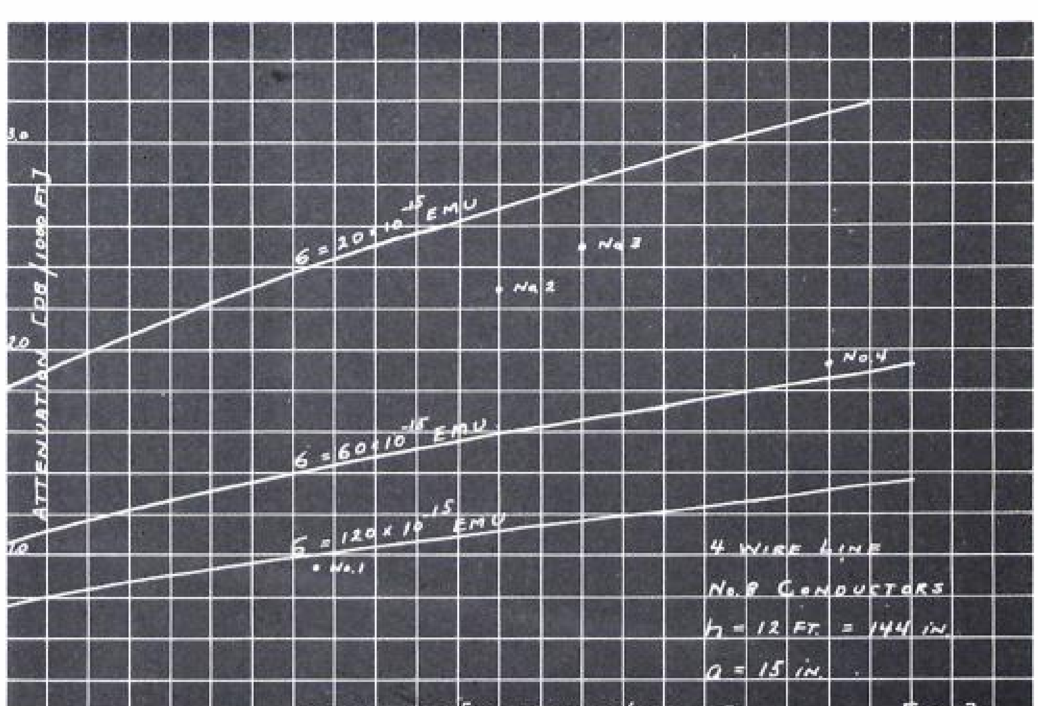
$$E_1 = 60v\left[Q_1 \log\frac{1}{\rho} - Q_1 \log\frac{1}{2h} + Q_2 \log\frac{1}{a} - Q_2 \log\frac{1}{\sqrt{(2h)^2+a^2}}\right] \qquad (4)$$

In this equation, the first term is the contribution to the total voltage due to the charge on Conductor No. 1, the second term is that caused by the image of No. 1, the third term is set up by the charge on No. 2, while the fourth term is caused by the image of No. 2. Rewriting (4),

$$E_1 = 60v\left[Q_1 \log\frac{2h}{\rho} + Q_2 \log\frac{\sqrt{(2h)^2+a^2}}{a}\right] \qquad (5)$$

* All logarithms used in this discussion will be taken with respect to the natural base unless otherwise designated.

Fig. 3.



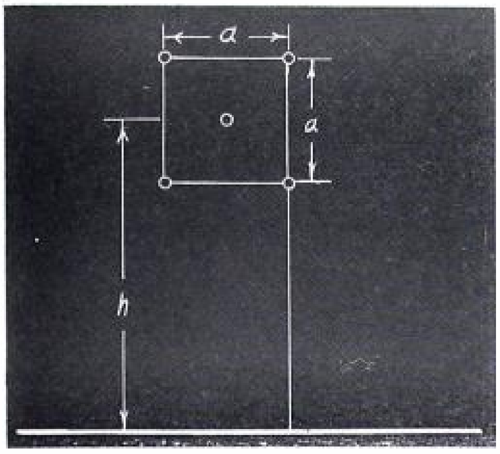


Fig. 4.

Following the same procedure, we find the voltage of No. 2 to be

$$E_2 = 60v \left[Q_1 \log \frac{\sqrt{(2h)^2 + a^2}}{a} + Q_2 \log \frac{2h}{\rho} \right] \qquad (6)$$

Now let us ground Conductor No. 2 so that it is at ground potential. That is, $E_2 = 0$. Under this condition, (6) yields

$$\frac{Q_2}{Q_1} = \frac{-\log \frac{\sqrt{(2h)^2 + a^2}}{a}}{\log \frac{2h}{\rho}} \qquad (7)$$

Equation (5) then becomes

$$\frac{E_1}{Q_1} = 60v \left[\log \frac{2h}{\rho} + \frac{Q_2}{Q_1} \log \frac{\sqrt{(2h)^2 + a^2}}{a} \right] \qquad (8)$$

But $\dfrac{E_1}{Q_1} = \dfrac{1}{C}$

Making use of (3),

$$Z_c = 60 \left[\log \frac{2h}{\rho} + \frac{Q_2}{Q_1} \log \frac{\sqrt{(2h)^2 + a^2}}{a} \right] \qquad (9)$$

If the spacing between conductors is small compared to the height above ground, (7) reduces to

$$\frac{Q_2}{Q_1} = \frac{-\log \frac{2h}{a}}{\log \frac{2h}{\rho}} \qquad (10)$$

and (9) becomes

$$Z_c = 60 \left[\log \frac{2h}{\rho} + \frac{Q_2}{Q_1} \log \frac{2h}{a} \right] \qquad (11)$$

So for a multi-wire line, we follow the same procedure. The voltage of each conductor is written in terms of the line dimensions and the charges on each conductor. If there are $m + n$ conductors, there will then be $m + n$ equations. If there are n grounded conductors, the corresponding voltage equations are set equal to

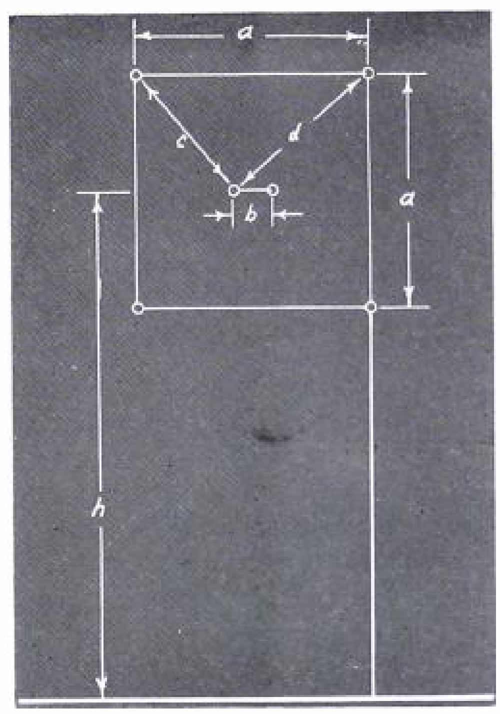


Fig. 5.

zero. These n equations, when solved, will then yield the ratio of the charge on the n grounded conductors to the charge on the m insulated conductors. The remaining m equations may then be quickly solved to yield the characteristic impedance.

The charge ratio equations, equation (7) for example, furnish other important information. The current flowing in any wire on a matched transmission line is related to the charge per unit length by the following simple relation.

$$I = vQ \qquad (12)$$

so that the ratio of the charges is the same as the ratio of the currents. That is, (7) is the ratio of the current flowing in the grounded conductor to the current flowing in the insulated conductor.

We will now assign specific values to the line in question. Assume that No. 8 conductors are used. Then $\rho = 0.064$ inch.

$h = 12$ feet $= 144$ inches.

$a = 15$ inches.

Equation (10) then yields

$$Q_2/Q_1 = -0.35$$

Substituting this value in (11), we find

$$Z_c = 443.0 \text{ ohms}$$

Since the ratio of the charges is -0.35, the ratio of the current in the ground wire to the current in the hot wire is

$$\frac{I_{gw}}{I_{hw}} = -0.35$$

The current flowing back in the ground plus the ground wire current is equal in magnitude to the hot wire current. Therefore,

$$\frac{I_{gd}}{I_{hw}} = -0.65$$

If we now substitute these values in equations (18A) and (3B),* we find that the attenuation of the line in a matched condition is decibels per 1000 feet =

$$\left[1.09 \sqrt{\frac{10^{-13}}{\sigma_{emu}}} + 0.086 \right] \sqrt{f_{mc}}$$

* Refer to Appendix A and Appendix B.

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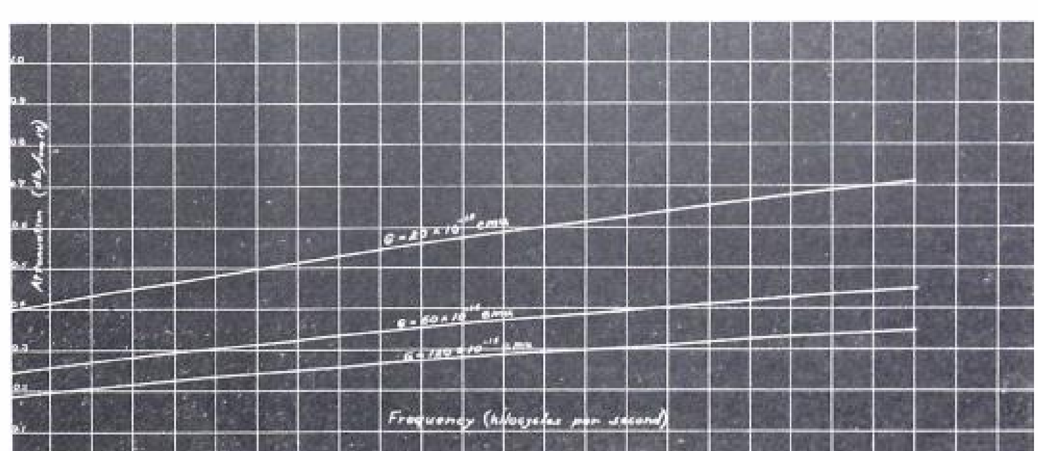
Fig. 6. Six Wire Line, RCA MI-9421 Assembly. h 12 ft.



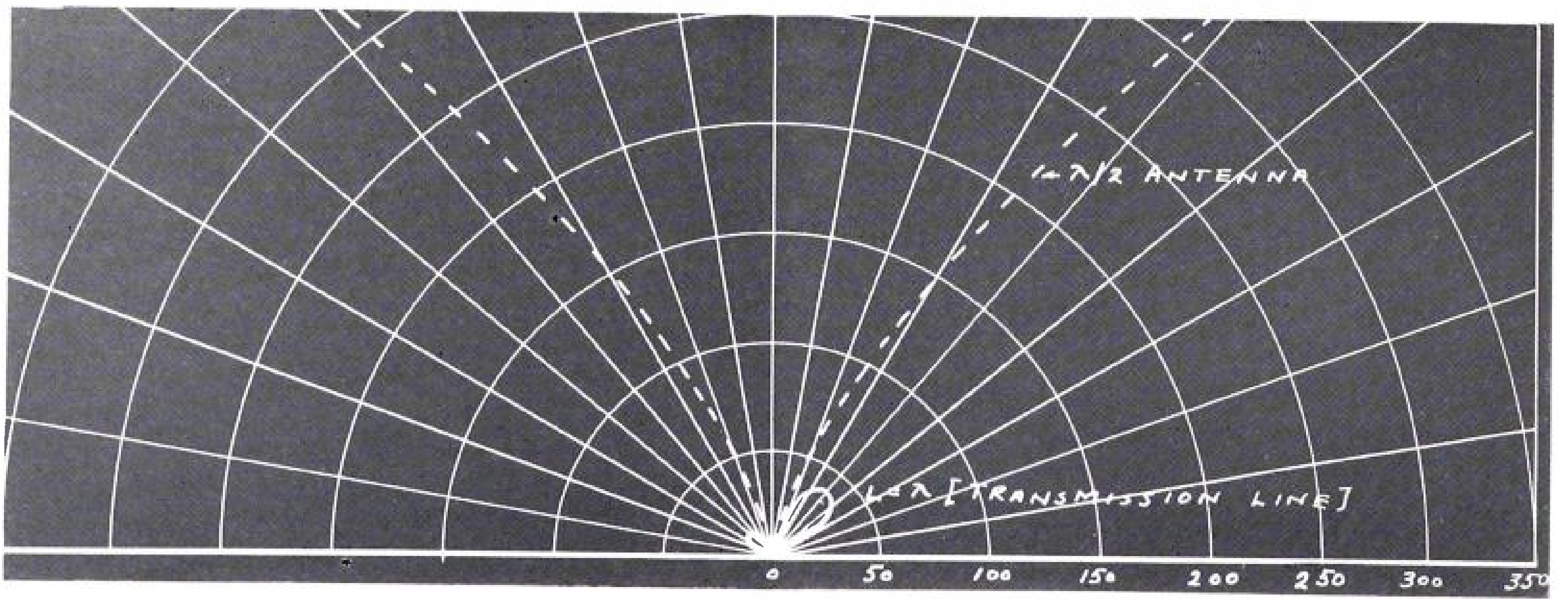


Fig. 7. Millivolts/meter at one mile.

