Western Electric

OSCILLATOR

Number 10 ★ February 1948

Microwave Relay ★ FM Transmitter Assembly Line

Try it! — and you'll come back for more!

THE NEW WESTERN ELECTRIC 755A 8-INCH LOUDSPEAKER

It's just this size!

Available immediately — in quantity!

Here's more quality than you ever thought possible in an 8-inch speaker!

This new Western Electric 755-A gives you wide frequency response—exceptionally brilliant tonal quality—ample output—all at surprisingly modest cost.

The relatively small space required to obtain such high quality with this 8-inch speaker makes it ideal for broadcast station use, wired music, program distribution and sound systems, home radios and record players—in fact *everywhere* for top quality reproduction!

Brilliant performance *is* possible with an 8-inch speaker. Prove it to yourself by putting the 755-A through its paces. We'll bet you'll be so pleased you'll come back for more!

Call Graybar today!

Get your 755-A's quickly—call your nearest Graybar representative right now—or write to Graybar Electric Co., 420 Lexington Ave., New York 17, N.Y.

Specifications of the 755-A

Power Handling Capacity
8 watts continuous

Frequency Response
70 to 13,000 cycles

Input Impedance
4 ohms

Efficiency
Sound level at 30 feet on axis is 81.5db above 10^{-16} watts per square centimeter at 8 watts input

Coverage Angle
70 degrees

Weight
4¾ pounds

Dimensions
Diameter: 8⅜″
Depth: 3⅛″
Baffle Hole Diameter 7″

Enclosure Required
2 cubic feet

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Western Electric
OSCILLATOR

FEBRUARY 1948

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Western Electric Company

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The *Oscillator* does not accept responsibility for quoted statements appearing in the magazine. Such statements reflect only the opinions of the person quoted.

THE COVER

FM transmitters in the making—the Kodachrome on our cover, taken in the Burlington, N. C. plant, shows the assembly line for the final amplifier units of Western Electric's 10 kw FM transmitters, with the similar line for the rectifier units visible in back of it. The units at the right end of each line are completely assembled and ready to go to inspection. On pages 22 and 23 are additional pictures showing inspection and testing of the completed units.

THIS ISSUE

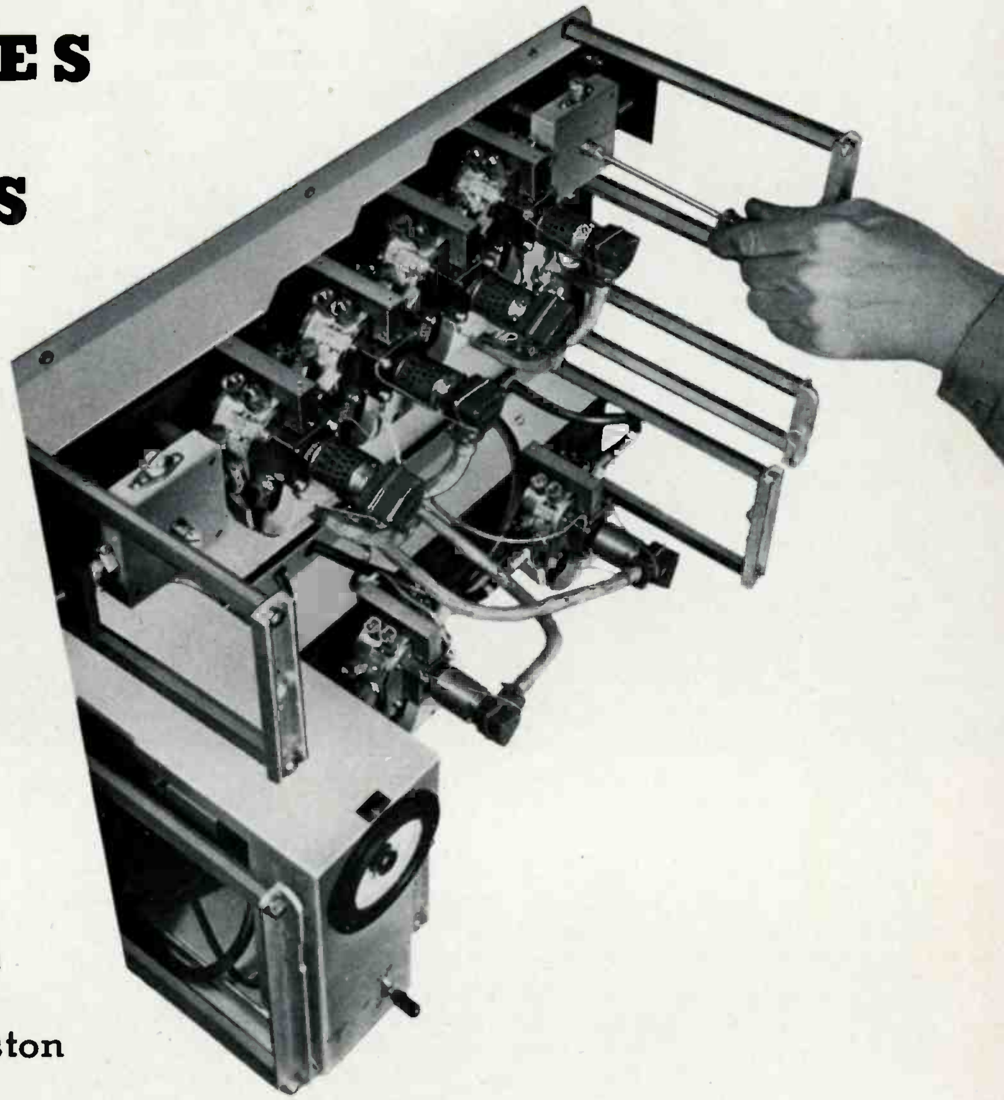
When you read this, a new year will be weeks old. A new year that will carry us closer to a world of peace or one that will shove us a little farther away from it.

We who make the coils and wires, the tubes, resistors and condensers which make up radio broadcast transmitters know that these are just inanimate parts which have no heart, no soul, no love for man, but we also know that when they are assembled and activated with current and the words of man, they come to life. Inanimate themselves but possessed of the marvel that is radio, they transmit to the far ends of the earth the ideas, the dreams, aspirations, fears, visions and hopes of a world.

For all of us who are part of this thing called BROADCASTING, let us remember that man cannot live for long in fear and despair. Let us realize the power, the force of our medium. Let us use it wisely and well. Let us use it so that someday fear and despair will be banished, and man everywhere can again hold his head high in peace, freedom and tranquillity.

W. W.

MICROWAVES IN HARNESS



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System characteristics and microwave techniques in the newly opened broadband relay which carries video-width signals between New York and Boston

CENTIMETER-BAND vacuum tubes, highly directional antennas, cavity elements for tuning, crystal mixers and other techniques that are new-born from the vast prewar and wartime development in the handling of microwaves are being given their first large-scale tryout in a draft-horse communications role in the recently opened New York-to-Boston relay system. This broadband radio relay link between the two cities, which opened for experimental operation as a facility of the Bell System last November 13, is expected to determine many of the technical and economic performance characteristics of microwave communications systems which employ repeaters at line-of-sight spacing to cover considerable distances.

The final service role of this radio relay link, and of similar relay systems over other routes which are being developed, is not expected to be determined for some time, but its potentialities are of great significance to television and broadcasting in general.

A trend in public service communications practice has been toward use of ever wider frequency bands to accommodate large numbers of telephone messages and other types of communications on a single carrier channel, through multiplexing methods. In the case of the coaxial cable, these wideband transmission capabilities are utilized alternatively for transmission of television signals. The intelligence handling capabilities of microwave radio relay systems can be used in much the same way, and thus such relay systems could conceivably play a many-sided role in television, AM and FM broadcasting, telephone, and other services.

The New York-to-Boston system was developed by Bell Telephone Laboratories and combines to a major degree the considerable experience of the Laboratories in microwaves, with their thorough knowledge of the performance characteristics required of a public communications system.

The system operates at frequencies near 4,000 megacycles, and provides facilities with a bandwidth of about 4.5 mc. As installed, it provides two 4.5 mc channels in each direction. Between New York and Boston seven repeaters are used, with highly directional antennas to concentrate the signal in a narrow beam from one repeater to the next. The repeaters are designed for unattended operation. The transmitting and receiving equipment at the New York and Boston terminals is designed to accept television signals, or any signal with a bandwidth not exceeding 4.5 megacycles, such as the multiplexed tele-

President Walter S. Gifford of A.T.&T. opens the microwave relay with first call, New York to Boston. Left, Frank P. Lawrence, Vice Pres., A.T.&T.; right, Carl Whitmore, Pres., N. Y. Telephone Co.

phone signals already referred to. Monitoring facilities for both television and multiplexed signals are built into the terminal equipment, as well as means for testing the essential characteristics of the system such as distortion and gain. Thus the system as a whole represents a marked advance in the solving not only of the difficult amplification, frequency stability, and other design problems of the microwave spectrum, but also problems of reliability, system monitoring, testing, and economics of operation.

Effect of Rain on Signal Studied

In choosing the characteristics of the New York-to-Boston system, Bell Laboratories had the benefit of a series of tests on microwave systems, carried out in the New York-Northern New Jersey area, which were started before the war and continued as soon as a return to peacetime conditions permitted. In these tests the depth of fading at various frequencies and over various path lengths was investigated, as a part of the work of determining the requirements for various elements of the proposed system. It was found that the depth of fading increases with path length, and that both depth of fading and attenuation caused by rainfall increase as the frequency is raised toward 10,000 megacycles. Thus, while the higher frequencies are advantageous in making possible highly directional antennas of moderate size, the fading and attenuation characteristics led to the choice of 4,000 megacycles as a practical carrier frequency, with repeater spacing limited to a maximum of 35 miles.

As can be seen on the map on page 6, the actual repeater spacings range from 11 to 35 miles. The average is 27.5 miles. Naturally in choosing sites for the repeaters, accessibility, availability, and nearness to other facilities had to be weighed in addition to the fundamental aim of obtaining a line-of-sight path to the adjoining locations. Choice of the sites thus involved study of topographic maps, surveys of probable sites, and actual check of individual paths with microwave test equipment, to guard against map inaccuracies.

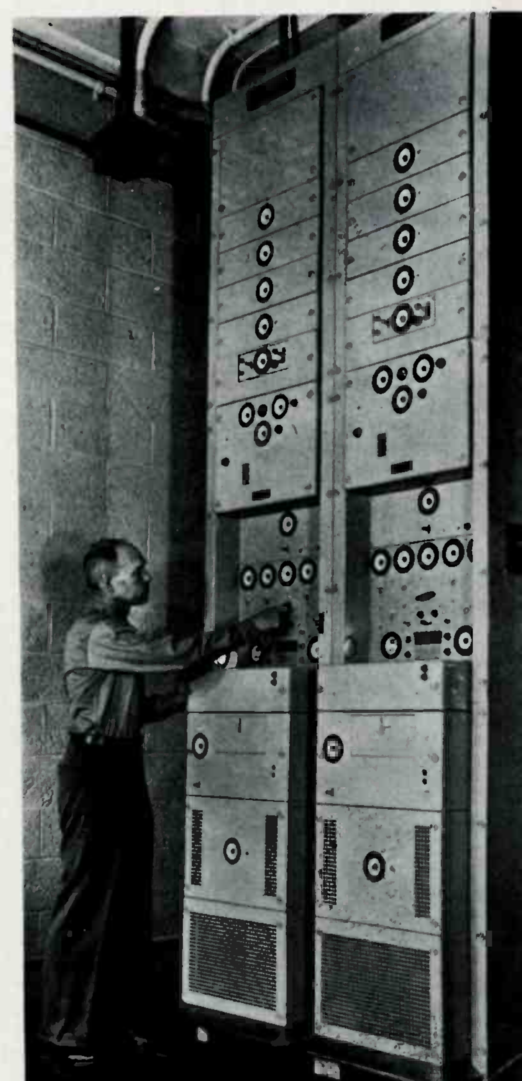
The operation of the repeaters can be described with the aid of the first block diagram in Figure 1 on page 7. One receiving and one transmitting antenna are used for the two channels in each direction, or a total of four antennas at each repeater station. The diagram referred to shows the equipment for two of the four channels of a repeater station. The antennas are of the metal lens type which has been described in the *Oscillator*, April, 1946. These permit the focussing of the microwave energy into a narrow beam between repeaters. Energy is fed to the antennas and taken from them through a metal horn and wave guide system.

Carrier Frequencies

The carrier frequencies used are spaced at small intervals in the neighborhood of 4,000 megacycles, as shown in Figure 1, to avoid interaction between the two channels using each antenna. At the next repeater station the frequency transformations would be from the outgoing frequencies shown, back to the incoming frequencies shown. This staggering of frequencies avoids bringing a high level and low level signal of the same frequency together at any repeater station. Thus four frequencies are actually sufficient for the entire two-channel, two-way system.

Vacuum tubes now available for wideband amplification in the vicinity of 4,000 megacycles are not developed to the point where the internal tube noise energy is low enough for use in low-level stages, when the amplification process is to be repeated

Two bays, each holding complete equipment for one channel, are mounted together at repeater station.



a number of times. Therefore, in the repeaters the major part of the gain and the avc action are obtained in i-f amplifiers operating at 65 megacycles.

The frequency conversions can be studied by following a signal through from receiving to transmitting antenna. Reference to Figure 1 shows that a carrier signal at, say, 3930 mc, is carried from the antenna in a waveguide along with the second channel signal which is at 4130 mc. The two are separated in the branching filter shown in the photograph on page 6. The 3930 mc signal is mixed with an oscillator frequency of 3865 mc in a silicon varistor modulator to produce the 65 mc i-f frequency. The signal then acquires the main repeater gain in a preamplifier and main amplifier at 65 mc, which contain the avc system that maintains constant output from the repeater.

A second silicon varistor modulator then converts the signal back to the microwave range, to the 3970 mc outgoing frequency, by mixing the i-f with a local oscillator frequency at 3905 mc. The microwave amplifier that follows raises the power level to the 1 watt at which the signal is sent to the antenna for beaming to the next repeater.

The gain of each complete repeater is automatically variable over the range 55-80 db, a design figure based on the finding that the probable maximum depth of fading under the conditions established for the new microwave relay link is about 25 db, with a figure of 55 db as the minimum gain at each repeater that would be required in the absence of fading.