III. The Four-Wire Line

Fig. 2 shows a four-wire transmission line which has been used quite extensively. Here the four wires are mounted on the corners of a square, where the square is a units on a side. Diagonally opposite wires are connected together, and one pair is grounded. Under this condition,

$$\frac{Q_{gw}}{Q_{hw}} = \frac{I_{gw}}{I_{hw}} = -\frac{\log\left(\frac{2h}{a}\right)^2}{\log\frac{(2h)^2}{\sqrt{2}a\rho}} \tag{13}$$

and

$$Z_c = 30\left[\log\frac{(2h)^2}{\sqrt{2}a\rho} + \frac{Q_{gw}}{Q_{hw}}\log\left(\frac{2h}{a}\right)^2\right]$$

$$= 30\left[1 + \frac{\log\left(\frac{2h}{a}\right)^2}{\log\frac{(2h)^2}{\sqrt{2}a\rho}}\right]\log\frac{a}{\sqrt{2}\rho} \tag{14}$$

Then, with No. 8 conductors, and a equal to fifteen inches, the following conditions prevail.

(See Table I.)

Measurements of capacity were made on a four-wire line, where the height was 12 feet and the other dimensions corresponded to those used in Table I. With a line length of 210 feet, the total capacity as measured by means of a 1000-cycle capacity bridge was found to be 920×10^{-12} farads. This corresponds to 0.1438×10^{-12} farads per centimeter. Substituting this value in (3), the characteristic impedance is found to be 232.0 ohms.

Figure 3 shows the attenuation of the four-wire line as a function of frequency for several values of soil conductivity. On this same curve sheet, measured values of attenuation are shown for four similar transmission lines installed at four separate locations. The line which corresponded to Point No. 1 ran over a swamp where the surface water was several inches deep. The line which gave Point No. 2 was placed above a combination of cinders and sand, while Point No. 3 was taken on a line which ran over sandy soil. The line corresponding to Point No. 4 was placed above a sandy loam soil.

Figure 3 shows that the attenuation is serious where long lengths of transmission line are used over poor soil at high frequencies.

IV. A Five-Wire Line

Fig. 4 shows a five-wire transmission line which has been used in a few installations. Four grounded conductors are placed at the corners of a square, with a single insulated conductor placed in the center of the square. For this arrangement

$$\frac{Q_{gw}}{Q_{hw}} = \frac{I_{gw}}{I_{hw}} = \frac{-\log\frac{2\sqrt{2}h}{a}}{\log\frac{2h}{(\sqrt{2}\rho)^{1/4}a^{3/4}}} \tag{15}$$

and

$$Z_c = 60\left[\log\frac{2h}{\rho} + \frac{Q_{gw}}{Q_{hw}}\log\frac{2\sqrt{2}\,h}{a}\right] \tag{16}$$

TABLE I

h (feet)	Z_c (ohms)	I_{gw}/I_{hw}	I_{gd}/I_{hw}	Attenuation (decibels per 1000 feet)
18	238.5	−0.558	−0.442	$\left[0.623\sqrt{\frac{10^{-13}}{\sigma_{emu}}} + 0.093\right]\sqrt{f_{mc}}$
12	234.0	−0.526	−0.474	$\left[1.1\sqrt{\frac{10^{-13}}{\sigma_{emu}}} + 0.0925\right]\sqrt{f_{mc}}$
6	223.0	−0.458	−0.542	$\left[2.875\sqrt{\frac{10^{-13}}{\sigma_{emu}}} + 0.092\right]\sqrt{f_{mc}}$

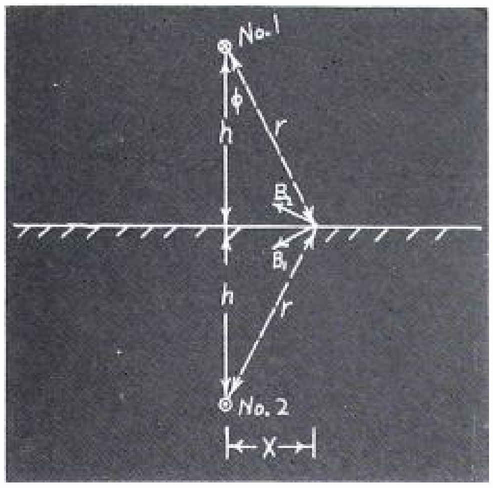


Fig. 8.

With No. 8 conductors, $a = 15$ inches, and $h = 12$ feet (144 inches).

$$I_{gw}/I_{hw} = -0.785$$

and

$$I_{gd}/I_{hw} = -0.215$$
$$Z_c = 350.0 \text{ ohms.}$$

The attenuation is

$$\left[0.151 \sqrt{\frac{10^{-13}}{\sigma_{cmu}}} + 0.11\right]\sqrt{f_{mc}}$$

= decibels for 1000 feet.

Because the current in the ground wires is very nearly equal to the current in the hot wire, the earth loss is greatly reduced. However, the value of the characteristic impedance is too high for good design of coupling equipment. The value of 234.0 ohms secured with the four-wire line proved to be a desirable value to aim for. Accordingly, a search was made for a line which would approach the loss characteristics of the five-wire line and at the same time have a characteristic impedance close to 234.0 ohms.

V. A Six-Wire Line (RCA MI-19421 Assembly)

The arrangement shown in Fig. 5 proved to have very useable properties. Four wires are arranged at the corners of a square. These wires are connected together and grounded. Two other conductors are mounted within the square as shown. These two wires are tied together and operated above ground potential. In this mode of operation,

$$\frac{Q_{gw}}{Q_{hw}} = \frac{I_{gw}}{I_{hw}} = \frac{-\log \dfrac{2h}{\sqrt{cd}}}{\log \dfrac{2h}{\rho^{1/4}a^{1/2}(\sqrt{2}\,a)^{1/4}}} \quad (17)$$

and

$$Z_c = 30\left[\log\frac{(2h)^2}{\rho b} + \frac{Q_{gw}}{Q_{hw}}\log\frac{(2h)^2}{cd}\right] \quad (18)$$

where

$$c = \tfrac{1}{2}\sqrt{a^2 + (a-b)^2}$$
$$d = \tfrac{1}{2}\sqrt{a^2 + (a+b)^2}$$

If we let

$h = 12$ feet $= 144$ inches
$a = 15$ inches
$b = 2.5$ inches
$\rho = 0.081$ inches (No. 6 wire)
$I_{gw}/I_{hw} = -0.792$

and

$I_{gd}/I_{hw} = -0.208$
$Z_c = 231.0$ ohms.

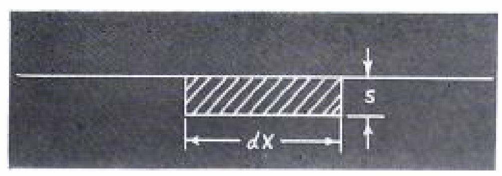


Fig. 10.

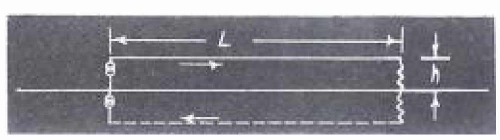


Fig. 11.

The attenuation is

$$\left[0.214 \sqrt{\frac{10^{-13}}{\sigma_{cmu}}} + 0.0755\right]\sqrt{f_{mc}}$$

= decibels for 1000 feet.

Fig. 6 shows the attenuation of this line as a function of frequency for a number of values of soil conductivity.

We shall next consider the matter of radiation from this transmission line. To be specific, let the transmitted power be 50,000 watts. Then the current in the hot wire is

$$I_{hw} = \sqrt{\frac{50{,}000}{231}} = 14.7 \text{ amperes}$$

and the ground return current is

$$I_{gd} = 0.208 \times 14.7 = 3.06 \text{ amperes.}$$

Fig. 13, Appendix C, shows the field strength radiated with one ampere of ground current. Then for the condition which we are considering, the field radiated from the line, when the line is one wave long, reaches a maximum value of about 30 millivolts per meter at one mile at an angle of about 45 degrees from the earth.

(Continued on Next Page)

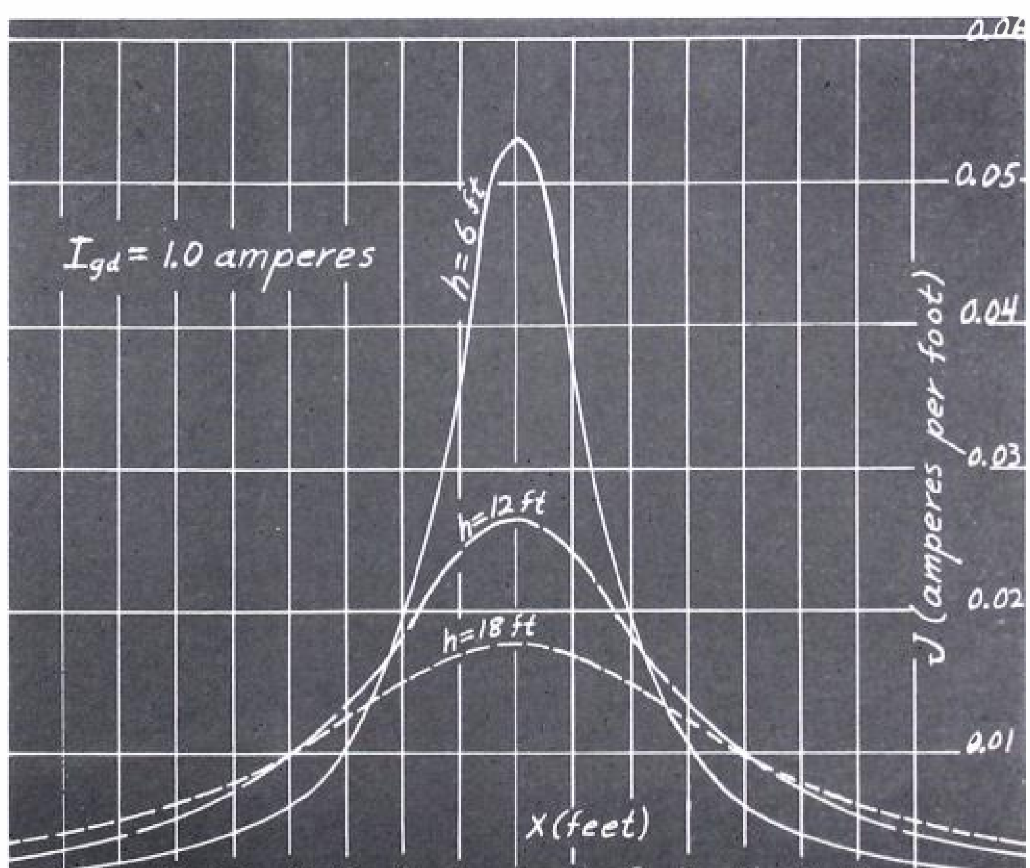


Fig. 9.

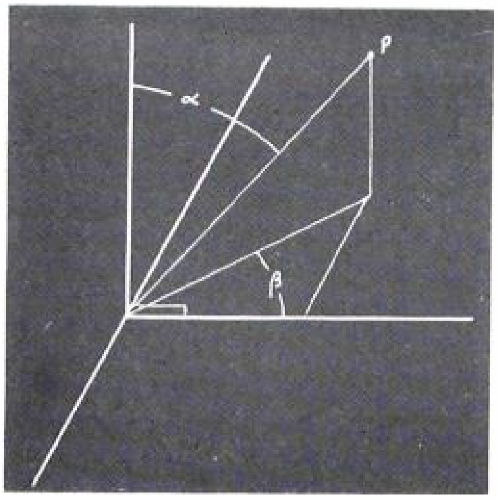


Fig. 12.

To compare the radiation from the line with that field radiated from the antenna, Fig. 7 has been prepared. With 50,000 watts into a half-wave antenna, the field strength at one mile along the ground will be 1660.0 millivolts per meter. The dotted curve on Fig. 7 shows a portion of the vertical pattern of a half-wave antenna fed with 50,000 watts, while the solid curve is the vertical pattern of the transmission line in the plane of the transmission line, where the transmission line is the RCA MI-19421 arrangement, with a height of 12 feet and an operating frequency of 1000 kilocycles.

With a frequency of 1000 kilocycles, the wavelength is 984.0 feet. With a transmitter power of 50,000 watts, $I_{gd} = 3.06$ amperes. Substituting in equation (5C), we find that the total power radiated by a line which is a half-wave long is Watts radiated $= 3500 \times 3.06^2 \left(\frac{12}{948}\right)^2 = 4.88$ watts or 0.00978 *per cent* of the total transmitter power.

For a wavelength of line, it is seen that the radiated power is 7.3 watts, or 0.0146 per cent of the transmitter power.

APPENDIX A

Losses Due to Conduction Currents in the Earth

In the multi-wire systems which we have been considering, we saw that the current returning in the grounded conductors was less than the current traveling down the line on the insulated conductors. A current which is the difference between the hot wire currents and the grounded wire currents must then flow back through the earth. To arrive at the distribution of the earth currents, we may replace our multi-wire transmission line by a single conductor, carrying a current which is the difference between the currents in the insulated and grounded conductors. Since we shall soon show that this current is equal to the current returning in the earth, we shall call the current in our new single conductor I_{gd}. In Fig. 8, we see a long conductor parallel to a conducting layer and h units above the layer. This conductor is carrying current into the paper. For the purposes of computing fields above the earth, we place another conductor or image h units below the surface of the earth. This image is effectively a conductor carrying current out of the paper. At a point x units along the earth as shown in Fig. 8, Conductor No. 1 sets up a magnetic flux density vector B_1 which is at right angles to the line r drawn from the conductor to the point in question. The magnitude of this flux density is

$$B_1 = \frac{\mu I_{gd}}{2\pi r} \qquad (1A)$$

where $\mu = 4 \cdot 10^{-9}$ and $r = \sqrt{h^2 + x^2}$. The flux density due to the image is B_2 and is exactly equal to B_1 in magnitude but points in the direction shown in Fig. 8. The vector sum of these two vectors is parallel to the surface of the earth and has a magnitude which is

$$B = 2B_1 \cos \phi = \frac{2hB_1}{r} \qquad (2A)$$

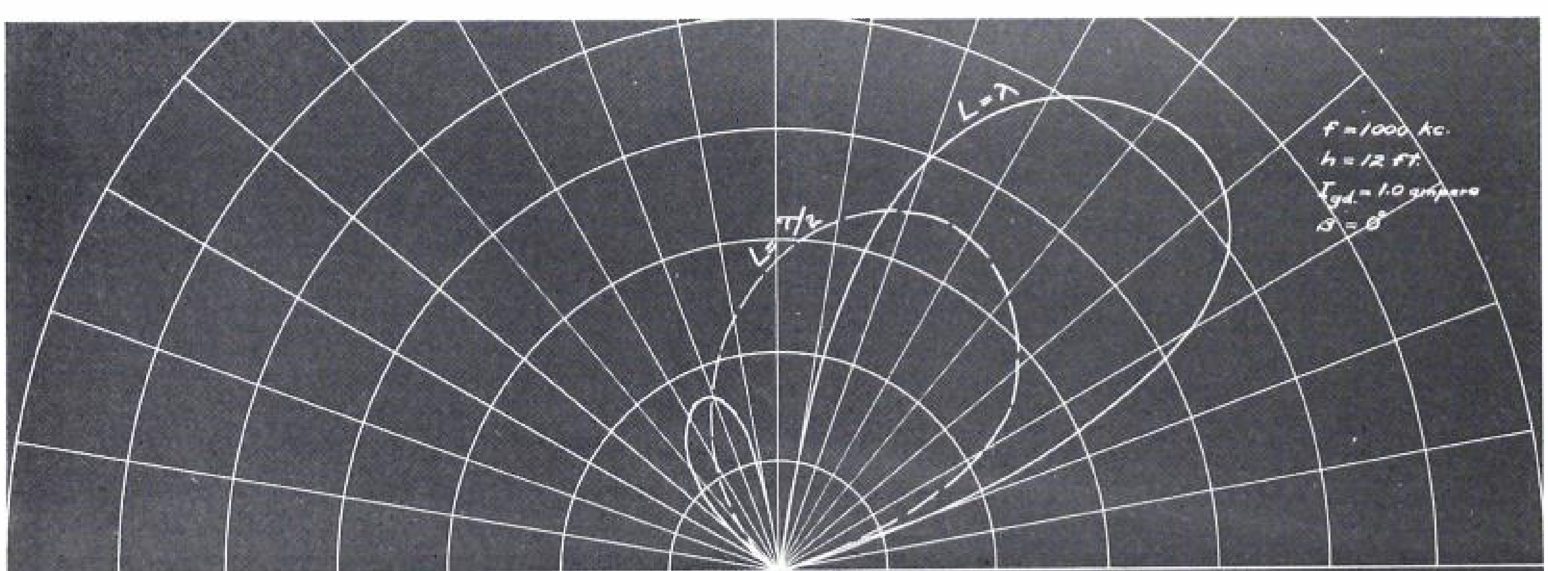
Now if the earth is a very good conductor, the current in the earth will be concentrated very near the surface. Then the current in the little patch shown in Fig. 8, where the patch is of unit width, is

$$J = B/\mu = \frac{I_{gd}}{\pi} \cdot \frac{h}{h^2 + x^2}$$

$$= \frac{I_{gd}}{\pi h} \cdot \frac{1}{1 + \left(\frac{x}{h}\right)^2} \qquad (3A)$$

The ground current is flowing out of the paper. If x and h are measured in centimeters, the current density J is measured in amperes per centimeter, while if the linear dimensions are expressed in feet, J is given in amperes per foot. Fig. 9 shows the earth current distribution in amperes per

Fig. 13.



foot, for a number of transmission line heights, with I_{gd} equal to one ampere. We see that as the transmission line is placed closer to the earth, the current density increases directly below the line, but drops off quicker in a lateral direction.

To digress from the main problem for a moment, let us sum up all of the ground current by integrating (3) from $x = -\infty$ to $x = +\infty$

Then

$$\int_{x=-\infty}^{x=\infty} J\,dx = \frac{2hI_{gd}}{\pi}$$

$$\int_{x=0}^{x=\infty} \frac{dx}{h^2+x^2}$$

$$= \frac{2}{\pi} h\, I_{gd} \cdot \frac{1}{h} \tan^{-1}\left(\frac{x}{h}\right)\Bigg|_{x=0}^{x=\infty}$$

$$= I_{gd} \tag{4A}$$

so we see that the total current flowing in the earth is equal to the current which we assumed to be flowing in the single conductor.

We will now proceed with a consideration of the losses in the earth. The current density J flows out of the paper in a small patch of unit lateral width and of thickness, s. This dimension s (Fig. 10) is the skin thickness.

$$s = \frac{1}{2\pi\sqrt{f\sigma \cdot 10^{-9}}} \tag{5A}$$

s is given in centimeters when f is the frequency in cycles per second and σ is the earth conductivity measured in mhos for a centimeter cube. The current flowing out of the patch shown in Fig. 3 is $J \cdot dx$. Now, if we measure the length along the line by a dimension y, the resistance of the patch shown, with a length into the paper taken as dy, is

$$\Delta R = \frac{dy}{\sigma s \cdot dx} \tag{6A}$$

The watts lost in this small element, by the simple I^2R law is

$$(J \cdot dx)^2 \cdot \Delta R = \frac{J^2\,dy\,dx}{\sigma s} \tag{7A}$$

If we now substitute (3A) in (7A) and integrate from $x = -\infty$ to $x = +\infty$ we have the power lost in the earth in a slice taken at right angles to the transmission line, where the thickness of the slice in the direction along the line is dy. Following this procedure,

$$\Delta P = \frac{dy}{\sigma s} \int_{x=-\infty}^{x=\infty} J^2\,dx$$

$$= \frac{2(dy)h^2 I_{gd}^2}{\pi^2 \sigma s} \int_{x=0}^{x=\infty} \frac{dx}{(h^2+x^2)^2} \tag{8A}$$

But

$$\int_{x=0}^{x=\infty} \frac{dx}{(h^2+x^2)^2}$$

$$= \frac{1}{2h^3} \tan^{-1}\left(\frac{x}{h}\right)\Bigg|_{x=0}^{x=\infty}$$

$$= \frac{\pi}{4h^3} \tag{9A}$$

so that

$$\Delta P = \frac{dy}{2\pi\sigma s h} I_{gd}^2$$

$$= \frac{I_{gd}^2 \cdot dy}{h} \sqrt{\frac{10^{-9} f}{\sigma}} \tag{10A}$$

With P watts passing a point in the transmission line, the change in power, dP, is the negative of ΔP. Let I_{hw} be the total current in the hot or ungrounded wires. The characteristic impedance of the transmission line is Z_c. Then if the transmission line is terminated in its characteristic impedance the power P is $I_{hw}^2 Z_c$.

We may then write

$$\frac{1}{P}\frac{dP}{dy} = -\left(\frac{I_{gd}}{I_{hw}}\right)^2 \cdot \frac{1}{Z_c h} \sqrt{\frac{10^{-9} f}{\sigma}} \tag{11A}$$

Again, if we have a properly matched line, the power at any point along the line is

$$P = P_0 \epsilon^{-2ay} \tag{12A}$$

Then

$$\frac{dP}{dy} = -2\alpha P_0 \epsilon^{-2\alpha y} \tag{13A}$$

and

$$\frac{1}{P}\frac{dP}{dy} = -2\alpha \tag{14A}$$

Comparing (11A) and (14A),

$$2\alpha = \left(\frac{I_{gd}}{I_{hw}}\right)^2 \cdot \frac{1}{Z_c h} \sqrt{\frac{10^{-9} f}{\sigma}} \tag{15A}$$

At $y = 0$, from (12), $P = P_0$.

At $y = L$, $P_L = P_0 \epsilon^{-2\alpha L}$.

Then the attenuation, in decibels, for a line L units long, is

$$10 \cdot \log_{10} \left(\frac{P_0}{P_L}\right)$$

$$= 10 \cdot \log_{10} (\epsilon^{2\alpha L})$$

$$= (2\alpha L) \cdot 10 \cdot \log_{10} (\epsilon)$$

$$= 4.34\,(2\alpha L) \tag{16A}$$

Substituting (15A) in (16A),

$$\text{decibels} = \frac{4.34L}{Z_c h}\left(\frac{I_{gd}}{I_{hw}}\right)^2 \cdot \sqrt{\frac{10^{-9} f}{\sigma}} \tag{17A}$$

For convenience we now let L equal 1000 feet, and measure h in feet. Also, we will measure the frequency in megacycles, and the conductivity in electromagnetic units, where $\sigma_{emu} = 10^{-9} \cdot \sigma_{mho\text{-}cm}$. Under these conditions, the attenuation is

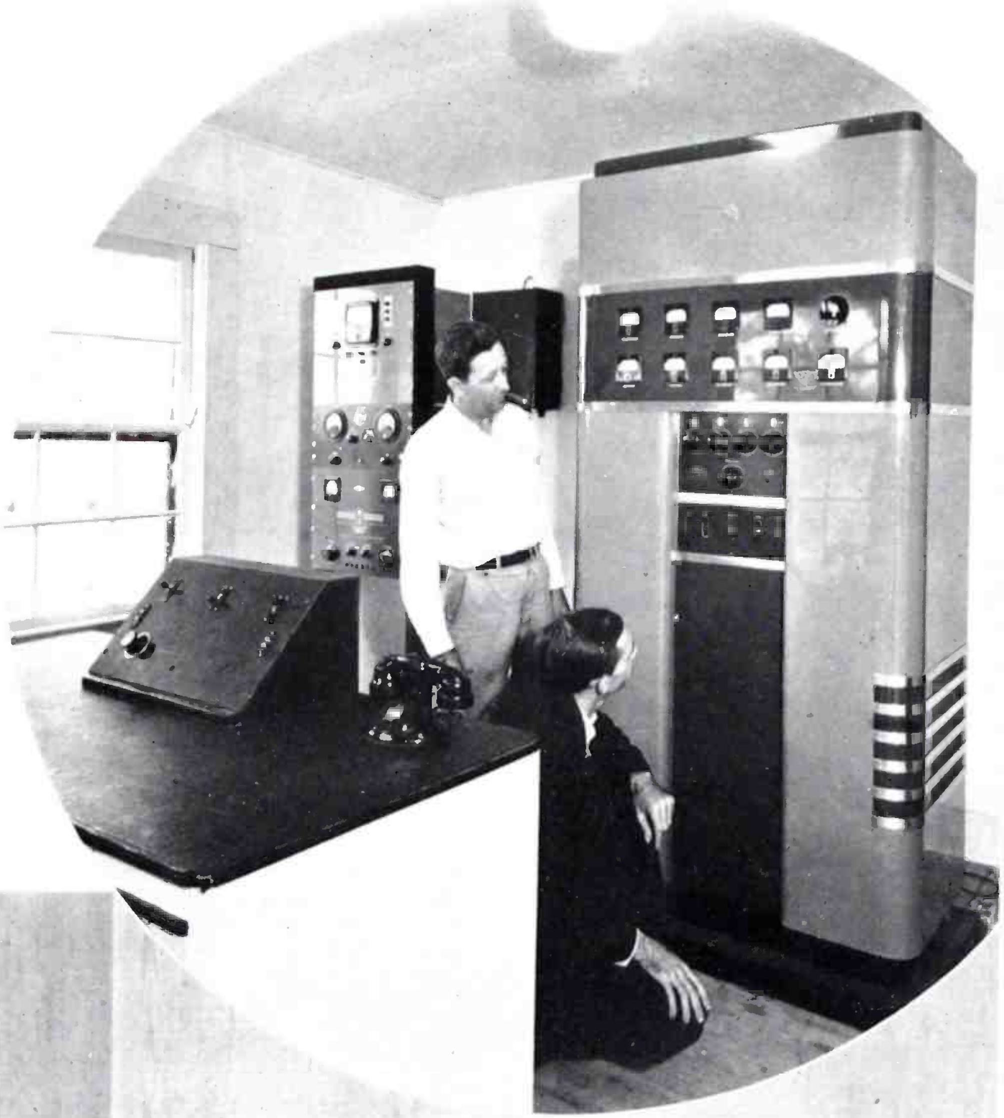
decibels per 1000 feet =

$$\frac{13{,}720}{Z_c h_{ft}} \left(\frac{I_{gd}}{I_{hw}}\right)^2 \sqrt{\frac{10^{-13} \cdot f_{mc}}{\sigma_{emu}}} \tag{18A}$$

This expression is the attenuation due to actual heating in the earth.