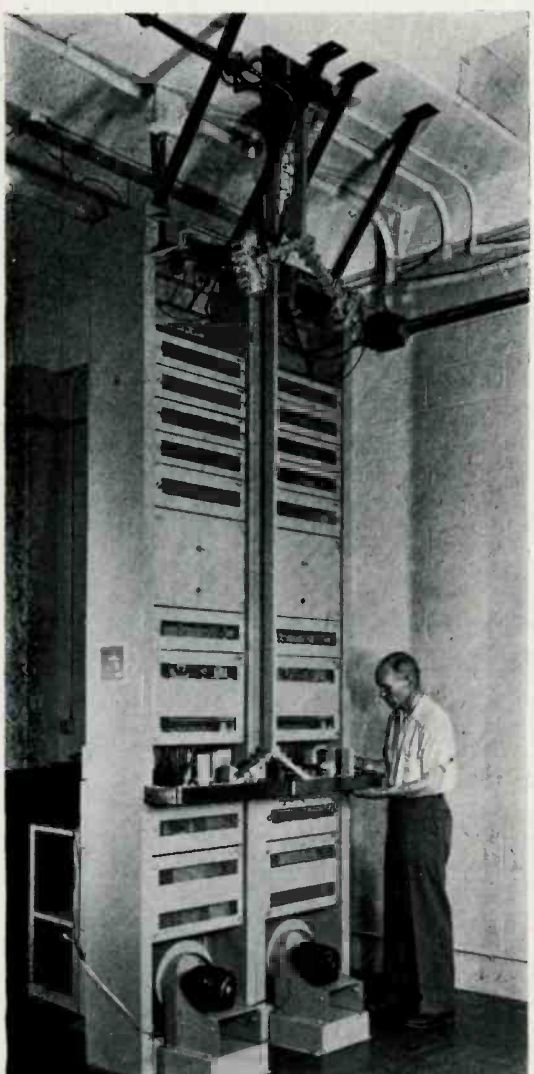
The frequency stability of the local oscillator and of the microwave amplifier is maintained in a number of ways. In each channel the two local oscillator frequencies with 40 mc spacing are produced with a highly stabilized microwave oscillator, and a 40 megacycle crystal-controlled oscillator. Techniques have been developed to reduce the variation of frequency in these two oscillators to the low figure of $\pm.005\%$. A typical crystal oscillator is shown in the photograph on page 6, with the front panel and the front of the temperature-controlled enclosure both removed.

A study of Figure 1 will show that the conversion system minimizes signal frequency variation in another way. As the same microwave oscillator supplies the frequency for both the "down" and the "up" conversions, any slight shift in frequency of the microwave oscillator will affect only the i-f frequency, since the error cancels itself in the two conversions. The microwave oscillator has automatic temperature control.

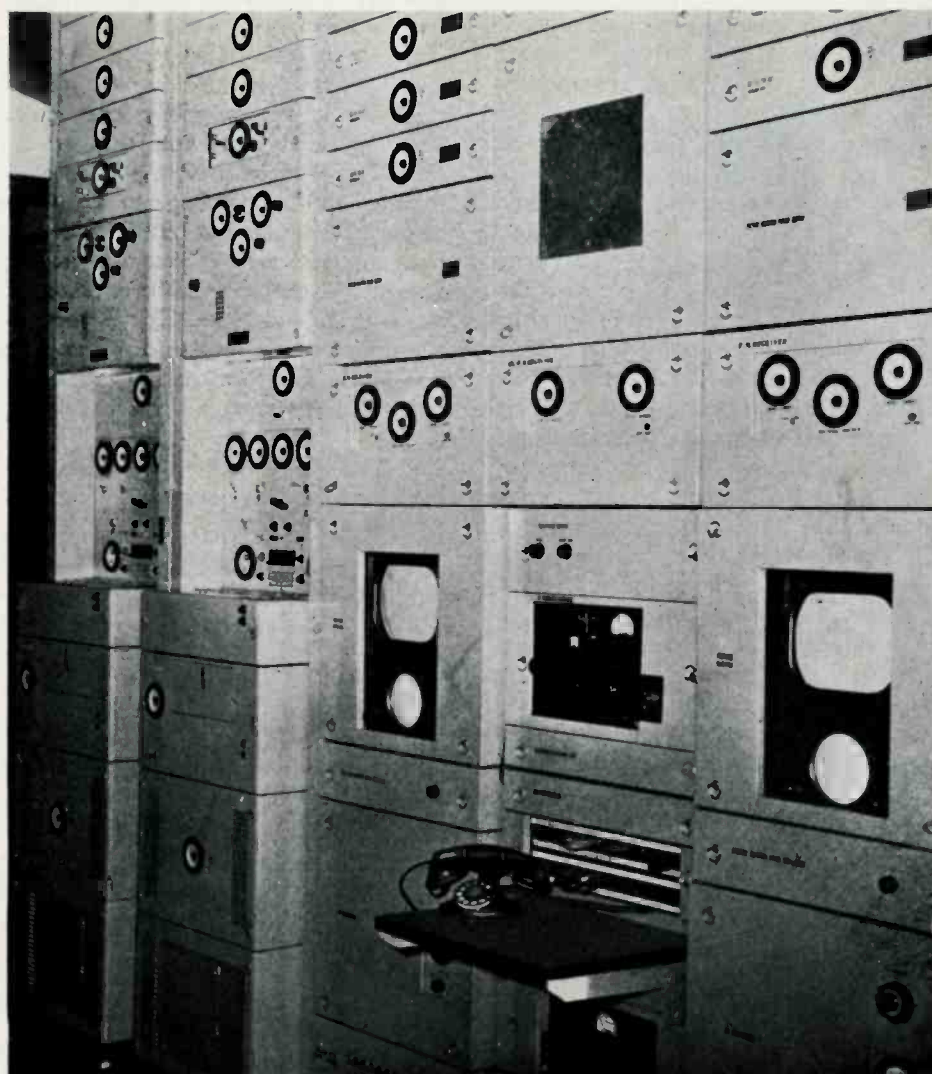
The photograph on page 3 shows the microwave amplifier unit with front cover removed. The output cavity is being adjusted with the threaded stud that acts as a frequency-setting element. The four vacuum tubes used in the amplifier can be seen, with two additional tubes used as buffer amplifiers below them, and below that the panel containing the modulator.

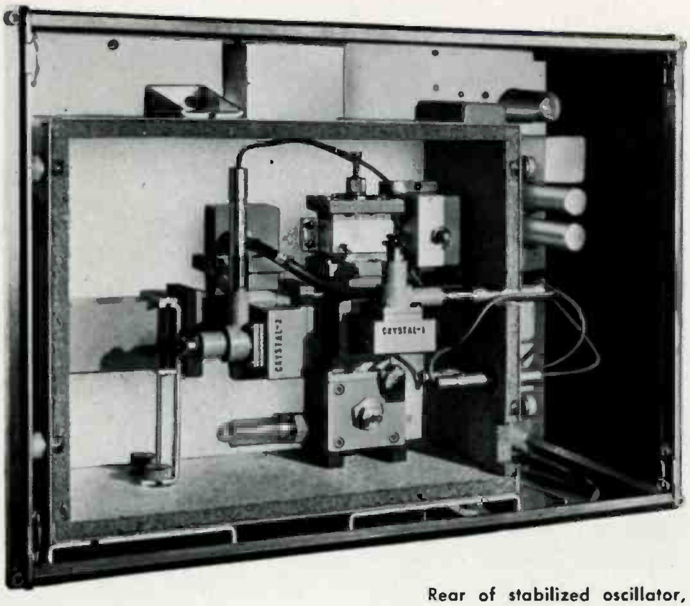
The anode end of each tube extends into an air cooling duct which is supplied

Rear of repeater bays shows branching filters at top and at waist level, cooling blowers at bottom.

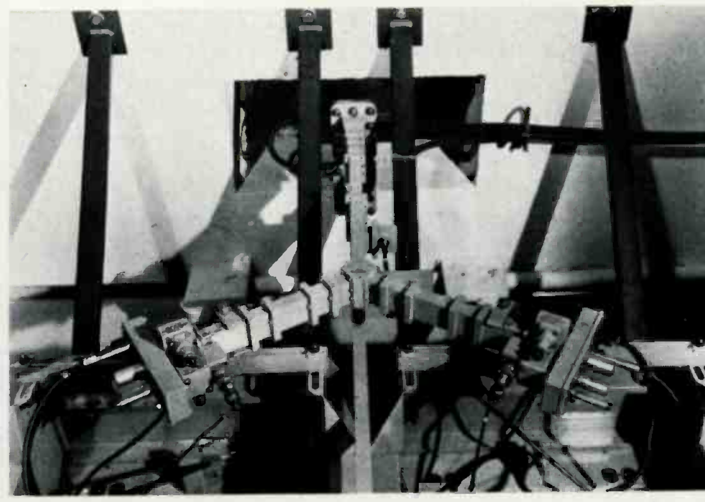


Terminal equipment includes two bays, at left, with units duplicating those in the repeater channels. In three bays at right are the FM transmitters and receivers and video and monitoring equipment.





Rear of stabilized oscillator, showing crystals in cavities.



Closeup of receiving branching filter at top of repeater bay.

with air by a blower at the base of the bay. Two complete repeater bays are shown in the two views, front and rear, in the photographs on pages 4 and 5. The front view shows a meter panel being read, just above which is the microwave oscillator, and below which is the microwave amplifier with cover in place. The rear view of the dual unit shows the wave guides with the branching filters — the receiving filters at the top, the transmitting filters closer to the floor level, and the blowers at the base.

The very exacting design requirements of a relay system using broadband microwaves, which is to be adaptable to multichannel telephony and television signals as well as other services, can be judged from the repeater characteristics shown in Figure 1. The most important characteristics are the amplitude-vs-frequency response and the amount of delay distortion. The latter, even in very small amounts, may become perceptible in television transmission, and may produce serious crosstalk in multichannel telephony. The curves in Figure 1 show that the repeater is uniform within ± 0.1 db over the 10 megacycle signal band, with delay distortion at no greater than 25 millimicroseconds over the same band. Relatively simple phase equalizers operating at intermediate frequency have been added at each repeater, reducing substantially even this seemingly small amount of phase distortion.

The necessity for reliability under conditions of unattended operation imposes further stringent requirements on every part of the repeater design. The repeaters operate on commercial power, but two emergency supplies are provided in the form of a gasoline engine driven alternator, and a bank of storage batteries, which are automatically cut into service in case of power failure.

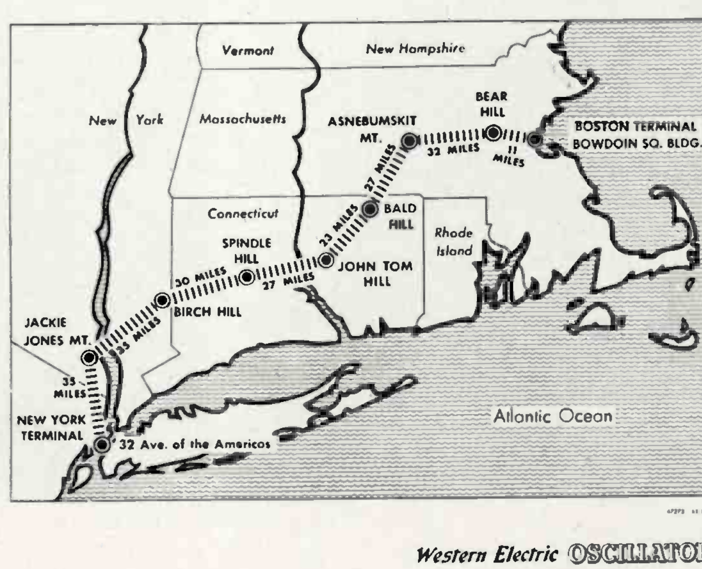
Typical of the automatic safety features is the system for guarding the microwave amplifier tubes against the overloads that may occur under certain abnormal conditions of operation. An overload relay removes the high plate voltage, restoring it approximately one second later. If the overload condition has not cleared in that interval, the relay again removes the high voltage to repeat the sequence. The overload circuit will make five automatic attempts to restore the high voltage. If the abnormal condition remains at the end of the fifth attempt, the plate voltage is left in the "off" state and a warning is sent to a control center indicating that the repeater is not operating.

Terminal Equipment

The transmitting equipment at the New York and Boston terminals is designed to accept a video signal from either a balanced or unbalanced line, to amplify it, and to apply it to an FM modulator which imposes it on a 65 mc "i-f" carrier. This 65 mc frequency modulated signal is then amplified in an i-f amplifier and raised to the microwave frequency in converter systems identical to those used in the repeaters.

The receiving equipment reverses this process, with an FM receiver that accepts a 65 mc frequency modulated signal from a microwave-and-converter system identical to that in a repeater. The second diagram in Figure 1 is a simplified block diagram of the transmitting and receiving equipment. The photograph on page 5, showing a partial view of the equipment at the New York terminal, includes at the left the two bays which, as is indicated by their appearance, contain the terminal apparatus duplicating that in the repeater stations.

Seven repeater stations are placed on facing hilltops between New York and Boston to make an unbroken line-of-sight path over the 220-mile relay link.



The three bays at the right hold the video equipment, and FM receivers and transmitters for the two channels, as well as the monitoring, testing, and calibrating equipment that is an important part of the terminal apparatus.

The third block diagram in Figure 1 shows the main features of the testing and monitoring techniques. In the upper part of the diagram a transmitter-receiver combination is set for monitoring the quality of television signals and for checking the operation of the automatic frequency control circuit.

Because of the nature of television signals, it is advantageous to regulate the frequency of the modulated oscillator to a fixed value at those periods corresponding to the tips of the synchronizing pulses, and to maintain this regulation regardless of the picture content of the television signals. To this end, the transmitting video amplifier contains circuits that abstract from the input wave a train of synchronizing pulses completely stripped of all picture signals. These pulses are used to "gate" an automatic frequency-control circuit which consequently samples the transmitter frequency only at the tips of the synchronizing pulses and holds it at a predetermined value. Manual frequency control is also provided for the initial lineup. The FM oscillator-amplifier finally delivers its output to the microwave transmitter at a level of 80 milliwatts. It also provides an input for an auxiliary system used for frequency monitoring.

To permit the operator to check the quality of the picture signal as it exists at various points within the terminal during a television transmission, three video monitoring points are provided. Signals from these points can be applied to a picture monitor which displays the picture as it appears in the ordinary home television receiver. This unit can be connected so as to display the picture as it exists at the point of application to the frequency-modulated oscillator, or as it is delivered to the local television network. In addition, it can be connected to a monitoring point located in the microwave equipment, where a special microwave discriminator and detector are located.