(Continued on Page 24)

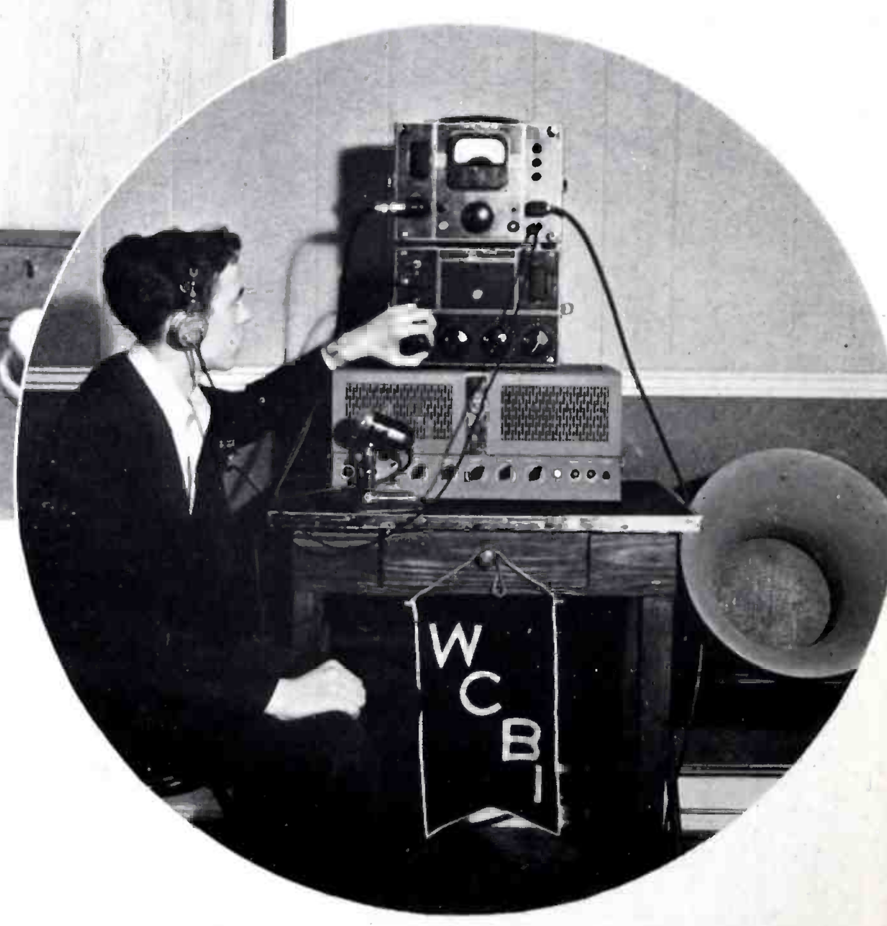
ANOTHER STOP ON OUR 250-K PARADE WCBI, COLUMBUS, MISS.



◀Installing and adjusting the RCA 250 K at the Columbus station.

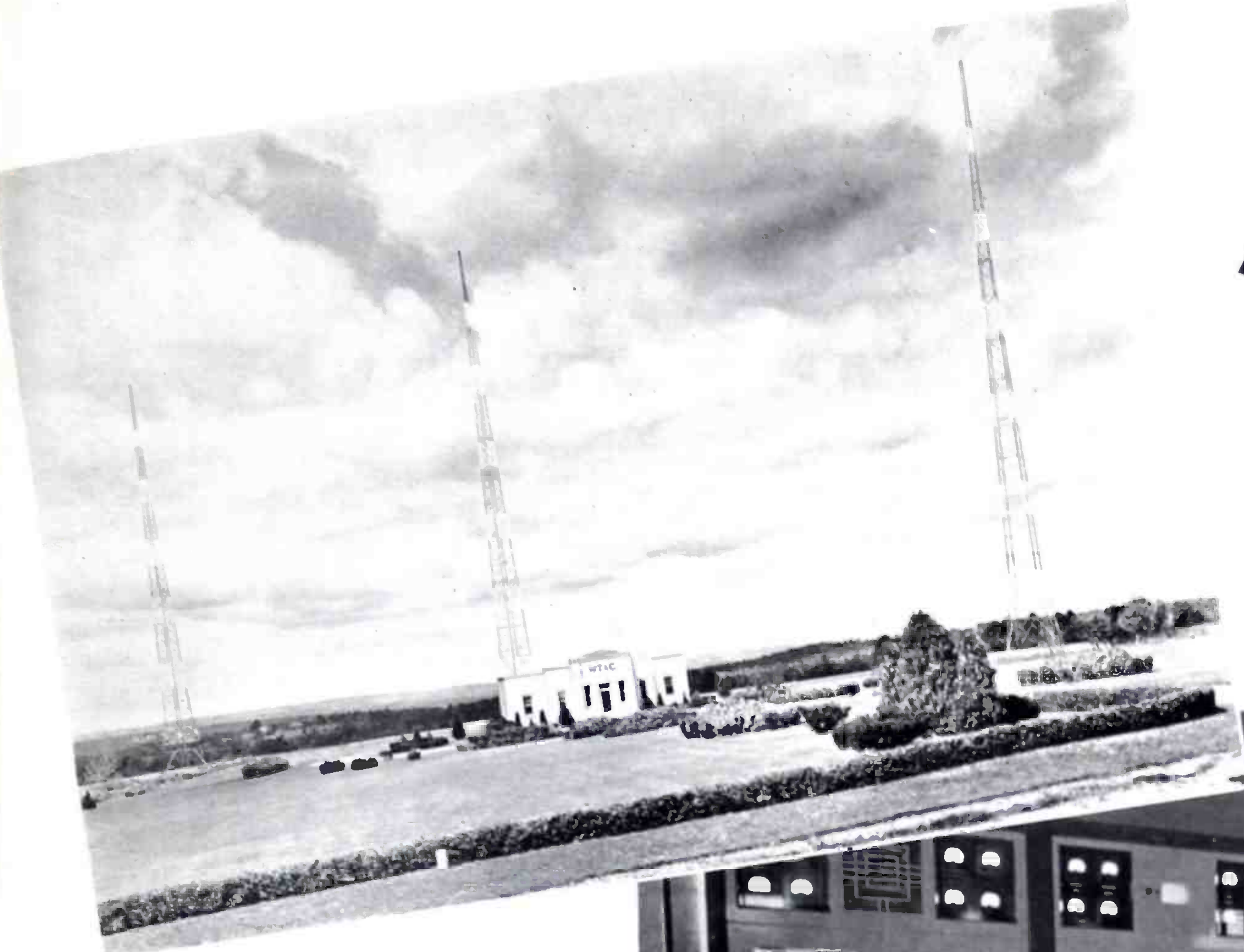
▲Control room at WCBI. Charles Holt, Announcer, at the Master Console.

▲Bob McRaney, General Manager of WCBI, with Miss Billie Sanson, Secretary.



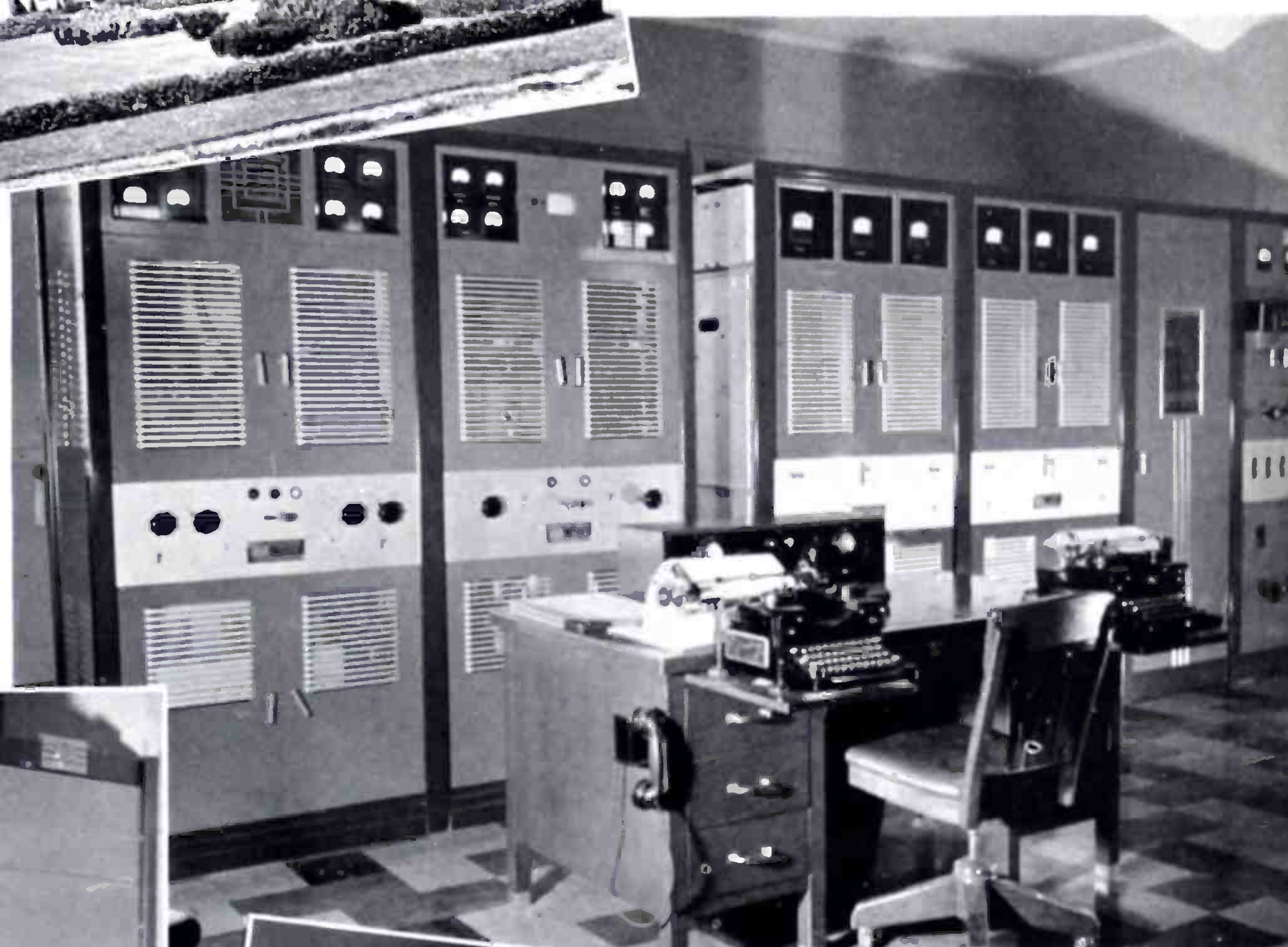
Monroe Looney operating the RCA▶ OP 6 and OP-7 Remote Equipment.