The picture monitoring unit is also equipped with an auxiliary oscilloscope which displays the television signal as it would be seen with the type of cathode ray oscilloscope commonly used for laboratory testing. This oscilloscope can be made to synchronize at either line or frame frequency. It is used primarily for observing and measuring the instantaneous frequency of the FM oscillator during normal operation. This is made possible by the use of a monitoring FM receiver which permits comparison of the frequency of the modulated oscillator corresponding to any portion of the television signal with that of an auxiliary generator of continuous waves, operating in the vicinity of 65 megacycles, which can be adjusted manually to any desired value. Comparison is made with the aid of an electronic switch. This consists essentially of two 65-megacycle amplifiers connected in parallel and so arranged that they are alternately energized for equal periods of time by a multivibrator circuit.

Energy derived from the transmitting oscillator is applied to the input of one amplifier of the electronic switch, while the second amplifier is driven by the calibrating oscillator. The composite output of the electronic switch is then impressed on the monitoring FM receiver which delivers a video wave containing information concerning the frequencies of both

(*Continued on page* 39)

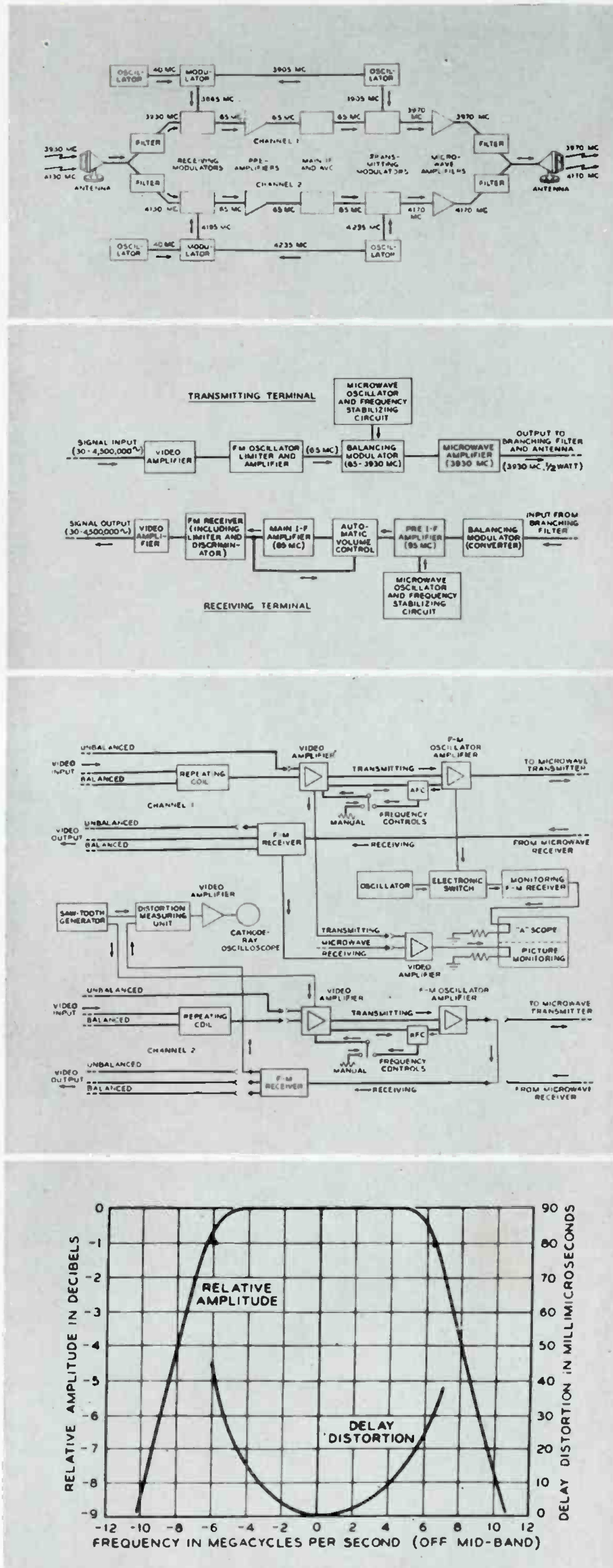
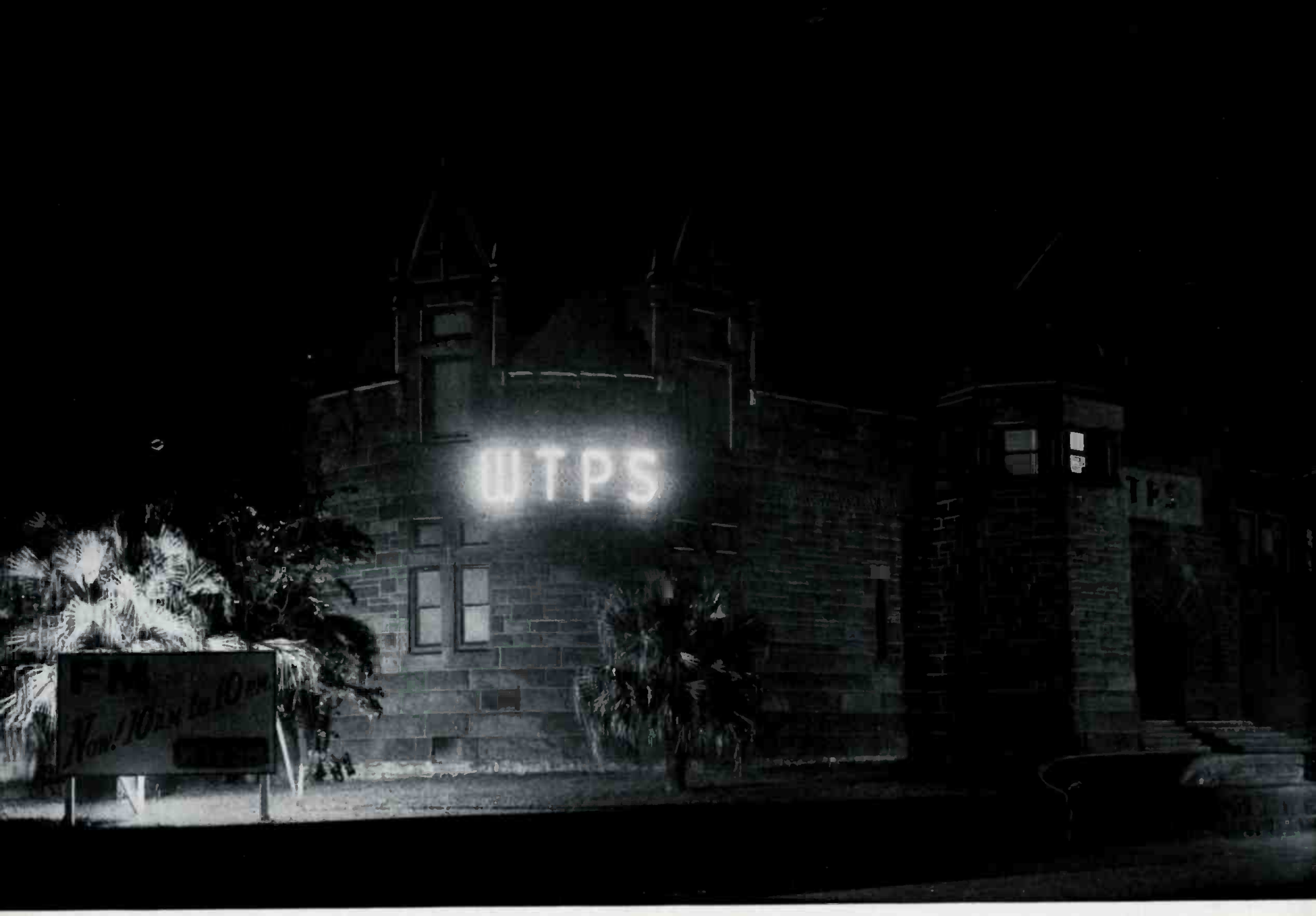


Figure 1—Top, block diagram of repeater equipment for two channels in one direction. Second diagram, functional arrangement of units in the transmitting and receiving terminals, including the video, FM modulating and demodulating, and microwave equipment. Third diagram, monitoring circuits in the terminal bays for showing the television signal at various points in the circuit, and measuring the distortion. Bottom, the repeater characteristics showing the flat response over the video band, and the minimum delay distortion.



WTPS-FM, NEW ORLEANS

The historic *Times-Picayune* and *New Orleans States* build a three-quarter-of-a-million-dollar FM voice

By George de Mare

NEW Orleans, the magic city . . . the boat ride around the crescent . . . Antoine's and crepes suzettes . . . the Vieux Carre—these are the landmarks people think of when one mentions this ancient and colorful city. And here it is that two of the South's great newspapers, the *Times-Picayune* and its sister the *New Orleans States*, the former of which has served this city for more than a hundred years, are building one of the most elaborate and carefully planned FM stations in the country — WTPS-FM, a three-quarter-of-a-million-dollar plant!

H. F. "Bob" Wehrmann is in charge of this enviable enterprise, as well as of the sister 1 kw AM station, WTPS. We, therefore, flew down to see him and learn something about the FM station—its aim, its policies, and its technical facilities.

Three major elements — the old city, the newspaper, and the management's faith in FM — run like a theme throughout the background of this station.

Management's Faith in FM

First FM.

WTPS-FM, "95.7 on your dial," is clearly designed to become one of the top power FM stations in the country with an eventual effective radiated power of 270 kw. Right now, it is a 1 kw FM station with a 10 kw transmitter on the way and a 50 kw FM on order. It has coverage throughout the city and has received letters remarking on the clarity of its signal from as far as Clinton, Mississippi. This particularly pleases Bob Wehrmann because he is not only a one hundred per cent FM man, but he believes that the possibilities of FM have thus far been underestimated and underdeveloped by the Industry. With WTPS-FM, growing out of, and owned and backed by, the city's largest and most influential newspaper, he intends to show the Nation what FM can do.

In WTPS's magnificent new studios in the old Howard Memorial Building on Lee Circle, we sat down to hear about the station. The studio building is a New Orleans landmark. Formerly a private library belonging to one of New Orleans old and wealthy families, this handsome Romanesque edifice of heavy sandstone is itself an indication of WTPS owners' policy of fitting the station into the life and heritage of the community. The building was designed in the last century by Henry Hobson Richardson, the designer of Trinity Church, Boston, and an outstanding architect of his day, and it was bought by WTPS with a condition by the original owners that the exterior be in no essential respect changed. This condition has been scrupulously respected. Inside, the studios are modern and beautifully appointed. Bob Wehrmann spoke on his favorite subject — FM.

"You find a lot of people saying that AM's doing all right. It's good enough for the public. And besides, they say, the public's got a tin ear. The public doesn't care about background noise if there isn't too much of it — it's used to it, and there's no use going to the expense of an FM revolution when AM can do the job. Well, I disagree one hundred per cent!

"I don't really think the public has a tin ear. I think more people would like to listen to FM but are prevented from doing so, because receiving set manufacturers won't manufacture enough FM sets or push them hard enough or as hard as their AM models, and finally because we broadcasters just haven't worked up any FM programs worth listening to! You know that as well as I do.

"For example, here's what the average FM program amounts to. Some announcer —generally a one-man FM program staff in himself — sits at a control desk. He flips a switch and says: 'Good evening, Ladies and Gentlemen. This is Station WXXX-FM on the air two hours a day from midnight to two in the morning, bringing you yesterday's up-to-the-minute news.' (Perhaps, I'm exaggerating a little.) 'Now, friends,' the one-man staff announces, 'let's listen to Bing — you know, ol' Bing Crosby — his new version of that great new hit, played for the first time on FM — *I'm Dreaming of a White Christmas* . . . And aren't we all . . . heh, heh. . . .' Then having floored his vast invisible audience, most of whom, if they lead respectable lives, are asleep anyhow at this hour, he puts down the arm on the turntable and for the next hour regales his listeners, if any, with old records thrown away by the recording library of the station's AM partner! That's what we call programming in FM!

How Far Is Good Coverage?

"Another point stressed by AM partisans, however," Bob continued, "is the matter of coverage. Let me ask you this, how much coverage do you need? Do people in Kalamazoo or Timbuctoo listen to New Orleans stations? Do people in Atlanta or St. Louis listen to New York stations? Of course not. People listen to their local stations—those that come in clear and strong, and we here want to blanket the New Orleans area with a strong, clear signal. We want to cover the areas our newspapers, the *Times-Picayune* and *New Orleans States,* cover with a day and night, winter and summer, rain or shine service. That's the kind of service we believe FM above any other type of broadcasting can give listeners!

"Of course, I know that FM hasn't the sponsors yet and that all is not as easy as it might seem at first glance. But we could do better — much better. So what is WTPS-FM doing about it?

"Well, right now," Bob continued, "we're doing *two* things. Initially, we're trying to put over FM technically in our own community. There are only about 15,000 FM receiving sets in the New


The Picayune.

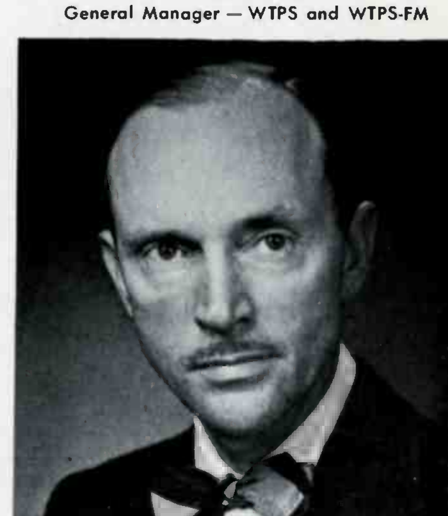
LEONARD K. NICHOLSON
President — Times-Picayune Pub. Co.

JOHN F. TIMS, JR.
Vice President — Times-Picayune Pub. Co.