A Fine Transmitting Plant at WTAG

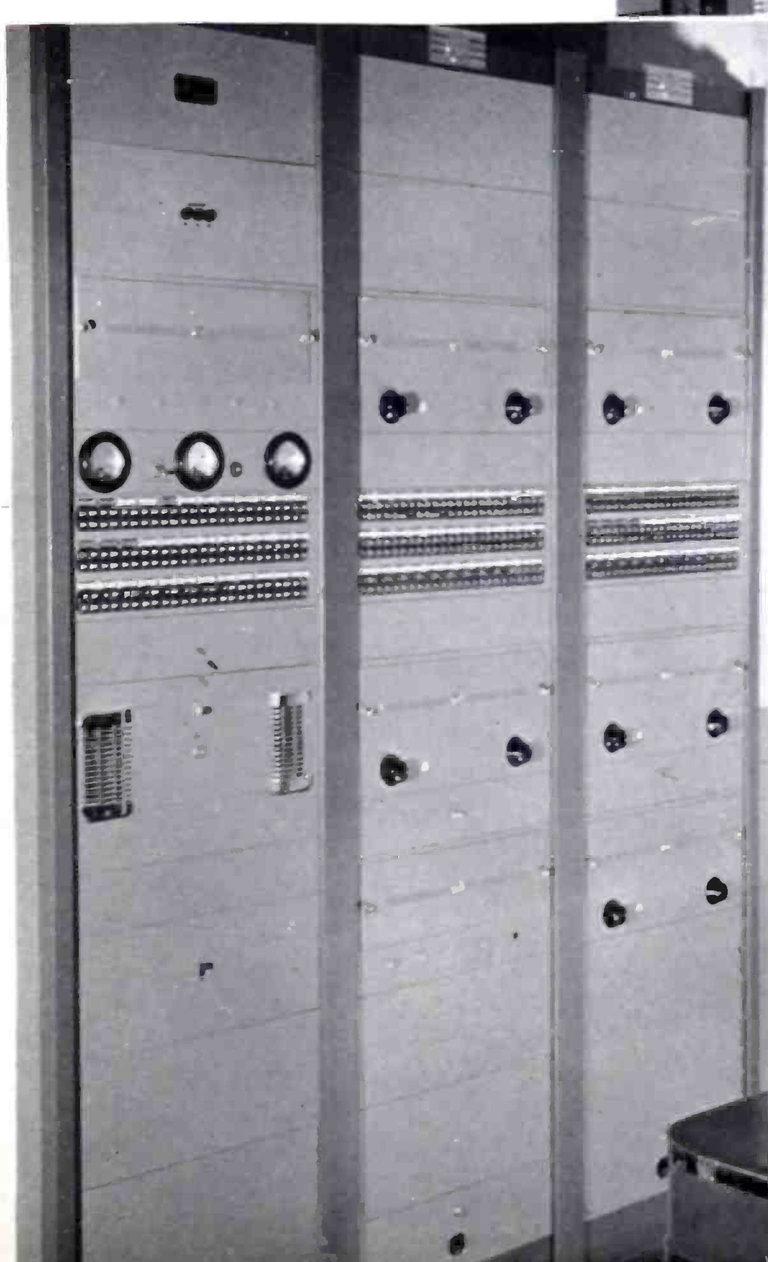


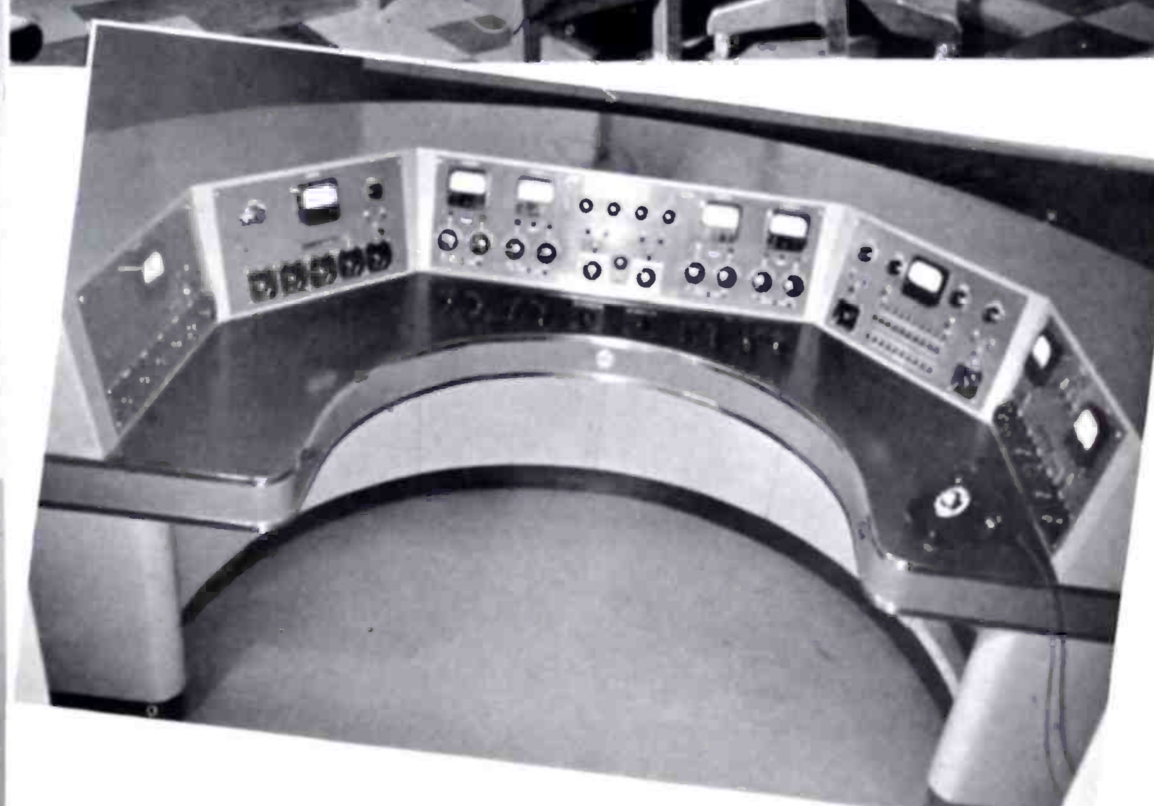
▲ Beautifully landscaped grounds surround the transmitter house at WTAG, Worcester, Mass.

RCA 1-D and 5 D1 Transmitters are located in the transmitter house shown in the photograph at the left. ▼



Three of the 6 Speech Input Racks. Built by RCA to WTAG specifications. ▼





▲ The RCA Custom Built Speech Input Control Desk at WTAG. Control panels are included for 3 studios and switching. "Preset" facilities for 4 outgoing lines are provided. The second panel from the right contains equipment for remote line switching and equalization.

OVERHEAD TRANSMISSION LINES

(Continued from Page [illegible])

APPENDIX B

Losses in the Copper Conductors

We shall next consider the copper loss in the transmission line. To take care of the general case let us assume that there are m insulated wires, all tied together, and n grounded wires. In the case of a symmetrical line we may assume that the hot wire current, I_h, divides equally on the m insulated wires, while the ground wire current, I_{ga}, divides equally on the n grounded wires. If all wires have the same radius, ρ, (measured in inches) the resistance per foot of a single wire is

$$R_a = \frac{\sqrt{f_{mc}}}{2000 \cdot \rho_{inches}} \qquad (1B)$$

The power lost in a length, dy, is

$$dP = \frac{\sqrt{f_{mc}}}{2000 \cdot \rho_{inches}} \left(\frac{I_{ha}^2}{m} + \frac{I_{ga}^2}{n} \right) dy \qquad (2B)$$

Following the procedure of Appendix A,

decibels per 1000 feet $=$

$$\frac{2.17\sqrt{f_{mc}}}{\rho_{in} Z} \left[\frac{1}{m} + \frac{1}{n} \left(\frac{I_{ga}}{I_h} \right)^2 \right] \qquad (3B)$$

APPENDIX C

Radiation from Overhead Unbalanced Transmission Lines

In considering the radiated fields from these unbalanced lines, we may consider that we replace the multi-wire system with a single conductor which carries the net current in the line. It has already been shown that this net current, which is the difference between the hot wire current and the ground wire currents, is equal to the ground current. We will consider only the case where the line is terminated in its characteristic impedance so that the current travels down the line from the transmitter, essentially constant in magnitude and with a uniform phase retardation.

The net current along the line is then

$$i_n = I_{n} e^{-j\frac{2\pi x}{\lambda}} \qquad (1C)$$

where I_n is the net current at the transmitter end of the line and x is the distance along the line, measured from the transmitter. The line, which has a height h above ground, has a total length L. (Fig. 11.) The effect of the earth currents is taken care of by the image current flowing in opposite direction to the line current.

A point P in space is located by means of two angles. The angle α is the angle measured from the zenith. (Fig. 12.) β is the horizontal angle measured from the transmission line. A direction in space located by α equal 90 degrees and β equal zero degrees points from the transmitter to the load.

Then the field strength in millivolts per meter at one mile at a point in space is

$$F_{\alpha,\beta} = 37.25 \left(\frac{2\pi h}{\lambda} \right)$$

$$I_{gd} \frac{\cos\alpha \sqrt{2\cos\left[\frac{2\pi L}{\lambda}(1 - \sin\alpha\cos\beta)\right] + 2}}{1 - \sin\alpha\cos\beta} \qquad (2C)$$

In the special case where the line is one-half wave long, this expression reduces to

$$F_{\alpha,\beta} = 37.25 \left(\frac{2\pi h}{\lambda} \right)$$

$$I_{gd} \frac{\cos\alpha\sqrt{2\cos(180 \sin\alpha\cos\beta) + 2}}{1 - \sin\alpha\cos\beta} \qquad (3C)$$

Where the line is a full wave long, the field intensity becomes

$$F_{\alpha,\beta} = 37.25 \left(\frac{2\pi h}{\lambda} \right)$$

$$I_{gd} \frac{\cos\alpha\sqrt{-2\cos(360^\circ \sin\alpha\cos\beta) + 2}}{1 - \sin\alpha\cos\beta} \qquad (4C)$$

Fig. 13 shows the vertical polar pattern in the plane of the transmission line ($\beta = 0$ degrees) for a line which is one-half wave long and for another line which is one wave long. These patterns are based on a transmission line height of 12 feet, with a frequency of 1000 kilocycles, and a ground current of one ampere.

The total power radiated from the line is obtained by summing up the Poynting energy vectors over the surface of a large hemisphere. These result in the following expressions.

$L =$ one-half wavelength

$$\text{Watts radiated} = 3500\, I_{gd}^2 \cdot \left(\frac{h}{\lambda} \right)^2 \qquad (5C)$$

$L =$ one wavelength

$$\text{Watts radiated} = 5250\, I_{gd}^2 \left(\frac{h}{\lambda} \right)^2 \qquad (6C)$$

THE OR-1 PORTABLE EQUIPMENT

The OR-1 is a portable disc recording equipment for cutting high quality instantaneous recordings both in the radio studio and on remote locations. Although a quality instrument, the device is compact enough to be enclosed in two carrying cases when ready for moving.

Built to the same standards set for RCA's radio studio equipment, the portable unit is a complete recording channel, with the exception of a microphone. It consists of a turntable, a record cutting attachment, and an amplifier and loudspeaker unit. The turntable and the amplifier-speaker unit may be used together as a high-quality record player. A complete story on the equipment will appear in our next issue.

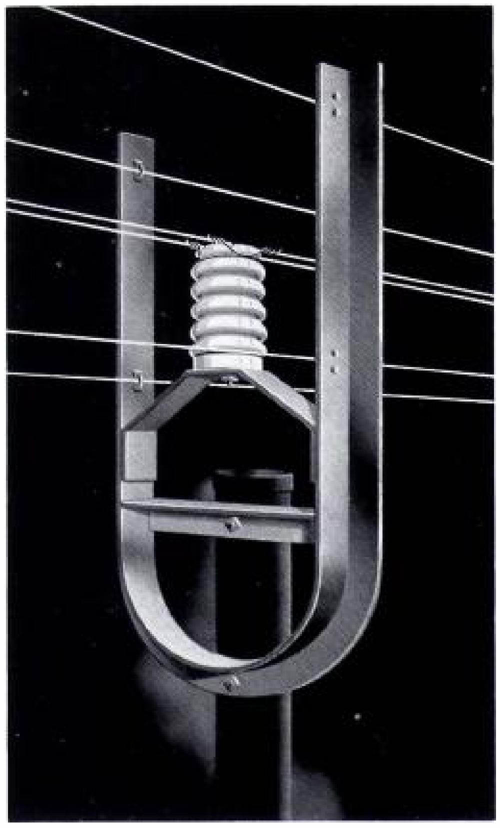


Fig. 5.

SIX WIRE TRANSMISSION LINE

(Continued from Page 3)

ductors there is little danger of a line becoming accidentally shorted from external sources.

The special insulator provided with the MI-19421 materials is eminently suitable for radio frequency service. Having dry and wet flashover ratings of 80 KV and 60 KV respectively, it is designed to withstand lightning surges and power arcs without damage. That it is extremely strong mechanically is illustrated by the two photographs (Figs. 3 and 4) reprinted herewith by courtesy of the manufacturer,[3] showing similar insulators that have been subjected to extreme punishment. The MI-19421 insulator is similar in all respects save for the special double conductor grooving and number of skirts.

Installation drawings furnished with the special hardware items give fully detailed ordering information for all materials required, as well as complete Span Data for tensioning the conductors at erection. All line materials specified are time-proven in utilities service and have been selected carefully with the engineering assistance of such well known concerns as Lapp, Hubbard and Delta-Star.

A sketch of the MI-19421 Double Bayonet is shown in Fig. 5.

[3] Lapp Insulator Co., Leroy, N. Y.

The essential electrical features of the six-wire configuration may be summed up as follows:

1. Attainment of a concentric electrical field by configuration as shown in Fig. 1.
2. Optimum characteristic impedance for best economy of phasing and terminating equipment.
3. Extremely high surge voltage rating and minimum leakance, with practically *no* insulation losses.
4. High power capacity at low cost. Because of the high safety factors inherent in the design, the line could be successfully operated at 500 KW carrier (peak power 2 megawatts), 21.5 KV.

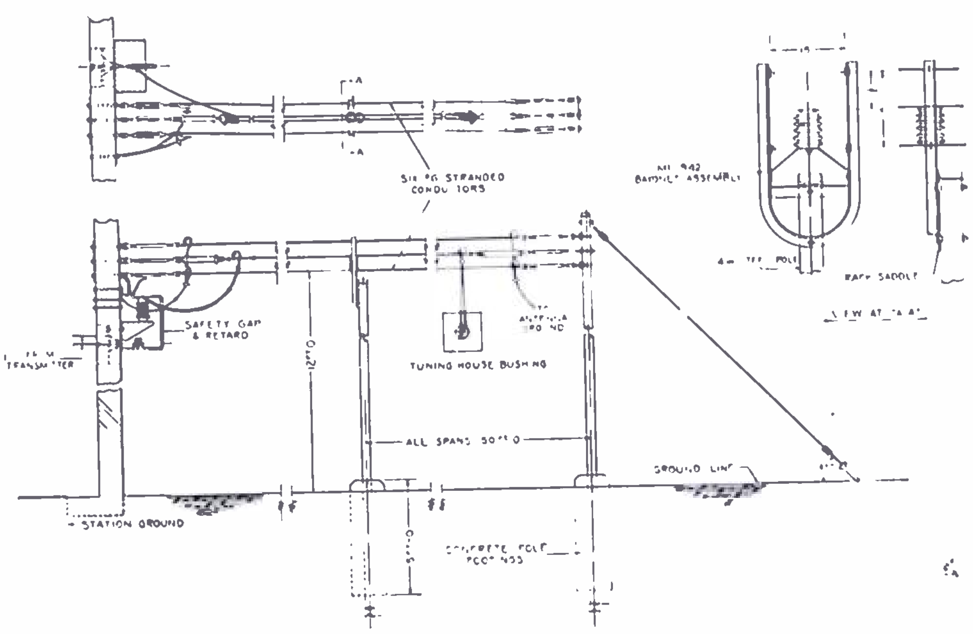


Diagram of the six wire transmission line.

S.S. AMERICA

(Continued from Page 5)

matically sounds a bell in the radio room. The advantage of an automatic alarm on a ship where radio operators maintain a constant watch lies in the fact that if, at the time of an emergency, the *America's* radio officers should happen to be receiving on some frequency other than 500 kilocycles he would not hear the distress signal of another ship. So far as is known, the *America* is the only vessel of its class so equipped.

Radio Direction Finder

In the chart room, just aft of the bridge, is another radiotelephone that is used only for ship's business. It is a 75-watt unit with a frequency range of 2—3 megacycles. Its chief purpose is for communicating with tug-boats during docking operations and with the pier or home office while the ship is in harbor. Both the transmitter and its associated receiver are crystal controlled.

During standby, the receiver of this unit is kept tuned to the coastal harbor radiotelephone frequency and the receiver audio output is fed into a selective device which responds to certain audio frequencies. When the ship's telephone number is dialed by a shore station, a bell will ring aboard the *America* to indicate the incoming call.

Of utmost importance to the ship's navigation equipment is the radio direction finder, installed in the wheel house. By means of this device, accurate bearing may be taken on shore beacon stations and the exact position of the *America* determined in a few moments during periods of fog and storm, when other means of obtaining this data are impractical. So indispensable is this device that all large ships are required by law to have them. Its significance as a factor of safety is further heightened by the fact that it may also be used

(Continued on Page 32)

5000 WATTS AT WFLA

Tampa, Florida Station, Has Latest In RCA Equipment

RCA 5-DX Phasing and Studio Equipment at WFLA.

WFLA was founded in 1925 as a Clearwater station and like most stations in its early history, operated to thrill the DX listeners, and with only 500 watts of power.

WFLA, until quite recently, divided time with WSUN at St. Petersburg, on 620 kc., but late in 1940 the FCC granted WFLA full time on 970 kc. This separated WFLA and WSUN into two full time stations.

In late September WFLA selected a new site for the new station and at the east end of Davis Causeway, only six miles from the Tampa Post Office, started construction on the home. In the brief weeks to follow the project from scrub land to a finished product was completed.

The new WFLA is as modern as tomorrow. Every possible convenience has been installed. In addition to the RCA 5DX transmitter, an auxiliary power supply, gasoline-driven generator is installed for emergency operation with automatic devices for instantaneous switching. Also a magic eye has been installed which automatically switches the tower light on and off at dusk and dawn.

(Below) W. Walter Tison, General Manager of the Tampa Station.

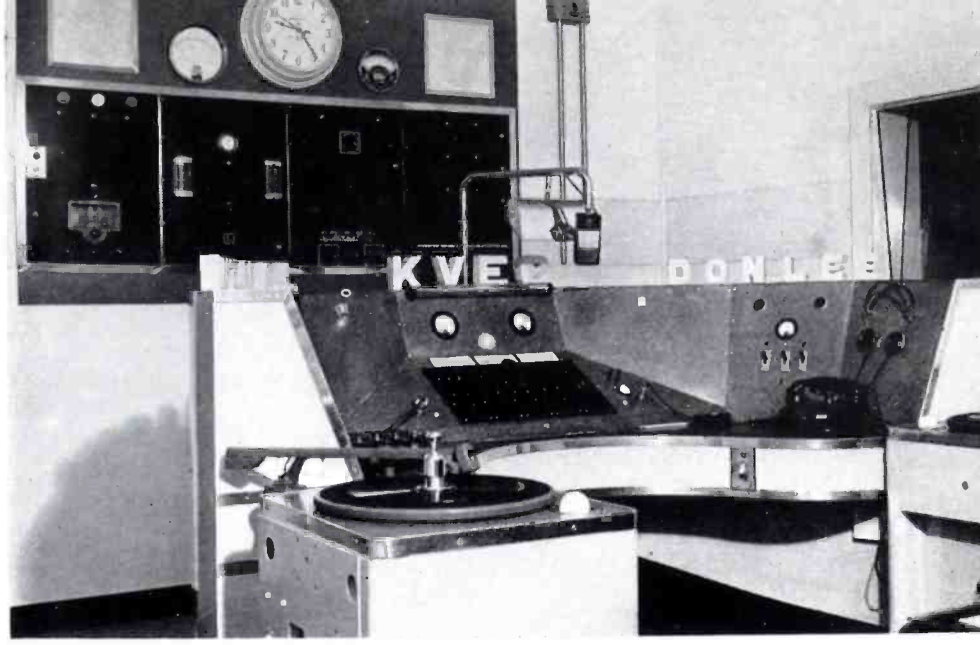
(Below) Transmitter House and Towers.

WFLA was originally installed by W. Walter Tison, in 1925. Mr. Tison has managed WFLA from its inception and today manages the new station for its present newspaper owners. Mr. Tison in addition to engineering experience gained in the Navy during the World War, spent several years not only with the Navy but also in the Merchant Marine as wireless operator. In 1922, Mr. Tison was instrumental in the founding of WSB in Atlanta as Dixie's first broadcasting station. He served WSB as engineer from 1922 to 1925, then to Florida during the boom and stayed with WFLA. Mr. Tison at one time owned a half interest in WFLA but sold during 1940 to the Tampa Tribune which resulted in the present set up. Mr. Tison is a member of the NAB Board of Directors, a past president of the Florida Association of Broadcasters, and a past president of the Tampa Adv. Club. Mr. Tison, away from work, enjoys his country place as a hobby with its orange grove and fish pools.

It is to be remembered that WFLA was the originator of the directional antenna system now so widely adopted as standard equipment.

TWO STATIONS ON PACIFIC TIME

In San Luis Obispo, KVEC does a swell job for Mutual—Don Lee



▲ Part of the All-RCA Equipment used by this Southern California Station.

▲ Les Hacker, Manager of KVEC.

The new transmitter plant is a solid looking modern structure. ▶

KRSC, Seattle, Wash., has an extensive building to house its activities.

●

This 1 KW plant goes right down the line with RCA Equipment.

NOISE REDUCTION IN DISC RECORDING

By R. A. LYNN
Engineering Department, National Broadcasting Company
Courtesy of A-T-E Journal

In the interests of maintaining transcriptions at a high degree of excellence, it is necessary that not only the program content be of high quality, but also that the surface noise or scratch of the transcription be of a low order of magnitude. The lower the level of scratch, the higher is the permissible dynamic range of the program.

Basically, the measurement of scratch is relatively simple. All that is necessary is to reproduce unmodulated grooves of the transcription through an amplifier with sufficient gain to obtain a convenient output reading. A few practical considerations must, however, be observed. Low frequency disturbances, originating from building vibration or from turntable rumble, is normally of sufficient intensity to cause errors in the scratch measurement. For this reason a 500 cps high-pass filter must be used in the reproducing circuit.

The location of the H P filter is important. If placed after the amplifier it is very probable that the rumble levels will overload the amplifier. If placed ahead of the amplifier there is a possibility that hum picked up by induction will be amplified through the high gain system and give erroneous readings. Careful shielding will minimize this condition. However, since the high gain amplifier system normally consists of two units, the easiest expedient is to place the H P filter between the two. In this manner the rumble disturbances have not attained sufficiently high amplification to cause overloading before they are attenuated in the filter and at the same time the inductive hum is not excessively amplified in the final amplifier unit.

The only requirement pertaining to the frequency characteristic is that the circuit be essentially flat from 1,000 cps up to 10 kc and, of course, the lower frequencies must be attenuated below 500 cps by the H P filter. The tone run taken by reproducing the RCA tone record No. 2485-2 is shown in Fig. 1A.

The amount of bass compensation used in the reproducer circuit is relatively unimportant since the 500 cps H P filter attenuate these bass frequencies in any event.

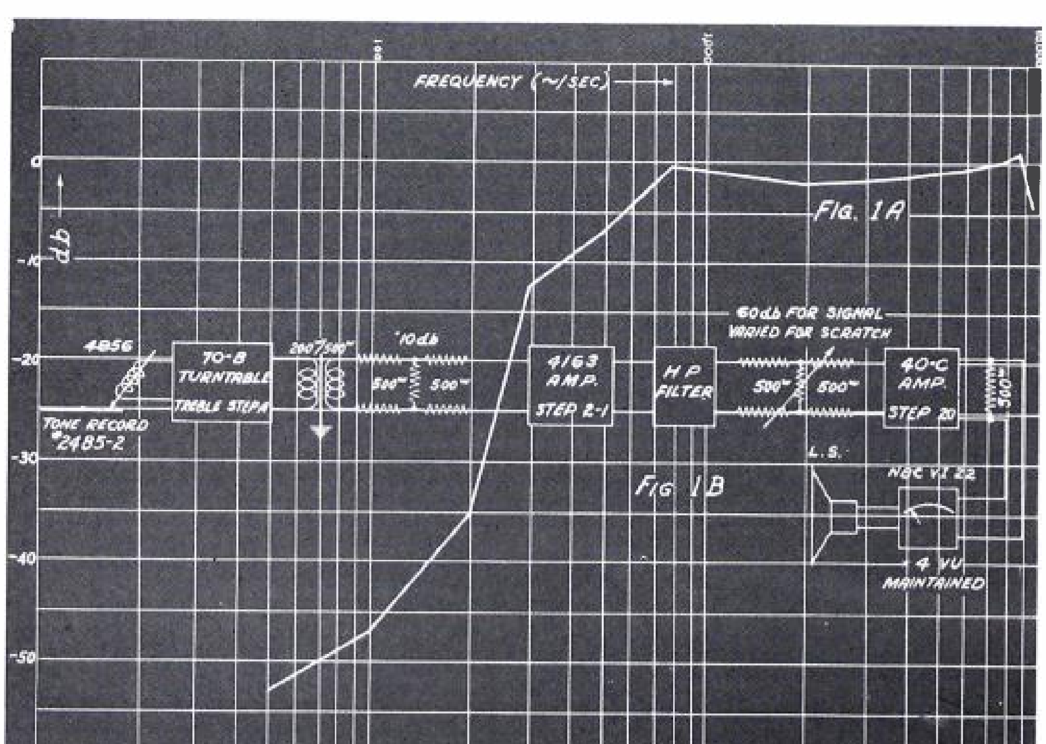
The equipment diagram used by the author is shown in Fig. 1-B. The turntable used is the RCA 70-B with the treble compensation switch set to step "Out" which gives a flat high frequency response.

A 60 db variable pad is inserted in the circuit, as shown, to permit the tone run. For purposes of calibration the gain is so established that a convenient reading is obtained from the tone record. The 1,000 cps reading is especially noted. The scratch sample is then reproduced and sufficient pad is removed from the circuit to permit the scratch reading to duplicate the previously obtained 1,000 cps reading. The 1,000 cps band of the tone represents the nominal value of a fully modulated transcription. Therefore, the value of the pad removed to make the scratch read the same as the tone represents the signal to scratch ratio and is expressed in db.

The results of the measurements show some interesting effects. It is readily apparent that the discs most commonly used today are easily divided into three general categories. Shellac discs display the highest noise, vinyl discs come next with lacquer displaying the least amount of scratch.

Figs. 2A and 2B show readings of —23 db for a shellac pressing and —47 db for a V-257 pressing, both pressed from the same master.

It is to be noted that shellac is not intended for transcription work even though it is quite often used for this purpose. It is of rather coarse texture and so designed to withstand the serious abuse given it on home reproducers and "Juke-Boxes." The reproducing heads are generally found to be heavy (3 oz. or more) with massive styli consisting of the typical steel phonograph needle or equivalent. Under such conditions it is desirable to have the coarse textured disc to cause the stylus to wear down rather than have the stylus wear out the

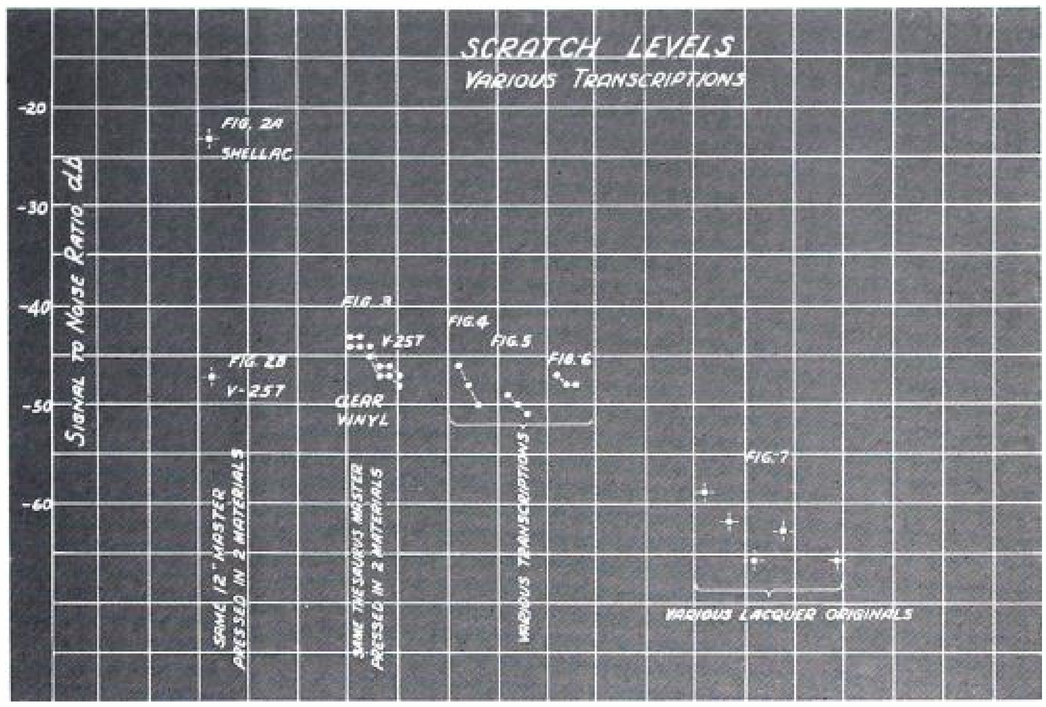


disc upon a few playings. Even so, a certain amount of wear is incurred on the disc.

An improvement can be obtained, however, when using shellac discs by incorporating a high fidelity type of reproducer which exerts a weight on the disc that is not in excess of approximately ¾ ounce. It is assumed that the stylus compliance is compatible with this figure, that is, no advantage is gained by counterbalancing the tone arm to this reduced stylus pressure if the reproducer contains a stiff moving stylus-armature assembly. In this case disc wear of unmodulated grooves is reduced but the wear of the modulation passages would still be severe. If shellac discs are to be used for transcription work with a high fidelity reproducer, care must be exercised to prevent even a single playing of the disc with an older type of reproducer which will mar the surface.

The various vinyl compounds have been designed specifically for transcription work. They are softer than shellac and will not hold up under conditions of home use. Light weight reproducers with permanent jewel joints of low mass and a very flexible armature movement are demanded for the most satisfactory results.