JOHN R. O'MEALLIE
Commercial Manager — WTPS-FM

BILL SEYMOUR
Program Manager — WTPS-FM

H. F. WEHRMANN
General Manager — WTPS and WTPS-FM



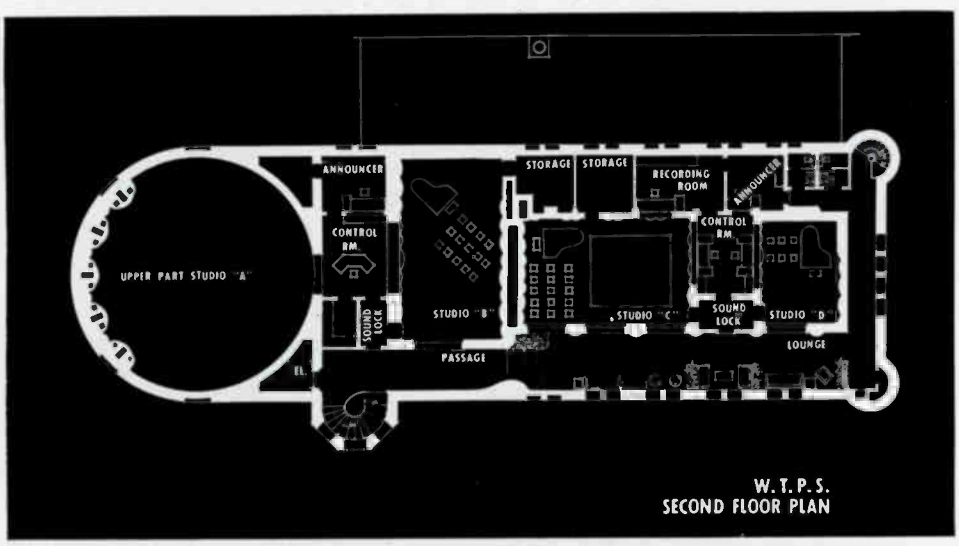
Orleans area. And even now people don't seem to know what FM is. For example, when WTPS-FM with much fanfare went on the air a year ago and we publicized the inaugural, the day after the ceremony the switchboards of the *Times-Picayune* were flooded with calls from people saying, 'I understand your station is on the air. Why can't I hear it on my radio?' Of course, the answer was they did not have FM receiving sets — and many of them did not even know such sets existed!

"Thus, we have been running advertisements — about $18,000 worth of them — in our papers to try to teach people what FM is and what it will do for them and to get people into the stores to buy FM receiving sets. Our ads say: 'FM means far more listening pleasure for you!' They say: 'Do you get your Stokowski mixed with Spike Jones?' 'Are you tuning in a beehive?' And we show a photograph of a stormy night in New Orleans with lightning licking through the sky and say: 'Even on a night like this, FM is static free!' As a matter of fact, during the recent hurricane down here with its 104-mile-per-hour wind, uprooted trees and floating debris, WTPS-FM stayed on the air and came in static free!

"The other thing we are doing is to start to work hard on a real job of programming. WTPS-FM is now on the air twelve hours a day, from 10 A.M. to 10 P.M. seven days a week. We used to be on from 2 P.M. to 10 P.M., but as is the case in many communities, a dealer in FM receiving sets could not even demonstrate an FM set in the morning because there were no FM stations on the air at that time!

"A few months ago, pursuing our policy of trying to build up and sponsor a real schedule of programs, we secured Bill Seymour as our program director. He has a staff of three writers and four announcers now, and he is working out a series of *different* programs, of live programs for FM, 'programs with thought,' we call them. These programs are going to be of three general types, like most good AM program schedules: first, entertainment — music, specialty acts, drama (we have our *Quizdown, Teen Hall Today,* our *Sports Rallies* and our *You Loved It Then* shows of this type. We are about to begin other programs, one of which, *Records for Children,* we expect to become a big thing in radio programming!) Number two, we are working on public service programs which are of particular importance to us, since we are born of a great public service newspaper rooted for more than a century in its community life. Here, we have our Topics for Vets, our Army Recruiting Programs, our Savings Bonds, Community Chest Drives and our fund raising campaigns for victims of the hurricane and our Cancer and Safety Drives. We are contemplating also a Fight Inflation program and we have in mind an educational program sponsored by Tulane University's Psychology and Sociology Departments. And then, we are planning a number of Community type programs — programs born and nurtured in this colorful community in which we live . . ."

Floor plan of the second floor of WTPS' two-story studio building showing arrangement of Studios A to D.



An Old and Exotic City

The city, as a matter of fact, is the second major element forming the background of the station. New Orleans is, of course, one of the oldest and most exotic cities of the Nation. Known as the Crescent City because it lies in a crescent-shaped bend of the Mississippi, it was founded in 1718 by the French, and its history is full of the sound of clangor and riot. The pirate Lafitte hid his gold here; the French and the Spanish mingled to produce the Creole, the beauty of whose women is famous the world over, and from North Rampart Street to the river front and from Canal to Esplanade Avenue, the high lacy wrought-iron balconies of the Old French Quarter hold the flavor of a time when Jesuits cultivated myrtle, oranges, figs and indigo, and Spanish and French made the city a distinctive and widely known center of artistic and social life.

New Orleans is actually a city reclaimed from under water, for most of its

Below: Viewing lobby giving view of Studios B to D in WTPS' new studios.

Below: Main lobby at entrance to WTPS studios, leading to executive offices.

200 square miles lie below sea level and must be drained by its canals from Bayou St. John to the Inner Harbor Navigation Canal and by a system of water drains into Lake Pontchartrain and the Mississippi. It is, of course, one of the world's great harbors, and along the river front one can see and smell the ten miles of spice-laden docks berthing ships from all over the southern world. Here also are the molasses plants and cotton seed oil mills, the oyster luggers and sulphur and salt docks and the famous coffee and banana wharves. And now that the city is oil rich, since Louisiana has become the third of the Nation's oil producing states, there may be seen the oil docks to the south.

This colorful background with the present-day vestiges of many old customs and manners, the station intends to recapture in programs. As Bill Seymour put it: "We have in mind to capitalize on much of the city's exoticism. For instance, we are planning to send a man down to the old coffee shops in the Vieux Carre to record the strange and indigenous language of the coffee market and to record the old peddlers' chants nearby ('I got 'nanas! I got 'nanas!') which have a flavor and beauty all their own . . ."

The *Times-Picayune*—A Major Influence

The third major element which has influenced the policies of the station is the newspaper — the *Times-Picayune.*

We drove to the handsome Times-Picayune building on Camp and North Streets to talk to James Witcher, Promotion Manager of the Times-Picayune Publishing Company. Jim Witcher had much to tell us of the history of this famous newspaper and how it went into radio.

"The *Times-Picayune*," Jim told us, "was founded January 25, 1837 by George W. Kendall and Francis A. Lumsden. It was then called 'The Picayune.' Kendall won journalistic fame as the first editor to organize a systematic coverage of a war. His pony express from battles of the Mexican War which he covered personally permitted the Picayune to scoop newspapers much closer to the scene of action. This on-the-spot journalism was a feature of this newspaper's stories in all the subsequent wars which the paper reported — the War between the States, the Spanish American War and World Wars I and II. A staff representative of the *Times-Picayune,* for example, was present at the historic Japanese surrender of World War II aboard the battleship *U.S.S. Missouri.*

"On April 6, 1914, the *Picayune* and the *Times-Democrat,* founded in 1863, merged to become the *Times-Picayune,* and in 1933 the Times-Picayune Publishing Company purchased the 53-year-old *New Orleans States.* Associated with these papers are many famous names of the past and present literary and journalistic fields —such as Mark Twain, Lafcadio Hearn, O. Henry, Roark Bradford, George W. Cable, Gwen Bristow and Dorothy Dix."

"How did the paper make its decision to go into radio?" we asked Jim.

"This is not the paper's first venture into radio," he replied. "As a matter of fact, we went into radio back in 1923 when the paper started station WJBO—the first radio station in this area. The experiment was carried on for several months and I believe quite successfully. There are a number of stories about why the station was abandoned, one of which I think may amuse you:

An Early Venture Into Radio

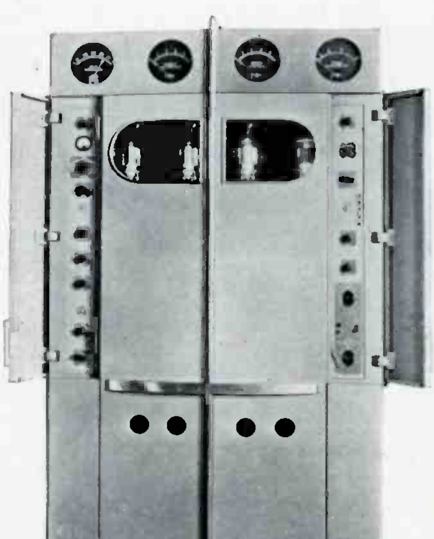
"It seems in those days the station used almost entirely local talent for its programs — people from around town — singers, specialty artists, cowboy entertainers, musicians from the clubs in the city. Well, the studios were situated at Tulane University and it was thought that it might be nice to provide at least transportation for these performers who gave of their services without recompense and merely for the possible publicity. So we drove them to the studios and back in taxis. At the end of the month, therefore, a bill was presented showing expenses: Taxi fares — $7.65. One of the officials looked at the bill a moment, turned to the man in charge of the project and said: 'It's too expensive. Kill the station!'

"We won't vouch for that story," Jim said smiling. "It's more likely the time was not ripe for a station, the public not equipped for radio here in its primitive form. Today, of course, there are not only plenty of AM stations down here but three other FM stations as well."

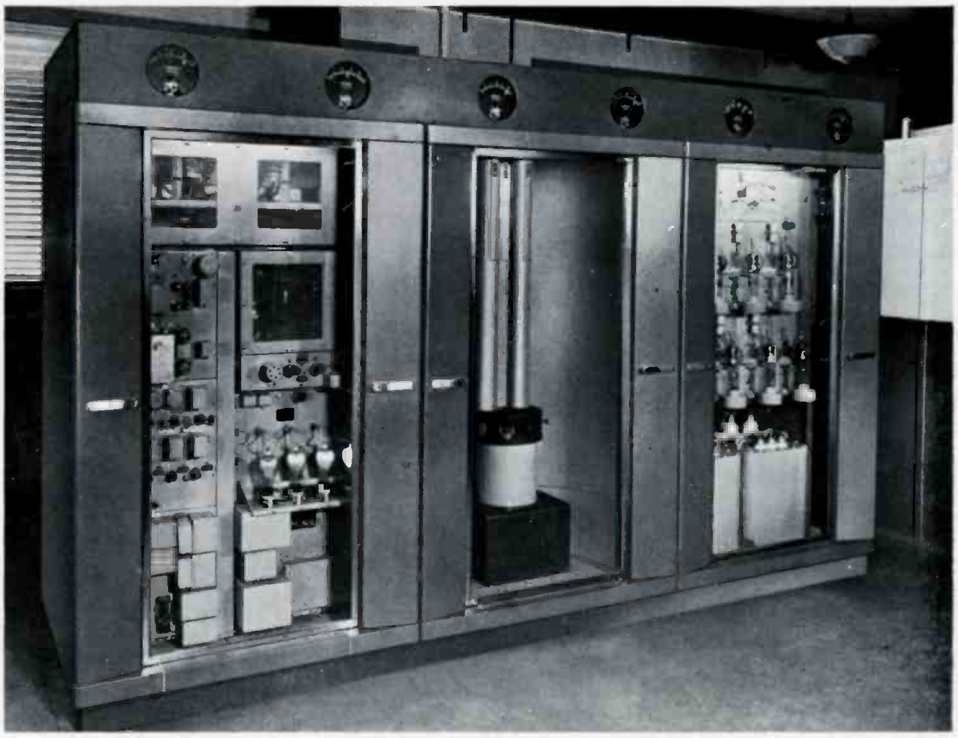
The men who are associated with the policies of the station and who run it are

(*Continued on page 35*)

Below: WTPS-FM has this Western Electric 10 kw FM transmitter on the way, and a 50 kw FM on order.



WTPS, the AM sister of WTPS-FM, uses this 1 kw Western Electric transmitter for its AM broadcasts. Building has space for higher power AM equipment.



STANDARDIZED QUARTZ CRYSTAL UNITS

By E. E. Selover
Radio Division, Western Electric

WITH the increasing use of quartz crystals for oscillator control in every branch of electronics, the need for standardization of these units has become apparent. In the past a limited knowledge of crystals and their characteristics made it expedient for design engineers to request specially made or "tailored" units. This has resulted in the development of many different types, designs and varieties of mountings for each crystal application.

Western Electric has just announced a new *standardized* line of crystal units which should eliminate many of the former problems confronting the circuit engineer. Designed by Bell Telephone Laboratories with emphasis placed on establishing a standard series of crystal units with nominal tolerances to cover a wide frequency range, they reflect significant advances in design and manufacturing techniques over units produced several years ago. In general these units are smaller, more rugged and give better performance.

The initial introduction of ten standard type units within the frequency range from 1.2 kc to 50,000 kc is accomplished in five standard holders, of which two are identical except for length. By the proper selection of crystal blank size, orientation, mounting arrangement and holder, it is planned to supplement these ten types to cover a still wider frequency range and maintain a minimum number of holder types. The following table shows the frequency ranges of the ten types introduced to date:

Type	*Frequency*
20J	1.2 to 10 kc
21N	16 to 100 kc
21E	90 to 300 kc
22D	200 to 500 kc
22C	300 to 1,000 kc
24A	2,000 to 10,000 kc
22A	3,950 to 10,000 kc
24B	4,000 to 15,000 kc
22B	5,000 to 15,000 kc
23A	15,000 to 50,000 kc

To insure the proper operation of crystal units with the earlier "tailored" method of manufacture, it was necessary for the purchaser to supply the manufacturer with an oscillator circuit for testing. After learning some of the factors governing the operating characteristics of crystal units it was possible for the manufacturer to duplicate a "using" circuit and employ it as a reference standard.

While it is not yet practicable from a manufacturing standpoint to define all characteristics of crystal units, it is practicable to standardize test oscillators for most applications. Eventually it will be feasible to define all characteristics independently of the oscillator.

For the new crystal units, the Bell Telephone Laboratories have developed a group of standard test oscillator circuits, as

Below are shown four of the quartz crystal unit types in the new standardized series. Left to right, 23 types, 24 types, 21 types and 22 types. A 20J type is illustrated in photo at top of page.

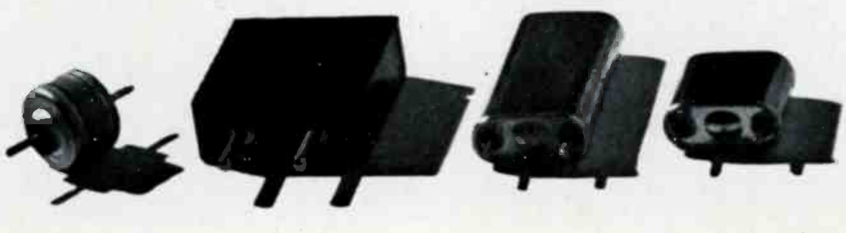


TABLE I

The letter coding used to designate the orientation and mode of vibration of the ten units in the new series listed on the opposite page is as follows:

First Letter of Code	Cut	Mode of Vibration
A	AT	Thickness shear mode
B	BT	Thickness shear mode
C	CT	Plate shear mode
D	DT	Plate shear mode
E	+5° X	Longitudinal mode
J	+5° X	Duplex plate, length-thickness flexure mode
N	NT	Length-width flexure mode

well as suggested "using" circuits, which embody the recommended operating conditions for the various units. The using circuits are correlated to the standard test oscillators. The use of these specific circuits is not necessarily mandatory for good operation of the crystal units, but they often provide an operating solution where none other is available. Figure 1 shows typical using and test circuits for the 22A type of the new series. In employing other circuits it is desirable to adjust the effective circuit capacitance and the crystal unit drive to the standard test circuit conditions. This standardization of test methods and provision of recommended operating conditions will assure uniformity of performance.

The variables which determine the performance of crystal units are:

(a) Nominal frequency.
(b) Type of quartz plate (angle of cut).
(c) Frequency tolerance.
(d) Operating condition.
(e) Temperature range.

With the new crystals, nominal frequencies have been set, as can be seen in the table, to cover a wide range in convenient steps. Specific orientations — angles of cut — have been chosen that give a minimum temperature frequency coefficient for a particular crystal unit. For example, low frequency crystals such as the 20J and 21E types employ +5° X cuts whereas high frequency units such as the 22A and 23A types use AT cuts. To obtain low coefficients in the other frequency ranges, double rotation of the plate is sometimes used.

The frequency of operation in an oscillator is determined by the crystal constants and the "effective" capacitance of the oscillator circuit (or operating condition). It is necessary to specify this capacitance or operating condition. The operating condition for most applications has been established as 32 mmf, 20 mmf, or series resonance.

To meet the variations in operating temperatures and to simplify testing equipment the temperature ranges shown in Table II have been standardized. Typical applications are shown for each range in the table.

Standardized Coding

In order to simplify the application of the crystals, a simple coding has been developed. The number refers to the type of holder, of which representative units are shown in the photographs on the opposite page; the first letter to the orientation and mode of vibration as shown in Table I; and a second letter indicates the performance characteristics under a specific set of conditions. A new bulletin,* *Western Electric Quartz Crystal Units, T-2471,* specifies the complete performance characteristics of this new series of crystals.

The advantages of thus standardizing crystal units and their characteristics, from an equipment design point, are apparent. The problem of determining what the control frequency shall be for a particular application is very much simplified. It makes the design engineer's job of selecting a crystal unit as easy as that of choosing a standard vacuum tube.

TABLE II

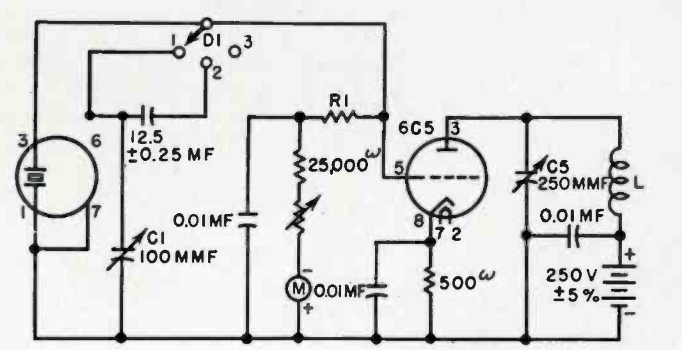
—55 to +90°C	Military and mobile use
—40 to +70°C	Military and mobile use
—35 to +55°C	Commercial aircraft use
+45 to +55°C	Oven control use
+65 to +75°C	Oven control use
+20 to +30°C	Normal room temperature use
—10 to +50°C	Fixed Station (unattended) use
+15 to +45°C	Fixed Station (attended) use
0 to +65°C	Marine use

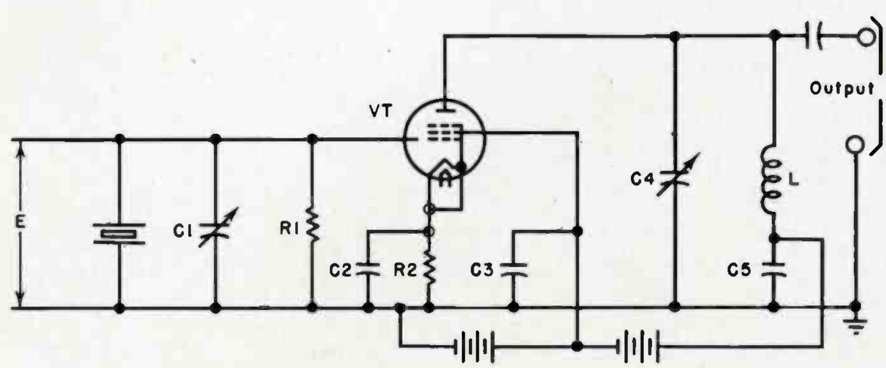
Several of the ten standard type crystal units are used extensively in Bell System applications such as mobile radio, power line carrier telephone, point-to-point, single sideband and other radio systems. Other applications in which these crystals are finding wide use include frequency standards, commercial airline communication, AM and FM broadcasting, police, transatlantic and ship-to-shore radio and military communications and radar.

Through this standardization of crystal units and the publication of complete characteristics it is felt that a more accurate job of frequency control can be accomplished.

*This bulletin should be obtained from Graybar Electric Co., 420 Lexington Ave., New York 17, N. Y.

Figure 1—At right, standard test oscillator circuit for 22A crystal unit, and below, recommended using circuit for this unit.





TWO WESTERN ELECTRIC FM TENS

WGHF—101.9 mc. With its new 10 kw FM transmitter WGHF, Captain W. G. H. Finch's enterprising station, inaugurates its third year of FM broadcasting. Its 1 kw Western Electric FM transmitter went on the air initially on February 25, 1946, and the station began commercial operation in June of that year.

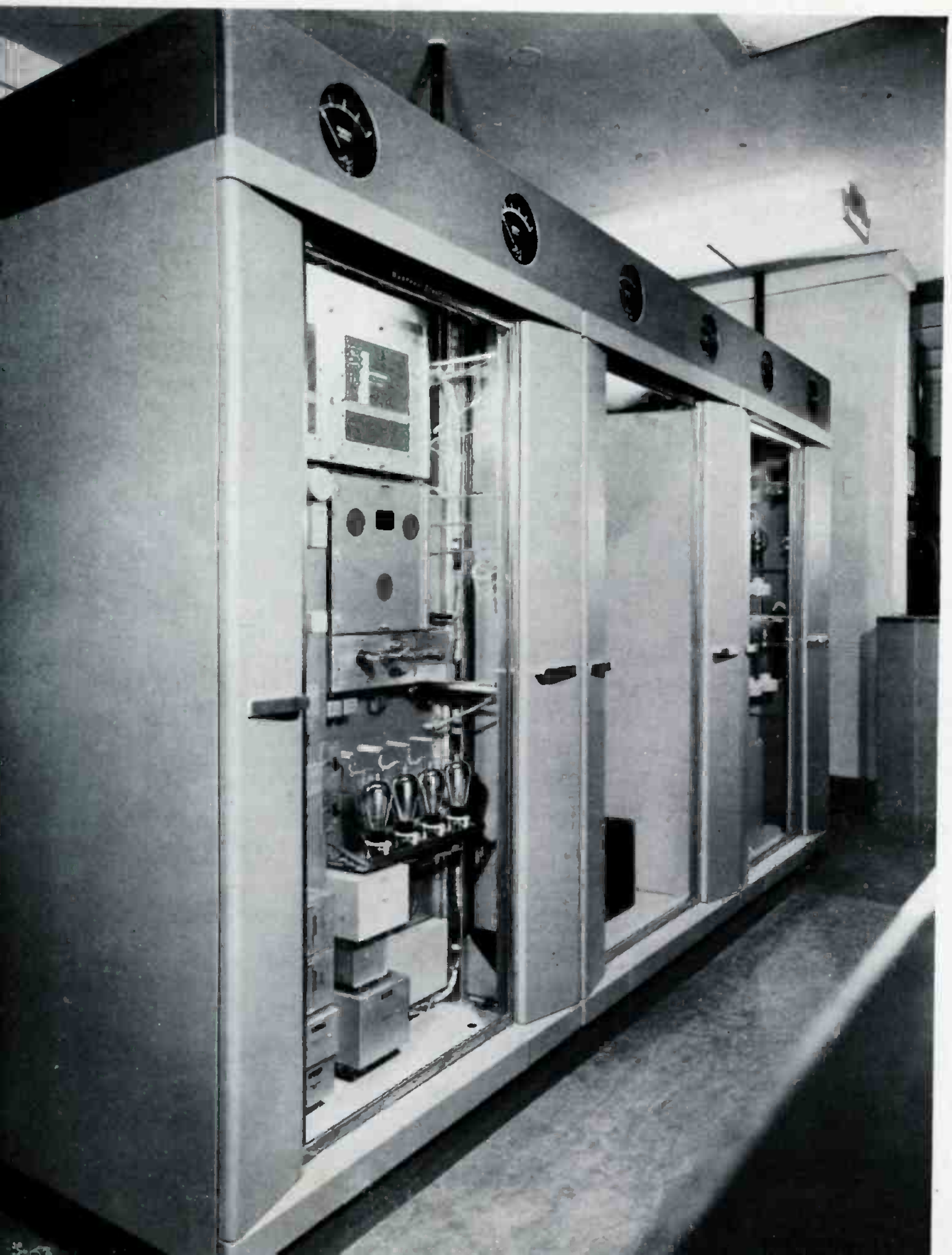
The station is situated on the 48th floor of a New York skyscraper, 716 feet above sea level. Its coverage includes the New York metropolitan area, and its programs have been clearly received from a distance of 130 miles.

Its studio equipment includes two Western Electric 23C speech input consoles with 109AA reproducer groups and 633A and 639B microphones.

Captain Finch, owner and general manager of WGHF, is well known in Broadcasting for his work in facsimile. He served with the FCC as head of the telephone engineering division until 1935. In 1941, he was called to active duty in the Navy as communications officer, where he received the Legion of Merit for his service.

WGHF Chief Engineer Veikko K. West has experience in both FM and television. He has served as transmitter and studio engineer at WABF and the experimental television station W2XMT.

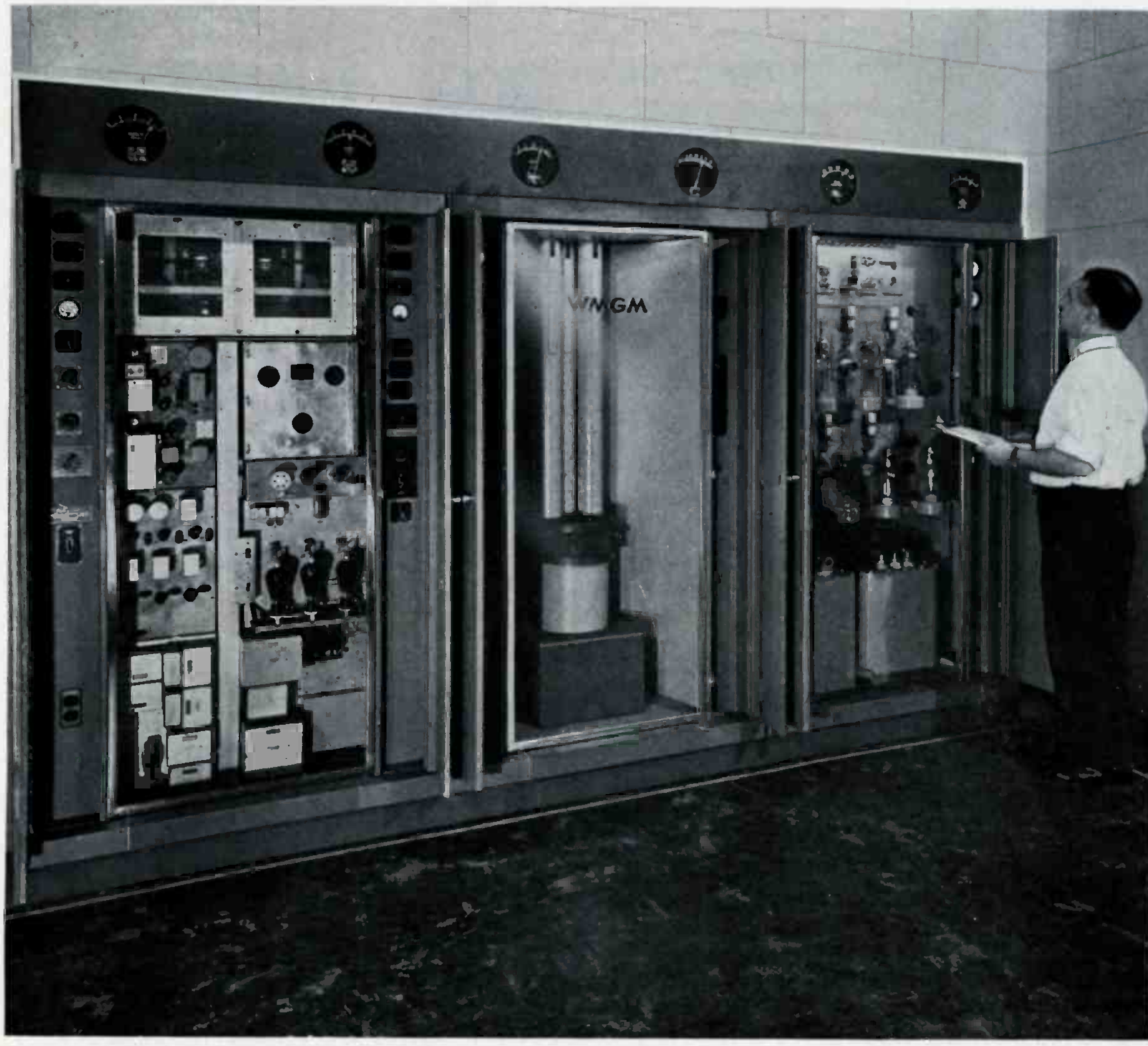
Captain W. G. H. Finch (right), owner and general manager of station WGHF and Veikko K. West, WGHF chief engineer standing before new transmitter.



Left: **THE NEW**—WGHF's 10 kw FM, one of the first Western Electric 10 kw FM's on air in New York.

Below: **THE OLD**—WGHF's 1 kw FM transmitter, which went on the air February 25, 1946. It is now the driver for the new 10 kw transmitter at left.

GO ON THE AIR IN NEW YORK . . .



WMGM—99.3 mc. One of the first FM stations to go on the air with the new Western Electric 506 Type 10 kw FM transmitter, WMGM now broadcasts its programs seven hours a day in one of the world's most thickly populated areas.