At the present day it can be shown that there is a negligible difference in the scratch content of the various vinyl materials used to make transcriptions. This has not always been the case. For instance, several years ago it was found advisable to use a certain amount of filler in the compound to give optimum results with the reproducers available as of that date. The principle was analogous to but not as severe as that described under the action of shellac and a steel stylus. As improvements have been made in reproducers it has permitted a modification of the filler used in the transcription disc. For the past year the NBC Thesaurus has been pressed in a material known as V-257. This is primarily a vinyl compound with a filler which is microscopic in size. Comparisons made to clear vinyl compounds show negligible differ-



ences in reproduced scratch. Fig. 3 shows such a comparison. Additional measurements of vinyl transcriptions are shown in Figs. 4, 5 and 6.

An inspection of the various measurements shows the scratch to be higher for the outside program bands than for the inner program bands. This effect is effected by one or more of several causes. The starting cut of a recording stylus is sometimes noisy which either clears itself or which is readjusted for optimum depth by the operator as the recording progresses. Also in the plating process of the record manufacturing, the deposition of metal is slightly irregular toward the outer diameters of the disc. A third contributing effect is that the flow of the compound, as the record is pressed, is somewhat irregular at the outer edge of the disc. These various factors should be so under control that the spread between the outer and inner diameters of the transcription should be not in excess of 6 db.

Fig. 7 shows that lacquer gives rise to the least amount of scratch upon reproduction. This material is very soft and is intended for transcription work where only relatively few playings are desired.

The scratch measurements as herein described are made with a flat high frequency response. With Orthacoustic, where high frequency attenuation is applied upon playback, a still further improvement is obtained in regard to the signal to noise ratio. The additional improvement amounts to from 6 to 12 db depending upon the distribution of the scratch noise throughout the high frequency spectrum. 8 db is taken as the average figure for this improvement.

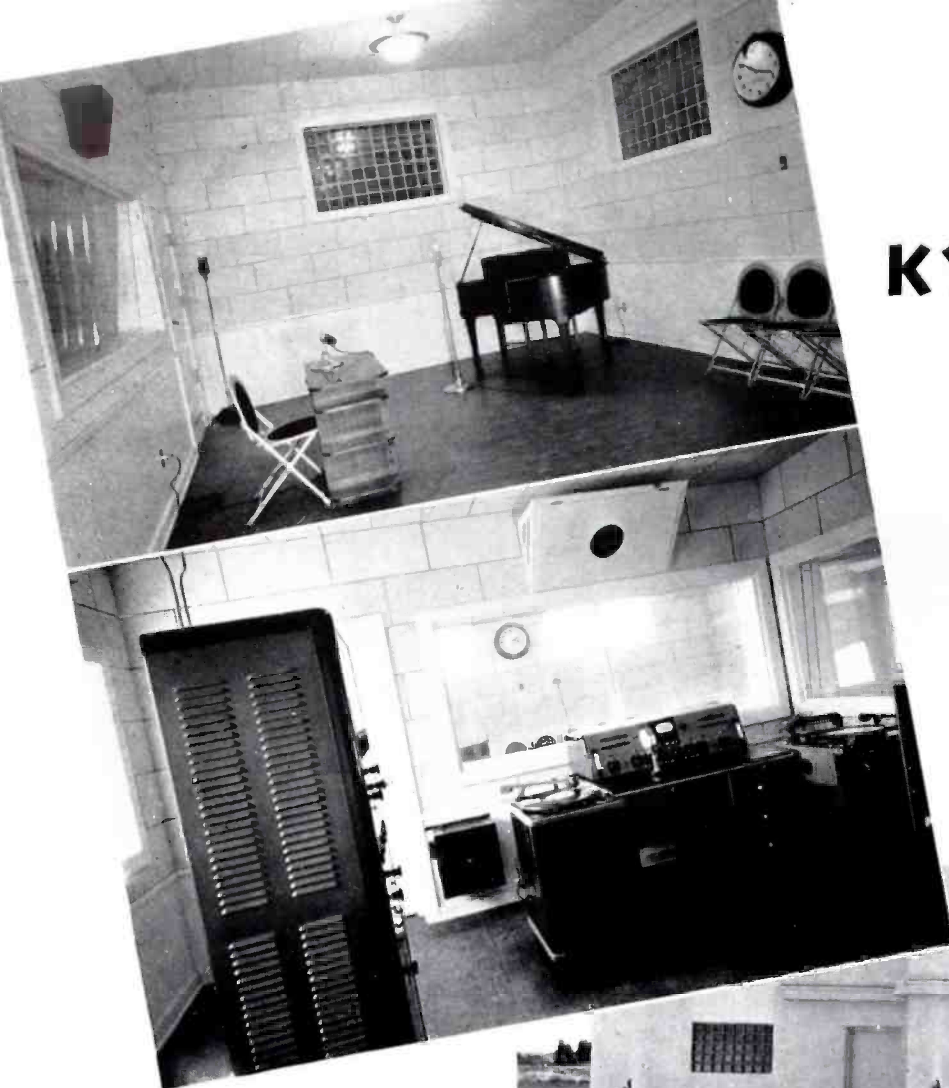
Although as has been pointed out, negligible scratch difference is encountered between V-257 and clear vinyl, V-257 has a definite advantage due to its lower susceptibility to accumulating an electrostatic charge. Electrostatic charges are detrimental since dirt particles, which eventually scratch the grooves under the wiping action of the playback, are attracted to the disc. Furthermore, any attempt at brushing off the particles builds up the charge to higher values causing the particles to adhere more persistently to the disc.

Some idea of the severity of this condition is indicated in the results obtained on an elementary laboratory set-up which included an electrostatic voltmeter with a working range from 3,000 volts to 15,000 volts. The mere withdrawal of a clear vinyl disc from the paper envelope created charge in the range of 3,000 to 5,000 volts, the value depending on such factors as the room humidity and the rapidity of withdrawal of the disc. Rubbing the disc with felt created potentials as high as 12,000 volts. Atmospheric

(Continued on Page 32)

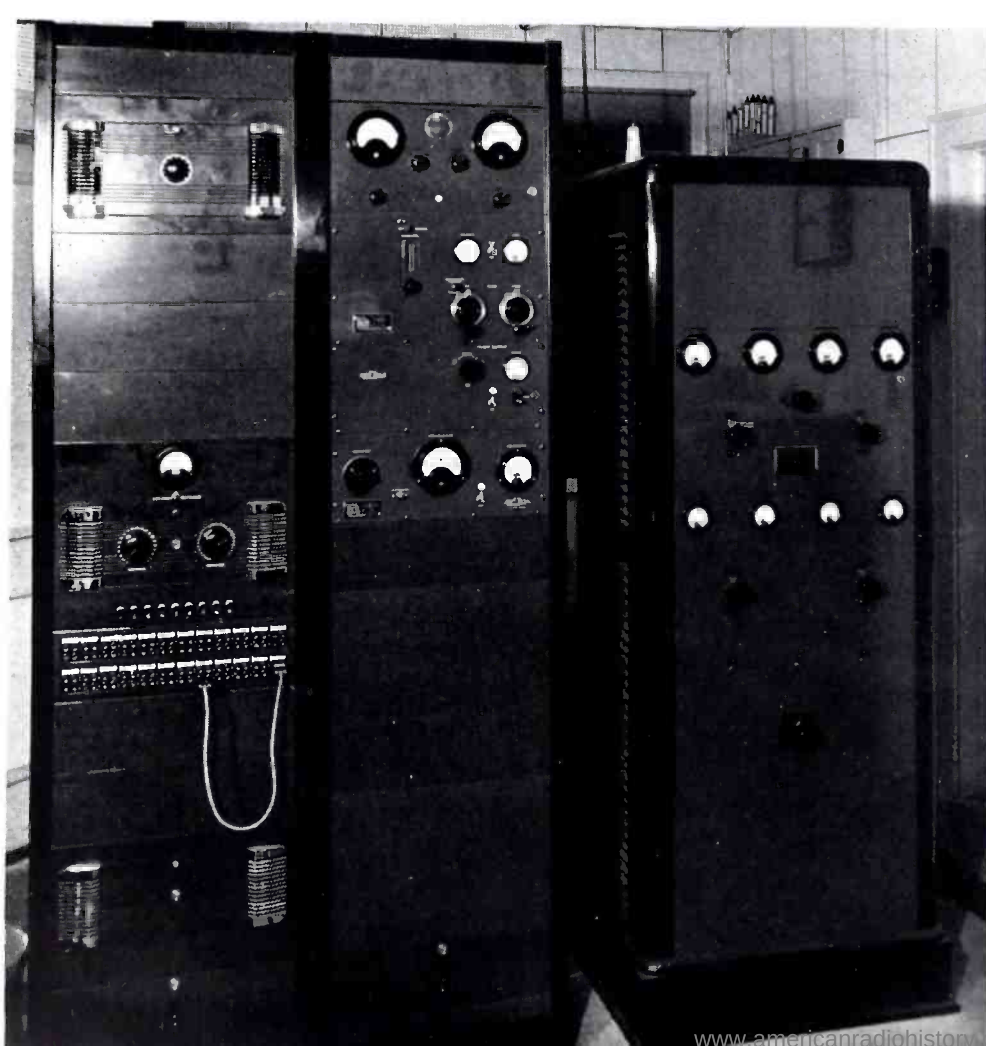
KYUM—ATTENTION-GETTER IN THE SOUTHWEST

A transmitter house that ranks with the best symbolizes this Yuma, Arizona station.



▲ TOP: One of the well arranged studios at KYUM. LOWER: RCA transmitter, turntables and consolette form an efficient set-up.

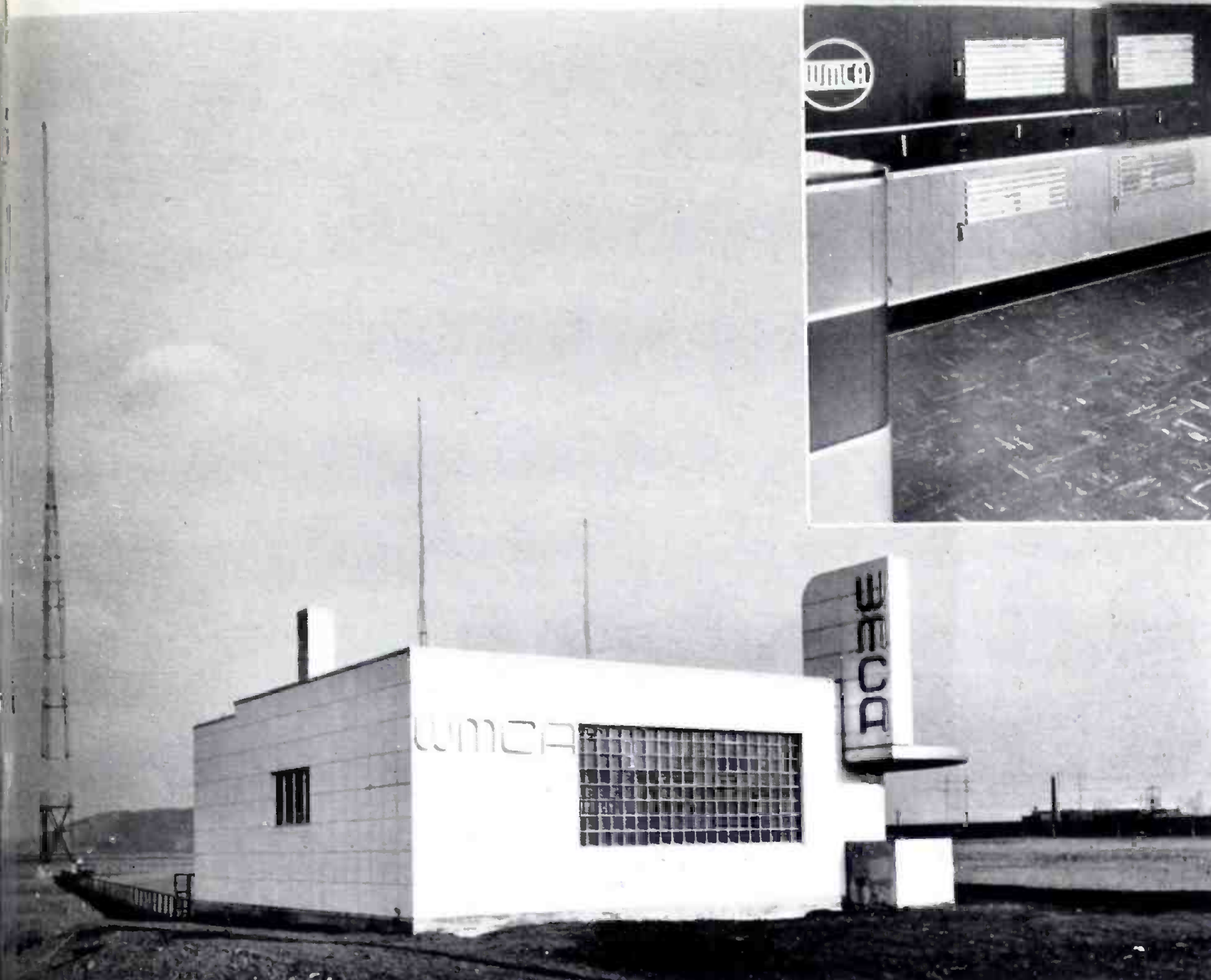
Down Georgia Way There's WMGA in Moultrie



▲ Control room at the Georgia station. Note the similarity to KYUM and WLOK in the arrangement of units.

◀ RCA 250-G transmitter and speech input racks at Moultrie.

TWO VIEWS OF WMCA



▲ The streamlined RCA 5-DX, 5 KW Transmitter, installed at WMCA with its associated control desk

◀ An exterior view of the transmitter house recently constructed by the New York station.

It's WLOK in Western Ohio

▲ Studio "B," at the Lima station, possesses a "living room" atmosphere.

◀ Murals in the modern manner convey the spirit of radio in the reception room.

▲ A section of the control room at WLOK.