The station began operation with a 1 kw Western Electric transmitter back in 1942 at a frequency of 46.3 mc and with the call letters W63NY (later WHNF). Since then, it has expanded in a big way, and the new 10 kw transmitter is the present culmination of some carefully laid plans.

In line with its established policy, Western Electric has worked with WMGM to keep its transmitter up to date, and at every step modern developments have been incorporated. When the band was raised to 88-108 mc, the original 1 kw FM transmitter was converted to transmit at the new frequencies and its circuits were completely modernized. Now WMGM's original 1 kw — housed in the new TRANSVIEW design cabinet — serves as a driver for the brand new 10.

Paul Fuelling, WMGM's chief engineer, has directed the growth of this station from the beginning with plans to make it one of the best equipped in the land.

The FM studios are located in the transmitter building at Cliffside, New Jersey. Facilities include a Western Electric 25A speech input equipment, two turntables with Western Electric reproducers, Western Electric 1126 Type Program Amplifier, and a Clover-Leaf antenna atop the 335-foot Blaw-Knox tower adjoining the transmitter building.

Top: **THE NEW**—WMGM's Western Electric 10 kw FM, beaming WMGM programs 7 hours a day to New York. At right is Grover Wizeman, transmitter engineer.

Below: **THE OLD**—Paul Fuelling, chief engineer, stands at the Western Electric 1 kw FM transmitter.

POWER AMPLIFIERS FOR THE MODERN AM TRANSMITTER

The Doherty Amplifier in Western Electric's AM transmitters combines the simplicity of grid modulation with high efficiency

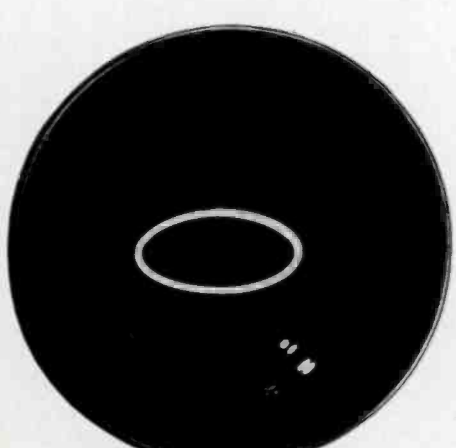
As the number of AM broadcast stations swings well past one thousand, it is obvious to every AM broadcaster that in the future there will be enlarged opportunities, coupled to a new intensity in the pace of competition. Medium and high power AM transmitters have come on the air in considerable numbers, bringing owners and operators face to face with the important problems of space requirements, quality of performance, and efficiency of operation, that center around high power broadcast r-f amplifiers.

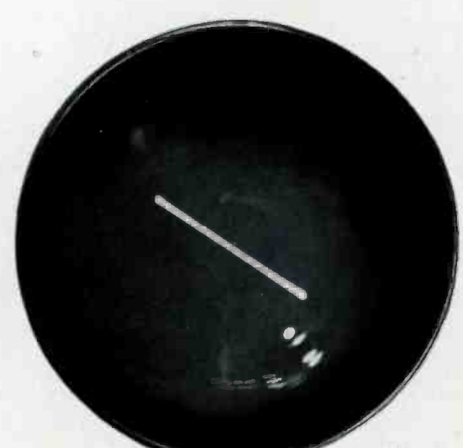
The combination of design features in the power amplifier stage of Western Electric's medium and high power transmitters produces basic advantages for the AM broadcaster. *Grid modulation* of power amplifiers is in general simpler than plate modulation, requiring less equipment and less modulator power. As is well known, grid modulated amplifiers must be linear amplifiers, which ordinarily entails the low plate efficiency of linear amplification. The pre-Doherty design choice was for the high plate efficiency of the Class C amplifier, which carries with it the necessity for plate modulation.

With the use of the Doherty *high-efficiency* linear amplifier, Western Electric's medium and high power AM transmitters offer the advantages of grid modulation, *combined with a high plate efficiency*.

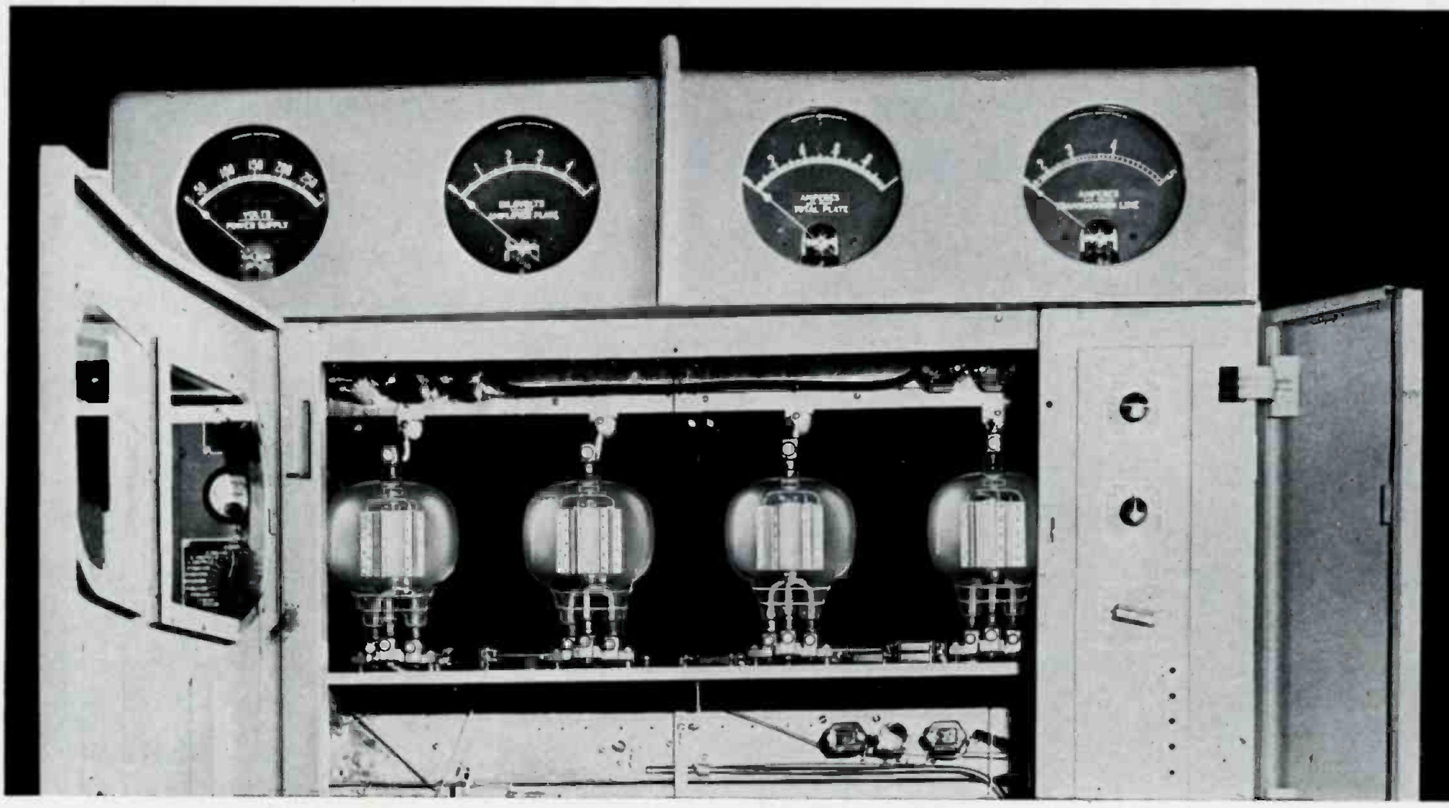
The principal results can be summarized:

1. The tube complement is simplified, with no high-power audio tubes required. In the 50 kw transmitter, for example, only two high-power tubes are employed, instead of the usual four in the plate modulation system.
2. No modulation transformer or large plate reactor is necessary for the modulation system, effecting another substantial saving in cost, maintenance, and space requirements.
3. As the modulation system does not involve large amounts of stored energy, it has freedom from transient and overmodulation surges.
4. Because of the absence of the modulation transformer with its phase shift, large amounts of negative feedback can be derived from the output envelope and applied to the audio input, resulting in very low noise, hum, and harmonic and intermodulation distortion, *without critical adjustment of circuits* or close dependence on precise tube characteristics.
5. Negligible carrier shift assures full utilization of the assigned carrier power.
6. The Doherty high-efficiency amplifier can be continuously overmodulated *at any audio frequency* for an indefinite period of time without endangering equipment in any way.
7. Plate power consumption in the





Front panel controls are provided for rapid setting of signal phase relations in power amplifier. In left picture above, adjustment is being made. The oscilloscope is plugged into sampling jacks at bottom of panel. Two patterns cover all adjustments: 90 degrees, center above, and "in phase", right picture above.



At the top of Western Electric's 1 kw AM transmitter can be seen the four W.E. Type 357 tubes used in the high efficiency linear power amplifier. The two tubes at the right are in parallel as "Tube No. 1" of the Doherty circuit; the two at the left work together as "Tube No. 2".

final amplifier is reduced by a factor of two to one, and the cooling load by a factor of three to one, as compared with the usual linear amplifier.

The operation of the Doherty *high-efficiency* linear amplifier has been described a number of times.[1,2,3] It may be useful in considering it here to reduce the actions taking place in the circuit to the *two* essentials of the design. Figure 1 is a block diagram of the power amplifier in Western Electric's 1 kw AM transmitter. Remember that the low efficiency of the conventional linear amplifier arises from the fact that it must be operated with a low r-f plate swing

1. "A New High-Efficiency Power Amplifier for Modulated Waves", *Proc. I.R.E.*, Sept. 1936.
2. "Doherty Circuit", *Pick-Ups*, July 1936.
3. "High Powered RF Linear Amplifiers", *Communications*, Nov. 1947.

at its carrier (unmodulated) value in order to permit the r-f plate swing to vary in amplitude between the limits of "zero" and "twice carrier swing" at 100% modulation. The logic of this is readily understood: 100% modulation raises the r-f plate voltage swing to twice its unmodulated value at the peaks of the modulation. A linear amplifier stops being linear when the r-f plate voltage swing exceeds a maximum value, near the d-c plate voltage. But the efficiency of an r-f amplifier is proportional to the ratio of the r-f plate voltage swing to the applied d-c voltage.

The problem, therefore, is to keep the r-f plate voltage swing at maximum, but to allow modulation to take place without overloading the tube. This makes clear the effectiveness of the *first* of the two essential actions in the Doherty amplifier:

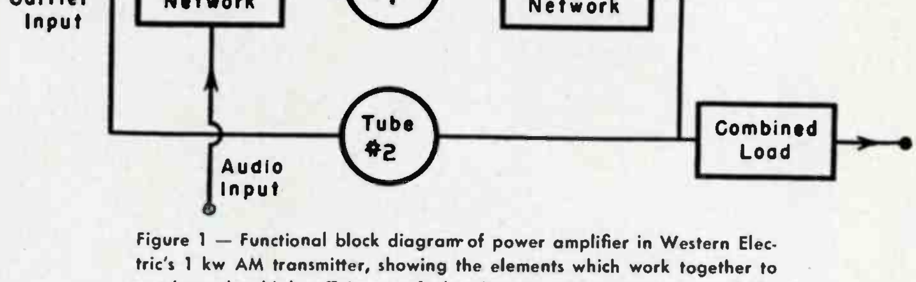


Figure 1 — Functional block diagram of power amplifier in Western Electric's 1 kw AM transmitter, showing the elements which work together to produce the high efficiency of this linear, grid-modulated amplifier.

(1) A linear amplifier tube (Tube No. 1 in Figure 1) is operated so that under no-modulation conditions the r-f plate voltage swing (E_p) is near maximum, but *so the load impedance (Z) drops at an audio rate in accordance with increases in the modulation,* thus allowing the modulation to produce additional power $\left(\frac{E_p^2}{Z}\right)$ from the tube without raising the r-f plate voltage swing above the maximum value.

It is clear from simple arithmetic, of course, that the power, $\frac{E_p^2}{Z}$, can be increased either by *increasing* the voltage E_p or by *decreasing* the impedance Z. In this case, we wish to maintain E_p at a constant level, so increased power is obtained by *decreasing* Z.

The *second* essential action in the Doherty amplifier is one that, in analogue, can be used to improve the efficiency of any system consuming power and carrying a varying load. The principle is most simple. When the load is light, only one tube, functioning as a generator, is required; as the load increases, a second tube, generator No. 2, is brought into action to help carry the load. Thus the consumption of power adjusts itself to the varying load. This can be stated:

(2) A second tube (Tube No. 2 in Figure 1) delivers power to the load in parallel to the first tube, the second tube

(Continued on page 36)

A NEW VENTILATING SYSTEM ADDS RELIABILITY TO FM TRANSMITTERS

It insures efficient removal of heat, negligible loading on air conditioning in building, and maintenance of operator's comfort

By Arnold K. Bohren

Bell Telephone Laboratories

WITH air conditioning recognized as such an important factor in increasing operator efficiency and comfort, it is appropriate that the new Western Electric 504B-2 (3 kw) and 506B-2 (10 kw) FM transmitters are designed for installation in air conditioned rooms. This is in line with the principle that an air cooling system for a medium-power broadcast transmitter must meet several important design requirements, in addition to the basic one of keeping the temperature of the larger amplifier tubes within safe operating limits. The effect on operator comfort and efficiency, minimizing of dirt, avoiding overheating the smaller components in the cabinet, loading on the cooling system in the building, must all be considered as prime factors in the design.

The cooling system in the new Western Electric 3 kw and 10 kw FM transmitters not only has improved cooling action for the high power vacuum tubes, but also makes specific provision for the additional design factors mentioned above. The first fact of importance is that the heat blown away from the high power amplifier tube does not create a second cooling problem by heating other components in the cabinet.

This is accomplished by connecting a duct to the power amplifier tube to carry the hot air away without allowing it to heat the air in the cabinet. The conventional method of cooling a high power vacuum tube by air is to force the air through the anode fins in an upward direction. Because the grid and filament connections must be made at the top of the tube, it is difficult to enclose the upper portion of the tube to carry away the hot air produced and at the same time have the tube easily removable from its socket.

A novel arrangement is employed in Western Electric's new FM transmitters which is without this disadvantage. Air is pulled down over the tube so the hot air may be carried away from the anode fins through a duct which is not complicated by the need for accessibility to terminals. Further, this method permits the intake air to cool the glass of the tube and the grid and filament seals by impinging directly upon them. In the upward blast method there is usually a "dead spot" directly above the envelope and in some cases an auxiliary stream of air is necessary to cool the glass and terminal seals. In the grounded grid circuit employed in the 3 kw equipment where the grid terminal of the tube is a disc, there is an annular space between the inside diameter of the disc and the glass envelope to allow air to pass from the top of the tube to the anode fins.