SPEECH INPUT SYSTEMS

(Continued from Page 12)

switching facilities, gain controls and communication circuits are located in the master control room. The selection of the incoming lines made with patch cords and switches or, if the number of lines is large and the personnel is limited, automatic dial selector systems may be employed.

Monitoring Systems

The monitoring facilities present a minor problem in the smaller installations. In the larger systems, however, special precautions must be taken to provide adequate monitoring facilities with protection against program interference. Such installations usually require monitoring speakers in the offices as well as the studios and control rooms. Also, it is generally necessary to provide a means of selecting the source of the program to be monitored. A typical monitoring circuit is shown in Fig. 15A. Monitoring circuits are provded for the outputs of each studio, the outgoing channels, the incoming network and the output of a receiver. Single or double-stage isolation amplifiers are used between the program lines and the monitoring buses. These amplifiers prevent impedance variations and monitoring bus circuit noises from feeding back into the program lines. The outputs of the isolation amplifiers are loaded with resistors and the monitoring stations are bridged across the low impedance buses.

Two methods of distributing the monitoring circuits are used. A multiple pair telephone cable may be run to every monitoring station where a simple rotary switch can be used as the selector as shown in Fig. 15B. Another method utilizes an automatic dial selector system which requires only two two-wire lines to each station.

(To be concluded in the next issue.)

NOISE REDUCTION

(Continued from Page 29)

conditions caused varying rates of decay of this charge. On one particular day a clear vinyl disc dropped from 11,600 volts to 6,000 in a two-hour period, while the same disc on another day dropped from 11,400 volts to 3,000 volts in the same time period. It was found that V-257, subjected to the same tests, could not be made to exceed a maximum potential estimated at 1,000 volts. The sensitivity of the meter was such that no further data can be presented at this time on the rate of decay of V-257. Sufficient evidence is displayed, however, to show the appreciable superiority of V-257 over clear vinyl from the standpoint of the susceptibility to electrostatic charge.

In the foregoing paragraphs mention has been made of "clear vinyl." To avoid confusion it is perhaps advisable to point out that the terminology "clear vinyl" is used for all vinyl compounds free from filler. However, various dyes are used to attain any desired color of disc, which dyes have no effect on the electrostatic characteristics. In some instances heavy concentrations of dark colored dyes are used which make the discs opaque and consequently similar in appearance to V-257 which is opaque due to the filler used. The susceptibility to electrostatic charging is a reliable test to differentiate the two classes of vinyl discs.

In concluding it is pointed out that the signal to scratch ratio of present day transcriptions is in the vicinity of 45 db to 50 db. With the applicaton of Orthacoustic a further reduction to the vicinity of 55 db is realized. Present day developments in the recording and processing techniques gives promise of attaining, within the very near future, transcription reproduction with a signal to scratch ratio in the order of 60 db or better. Experience has demonstrated that this figure is entirely satisfactory for all broadcast requirements.

S.S. AMERICA

(Continued from Page 25)

just as readily to determine the position of other ships at sea.

Lifeboats Radio-Equipped

The direction finder uses a highly sensitive and selective superheterodyne receiver, and is designed with an automatic compensator so that deviations in the radio bearings are automatically corrected. The unit is also used in conjunction with the ship's gyro repeater system, thereby enabling radio bearings to be taken with reference to true North at all times.

Permanently installed in each of two motor-driven lifeboats of the *America* are complete radiotelegraph transmitters and receivers. Designed to withstand the weather conditions encountered by a lifeboat, this equipment permits communication on the distress frequency of 500 kilocycles. Power is derived from storage batteries.

Thirteen antennas are used in the *America's* radio communication system. Including the two life boat antennas, they are the radio direction finder loop antenna, the direction finder sense antenna, the harbor telephone antenna, the five doublet receiving antennas, the main flat-top, the horizontal V and the forward inverted L antennas.

Power Generators

Power for operating the ship's radio equipment is derived from four motor generators located in a room just forward of the radio quarters. Unit No. 1 supplies 2500 volts for operation of either the intermediate or low frequency transmitters. Unit No. 2 is similar to No. 1 and powers the high frequency transmitter. A switching panel is provided so that, in event of failure of one unit, either of the other units may be quickly connected to the desired transmitter.

2 New RCA Measuring Instruments TO SIMPLIFY STATION OPERATION!

RCA Model 322-A

F-M MODULATION MONITOR

Precise indications of carrier-swing up to 90 kilocycles (equivalent to 120% modulation on standard 150 kc. channels) are secured directly with this new RCA Type 322-A monitor. The Neon warning indicator may be set to flash at any predetermined threshold of peak modulation.

Asymmetrical modulation—in which the carrier swings farther on one side of the resting frequency than on the other—presents no problem with the 322-A. Overswings are eliminated, because the 322-A will read *either* plus or minus swings at the touch of a switch. Wide band discriminator, low temperature-coefficient crystal control, and extremely stable amplifier design keep the 322-A highly accurate over the entire scale. Unique linear circuit creates less than 0.1% distortion in the discriminator—gives accurate overall distortion measurements in conjunction with standard RCA Model 69B Distortion Meter. The 322-A operates directly from your 110-volt line; requires only to be plugged in and connected to the R-F supply.

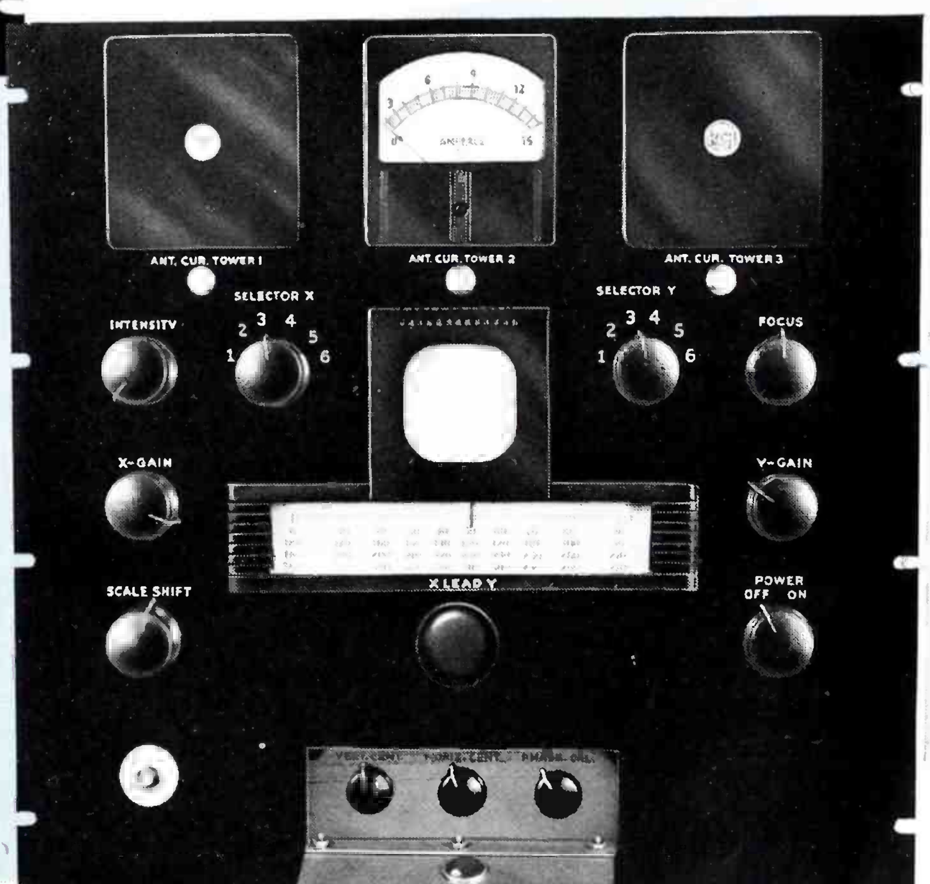
RCA Model 300-C

PHASE MONITOR

Here is the simplest, most accurate phase monitor for directive-array systems that has yet been developed! With the 300-C, you can read the current in up to three lines *simultaneously* . . . without switching or complicated preliminary adjustments!

Balance can be read to within ½ of 1° on the three-inch cathode-ray screen. Voltage division is *independent* of the total signal amplitude . . . and circuit-errors are balanced out by a unique *comparative* method of indication. Scale extends a full 8 inches.

Usable with any type of sampling coil, the 300-C comes equipped with sampling coil and meter of the parallel-tuned-circuit type for each element in your array. Because the sampling current is fed into a pure resistive load, coupling-variations introduce no more than negligible error. Write for complete data.



Use RCA Radio Tubes in your station for finer performance

RCA

FOR FINER PERFORMANCE... GO RCA ALL THE WAY

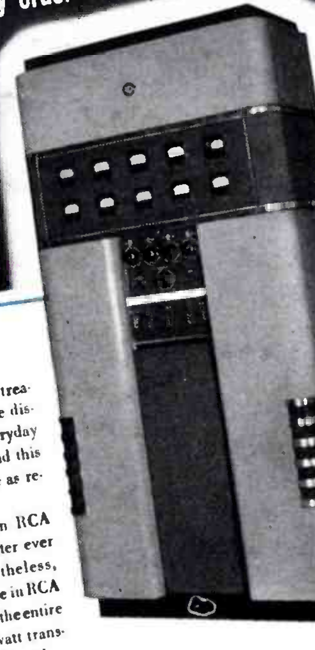
Microphones
Speech Input Systems
Associated Equipment
Transmitters

Broadcast Equipment

RCA Manufacturing Company, Inc., Camden, N. J. • A Service of the Radio Corporation of America
In Canada: RCA Victor Co., Ltd., Montreal

They let their CONFIDENCE be their Guide

Sight Unseen . . . Sound Unheard . . . Broadcasters buy entire factory order of New RCA 250 watt transmitter



IN THIS TROUBLED WORLD where treaties are scraps of paper . . . where discord, distrust, and discontent are everyday headlines . . . we believe you will find this report of good-will and confidence as refreshing as we did.

No broadcaster ever saw an RCA 250-K Transmitter. No broadcaster ever heard an RCA 250-K. Nevertheless, broadcasters had such confidence in RCA engineering that they purchased the entire factory order of this new 250 watt transmitter . . . sight unseen, sound unheard.

RCA tries to merit confidence of this nature through the application of sound fundamentals of good engineering practice. Ours is a constant and studied effort to design and build the best possible equipment at the right price . . . We would welcome an opportunity to be of service to your station. We are confident that the engineering resources of RCA will find the correct solution to any problem you may have.

Use RCA Tubes In Your Station For Reliable Performance

Specifications of the RCA 250-K

Frequency Response: Flat within ±1.5 DB from 30 to 10,000 cycles at any percentage of modulation from 0 to 95.

Operation: Three power outputs, 100, 250, 100/250 Watts.

Frequency Range: 550-1600 KC.

Fidelity: Stabilized feedback reduces distortion to less than 3% RMS between 50-7500 cycles up to and including 95% modulation.

Carrier Noise Level: At least 60 DB below the level for 100% modulation—unweighted.

Utilizes power change switch and equipment where required.

High level class B modulation.

Uses RCA "V"-Cut Crystals

All meters at eye level for convenience in reading.

Low Maintenance: Uses minimum number of inexpensive tubes.

Broadcast Equipment

RCA Manufacturing Co., Inc., Camden, N. J. • A Service of the Radio Corporation of America

New York: 1270 Sixth Ave • Chicago: 589 E. Illinois St. • Atlanta: 530 Citizens & Southern Bank Bldg. • Dallas: Santa Fe Bldg. • San Francisco: 170 Ninth St. • Hollywood: 1016 N. Sycamore Ave.

Only a little over a year ago, this advertisement announced that the RCA 250-K transmitter was a sellout sight unseen. Since that time, 60 American Broadcasters have chosen the 250-K . . . and nine have gone to foreign countries.

. . . and today, more than ever, IT'S AMERICA'S FIRST CHOICE!

250-WATT TRANSMITTER MODEL 250-K

These American Stations Have Chosen the 250-K

KANA	KBIX	KBUR	KFBC	KFMB
KFPW	KFXM	KHAS	KLUF	KRJF
KVFD	KVOE	KWIL	KYAN	KYCA
WAJR	WARM	WATN	WBIR	WBTA
WCED	WBML	WBOC	WDAS	WDEF
WCBI	WDAK	WHKY	WFIG	WGTC
WHBQ	WGOV	WJHP	WHUB	WFPG
WINX	WIZE	WHYN	WGAC	WLBJ
WKIP	WKMO	WKWK	WKPA	WLAV
WLOK	WMJM	WMRN	WMOB	WMOG
WGGA	WORD	WSAV	WSOO	WSLB
	WTHT	WSOC	WTJS	

Never has ANY broadcast transmitter seen such universal acceptance . . . IN A LITTLE OVER A YEAR!

TRAVEL where you like throughout the length and breadth of America . . . you're seldom far from the service area of *someone's* 250-K transmitter! For the RCA 250-K has won an acceptance never before accorded to *any* transmitter by *any* manufacturer!

American stations, built or building, have purchased 60 of these high-efficiency, high-fidelity, 250-watters. Foreign purchasers account for nine more.

Performance alone can make that kind of record possible . . . and *performance* is precisely what the 250-K offers! Flat within 1½ db. from 30 to 10,000 cycles up to 95% modulation, with extremely low inherent distortion and noise-level, the 250-K puts out the quality that pleases audiences and advertisers alike.

Learn the advantages of the 250-K for yourself—write for the complete story.

Use RCA Radio Tubes in your station for finer performance

FOR FINER PERFORMANCE . . . GO RCA ALL THE WAY

Microphones
Speech Input Systems
Associated Equipment
Transmitters

Broadcast Equipment

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