Importance of Cabinet Temperature

If air is blown upward through the radiator of a high power vacuum tube and allowed to permeate the cabinet, the temperature inside the equipment will be about 35° Fahrenheit higher than if the hot air is carried away from the fins of the tube by duct. A high temperature within the cabinet has the four following effects which are important considerations in the design:

1. The apparatus components in the equipment are unnecessarily subjected to higher temperatures, reducing the life expectancy of these components.
2. The hot air will escape through unavoidable openings in the cabinet and materially add to the load on the room air-conditioning system. Measurements made on a cabinet the size of that used in the 10 kw equipment show that about 88% of the air will flow through these openings and only 12% through an opening 6" x 14" provided to exhaust the hot air, if no duct from tube to opening is used.
3. A cabinet operating at a high temperature will radiate heat to the room adding to the air-conditioning load or causing operator discomfort

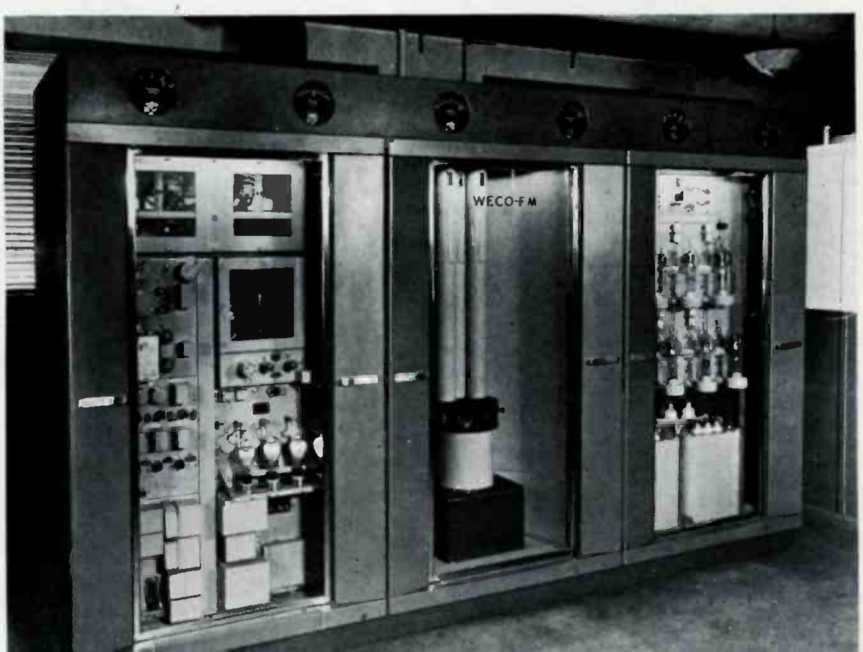


Figure 1 — Front view of 10 kw FM transmitter. In the center bay can be seen the circular housing for the amplifier tube, with the grille into which cooling air is drawn. Air comes into center bay after cooling driver.

where air conditioning is not provided.

4. The high temperature in the equipment will exceed temperature limits established for mercury vapor rectifier tubes causing arc-backs.

From the above it is obvious that a better design results if the hot air produced by the high power vacuum tubes is carried directly by duct out of the cabinet rather than allowed to add to the heat produced by other tubes and components in the equipment before it is discharged.

Because the air is pulled through the fins of the tube, the cabinet is subjected to less than atmospheric pressure, and air from the room moves in through the seams of the cabinet. In urban locations where the external air is particularly dirty, and for installations in air conditioned spaces, it is recommended that a small blower be added to the system, in the duct supplying intake air, to maintain a slight positive pressure in the cabinet. This positive pressure minimizes movement of dust from the room into the equipment, and prevents expensive cooled air from being pushed out of the building through the exhaust duct.

Pressurizing Blower

This added blower in the intake duct may have a small capacity since it must force air only through ducts, not through a vacuum tube. The duct and filter loss in the intake duct in most installations will amount to about 0.13 to 0.4 inches of water (static pressure) in comparison with about 1.0 inch of water for forcing air through a vacuum tube. Use is made of the intake air to cool the driver unit by directing this air through the driver before it reaches the amplifier, in such a way that it sweeps over the components in the driver where most of the heat is produced. The air after cooling the driver is then sucked into the high power vacuum tube in the amplifier unit, through the grille in the front of the tube housing, as shown in Figure 3.

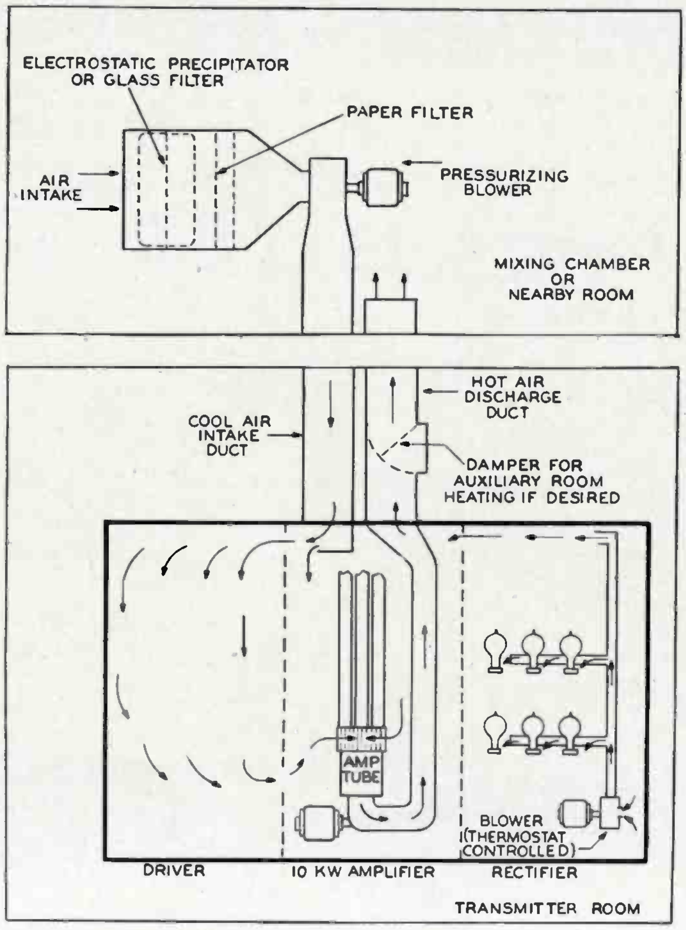


Figure 3 — Cooling air in 10 kw FM transmitter follows course shown in this diagram. Most of air flows from intake duct to driver unit, then into amplifier bay, where it is drawn into grille over amplifier tube. After cooling tube it is carried by duct out of cabinet and discharged. Secondary cooling system is controlled by thermostat to keep rectifier tubes from exceeding safe temperature. Filters at intake and pressurizing blower are additional equipment recommended when air carries large amounts of material.

To avoid pulling dust into the transmitter through the intake duct, it is recommended that a 2″ to 4″ thick spun glass filter or an electrostatic precipitator be installed at the intake of the external blower. In locations where a large amount of material is carried in the atmosphere, a paper filter may be placed behind either of the two afore-mentioned filters to obtain optimum cleaning. A fireproof unimpregnated type of paper filter is preferred. The filters should be located at the intake side of the blower and the filter dimensions should be limited to approximately 20″ or 24″ square to obtain the optimum air velocity for most efficient cleaning.

Figure 1 shows the 10 kw equipment, front view. The cooling air passes through the grille in the vertical surface of the circular housing for the vacuum tube. This forces the air to sweep across the top of the tube to cool the glass and terminals. Figure 2 shows the rear view of the transmitter and the intake and discharge ducts overhead. The duct at the left is the discharge duct and the one at the right is for supplying intake air. Openings are provided in the top of the cabinet for use if it is desired to run the ducts to the ceiling. The blower for sucking air through the amplifier tube is seen in Figure 2 in the lower portion of the center unit. The duct arrangement, and the general flow of cooling air in the transmitter, are shown in Figure 3. The same system is employed for the 3 kw equipment with the duct connections made at the amplifier-rectifier unit.

(*Continued on page 39*)

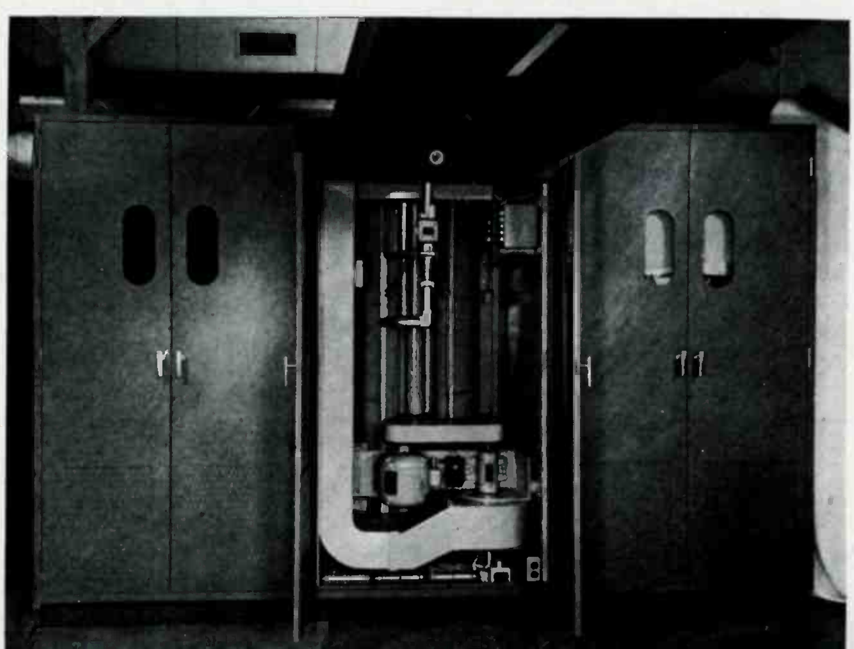


Figure 2 — Back view of 10 kw transmitter shows blower in lower part of amplifier bay for pulling cooling air down over tube. Exhaust duct goes up left side, leaves cabinet at top left. Cooling air enters through duct at right top.

" THIS IS THE LIFE "

or

Making Your Way With a First Class Ticket in Alaska

Here is a saga of the days when men were men, but a job like this could break a man's heart! J. A. Johnson, now a Western Electric Field Engineer, recalls his pre-Western Electric experiences as a radio operator in the Alaska wildernesses of a canning factory -- a tale to make the blood run cold and set the strongest key-pounder sobbing!

Big job. Is all hopped up at prospect of nice trip to Alaska and nothing to do but install new transmitter (not Western Electric) and operate it for couple of months. Stops in at home office of canning company few days before sailing. Is handed blueprint diagram but doesn't see set already shipped. Studies diagram. Makes a few notes. Thinks must be swell set. Nice diagram.

Leaves on boat. Meets couple of Swedes who were there last year. Both say it is a helluva place and that the Supt is a %#*$.

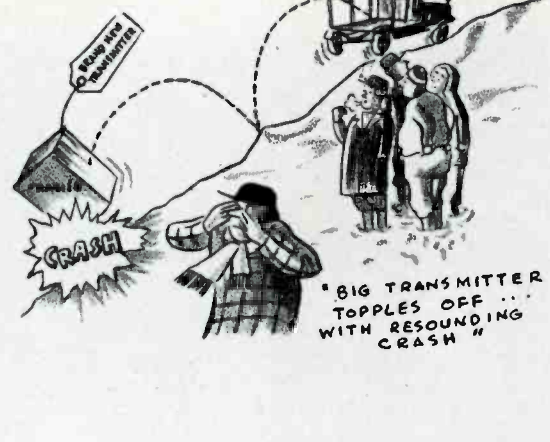
Arrives at Cannery. 3 A.M. Raining. Next morning up early. Supt says last year's operator not much good. New operator tells Supt no chance of anything going wrong this season with brand new set - latest thing out - lots of power. Supt gives operator three messages and tells him to send them right away.

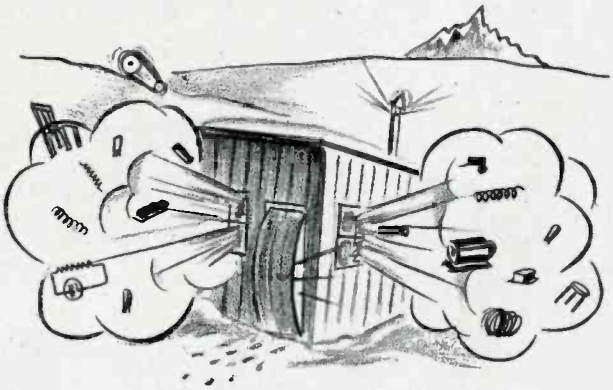
New operator inquires for key to Radio Station. Doesn't see any antenna. Nobody knows where key is. Oldest inhabitant points to shack on hill up in woods.

Goes up to shack. Scraps of wire, old burned out tube bases, old pieces of a spark transformer, and other radio junk lying around shack. Can't get in door - finds window broken so goes in that way. Two 18 foot spreaders and a 300 foot flat top antenna fill room in one grand tangle, as only phosphor bronze wire can kink and tangle. Transmitter covered with dust, and pulled out from the wall and at a weird angle. Much hay-wire stretched around. Lifts up lid of receiver and looks in - shudders.

Goes outside and looks around. Nice big trees - beautiful view of baybirds singing. Nice place. Goes back inside shack. Shudders again. Cleans up place - gets antenna up - repairs stovepipe and gets fire going to dry place out. No light - Cannery generator not in operation yet. So to bed and early start next morning.

In morning operator gets help of gang of husky Swedes to bring transmitter to radio





"STARTS ENGINE . A FLASH ... A CURL OF SMOKE ... LIGHTS GO OUT ...!"

shack. Box is marked: "FRAGILE - This side up - Handle with care - Do not drop - Delicate instruments." Big Swedes walk around box three times, then pick up and set it very carefully on a truck. They start slowly and carefully for the radio shack. Operator thinks must be swell guys to be so nice to help him.

Truck wheel slips and big transmitter box topples off and down into brush in small gully with resounding crash. Swedes start cussing each other in loud voices. Operator shudders. Go down to Cannery to get block and tackle. Come back in an hour and with a lot of heaving and hooing set box up on truck again. Box too big to go in door so is uncrated outside. Supt comes up to look at new set. Operator explains how wonderful it is. Supt tells operator to go down and fix lights in fish house right after lunch.

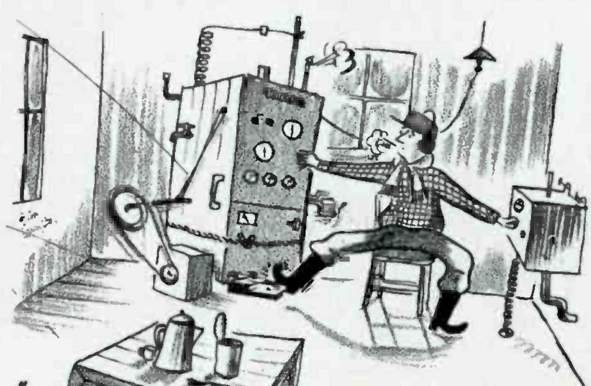
Gets back from fish house about 4 P.M. Is told there will be no cannery power for several days so he had better use emergency engine in shanty behind radiohouse. Engine is so rusty it won't turn. Engine governor assembly missing - broken off. Finds governor in box with old spark plugs, rusty bolts and miscellaneous junk. Beyond repair.

Starts work connecting up new set in morning. Locates set where it goes. Then chases all over Cannery to find carpenter to borrow brace and bit to bore holes in table. Carpenter shop is locked and no one knows when he will be back - maybe day after tomorrow.

Decides to get receiver going. Hooks up "B" batteries. Finds a storage battery that has a little life in it, and listens. Set won't oscillate. Takes set out of cabinet and traces wiring. Finds wire corroded off. Fixes it and checks battery connections. Hears many stations working, with strange calls. Finally recognizes WXX, station he is supposed to work. Sounds like operator has "Jits", uses bug with weights off so dots don't come thru then tries to send a mile a minute. Sends a whole string of dots for an "H" or "5". Operator changes battery voltages. Receiver works better. Operator feels proud. Lays phones on table to see how far away he can hear "WQN". Steps outside just in time to hear a couple of "Poofs" from direction of the Cannery. A couple of more "Poofs", a continued "Poofing", as big diesel engine gets down to business. Roar comes from radio shack. New operator dashes in and shuts off receiver just in time to save his pet pair of phones. Swallows hard. He had heard of induction at canneries. This must be it.

But he was ready. Had along couple of condensers for such an emergency. Puts them on. Someone has beat him to it with 10 mfds. across the things. Also ground leads in every direction. One big wire through the dock floor to the beach. Fellow here last year dug a hole four feet deep and ten feet long in mud under dock and buried stuff for a ground, he is told. Tries antennas. Long ones - short ones - high ones - low ones with a ground and without a ground. Finally hits combination where can hear "WXX" enough to read through the stuff. Will have to do for now.

Starts hooking up transmitter. Finds wire sent will not reach to back room so puts motor generator under table in radio room. Hooks set up according to diagram. Finally gets her against wall with all sixteen wires on back. Hooks up the motor-generator, soldering all connections, putting on lugs, fixing everything shipshape. Dusts off front panel of transmitter. Shines up nickel.



"AFTER THREE DAYS ... IT DOESN'T LOOK THE SAME ..."

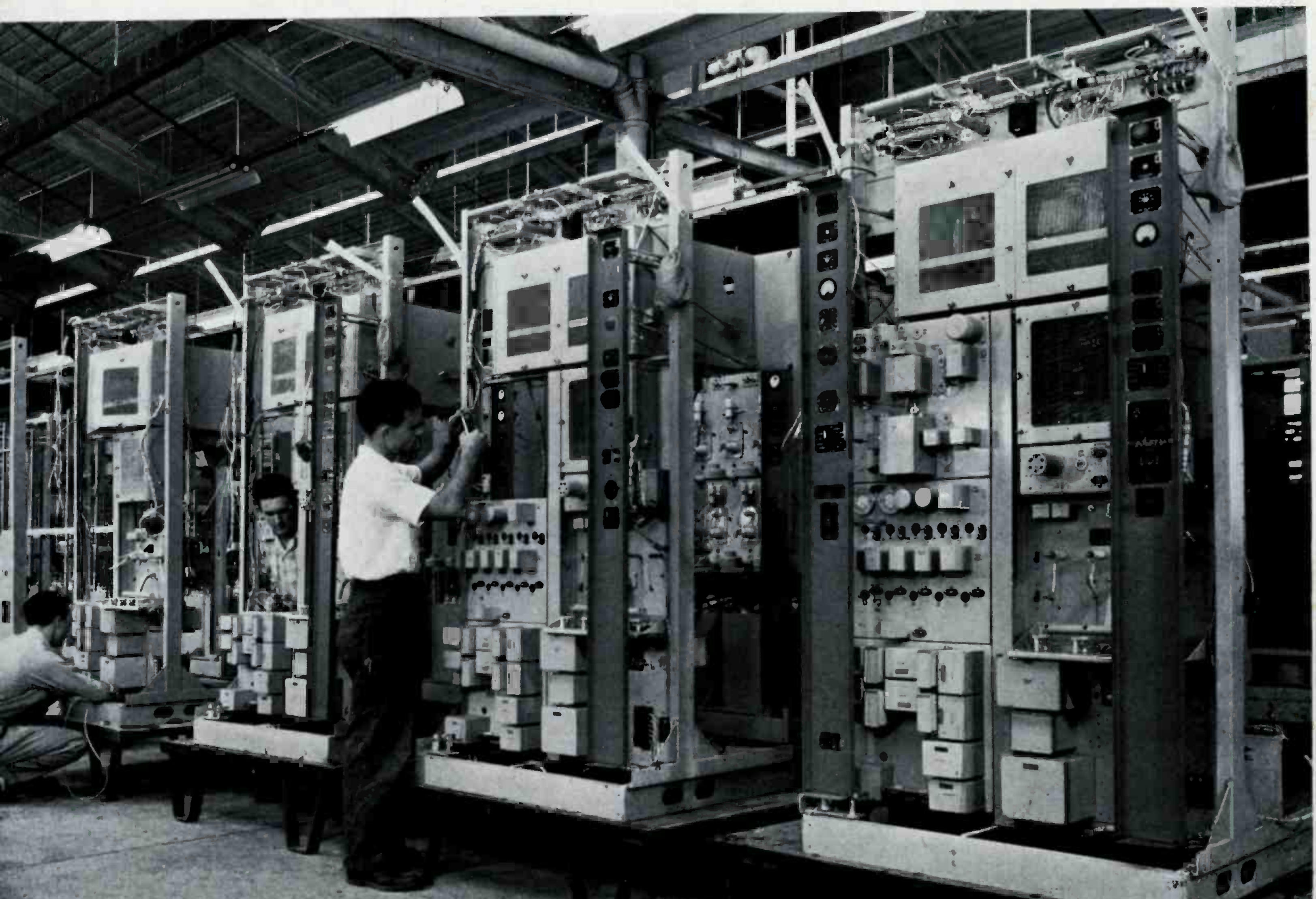
Turns on transmitter. Just filaments first, with high voltage disconnected. Filaments dull red. Cranks up rheostat. Rheostat already against peg.

Looks at voltmeter - shows 8 volts, instead of 10. Key won't work. Voltage too low for

(continued on page 38)

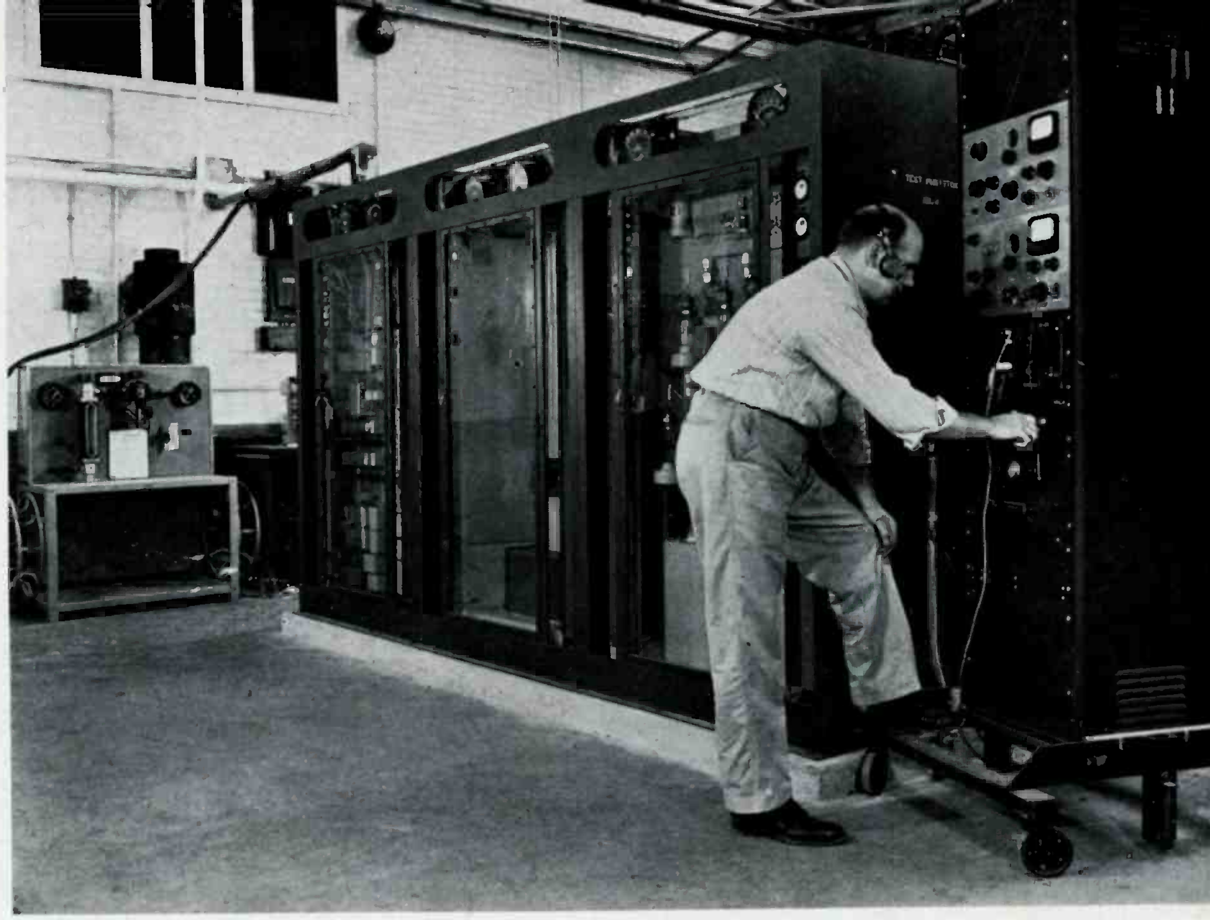
PRODUCTION LINE FOR FM TRANSMITTERS

In the Burlington, N. C., plant, Western Electric's new FM transmitters are assembled, inspected and tested on a production line designed for efficient manufacture and precise quality control

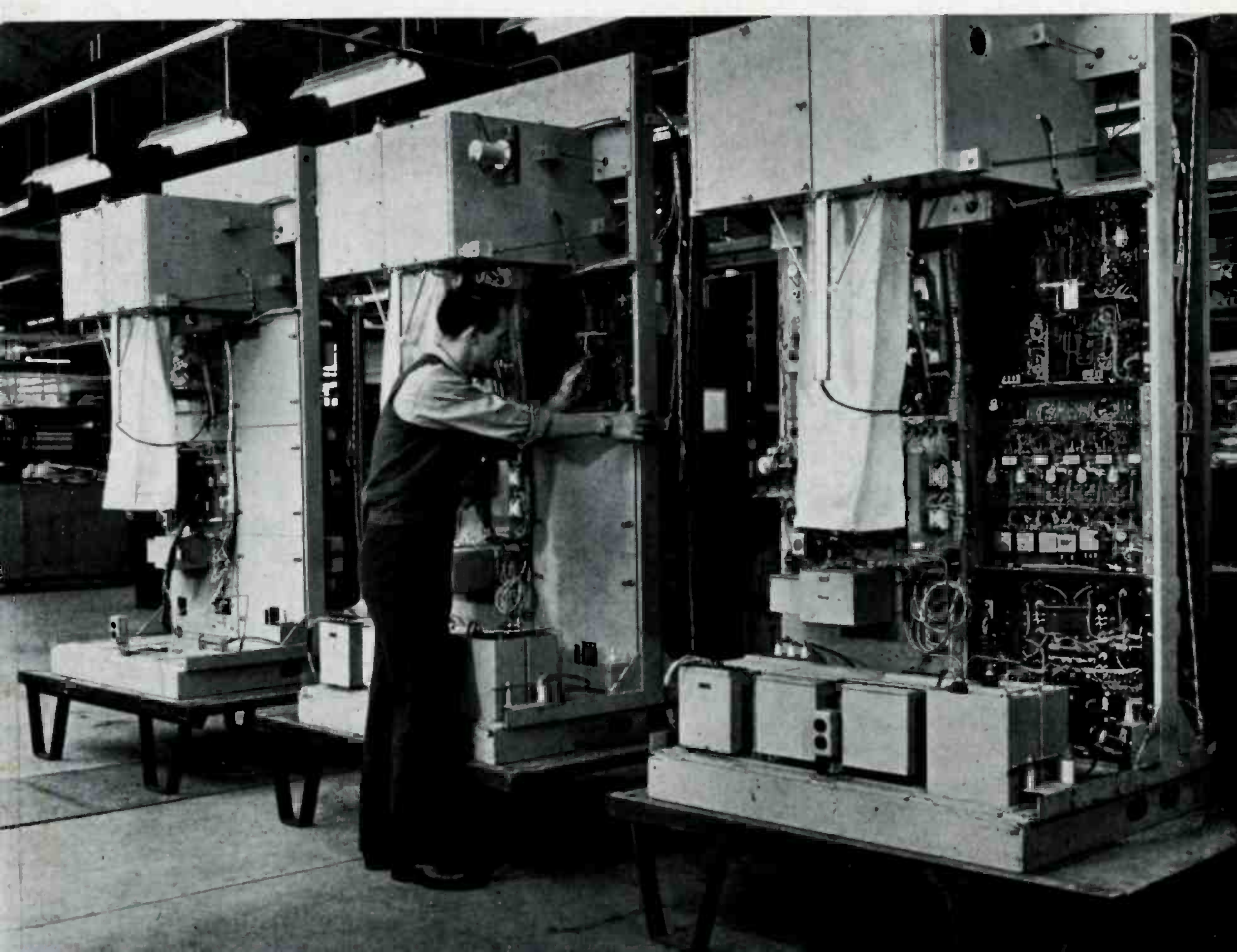


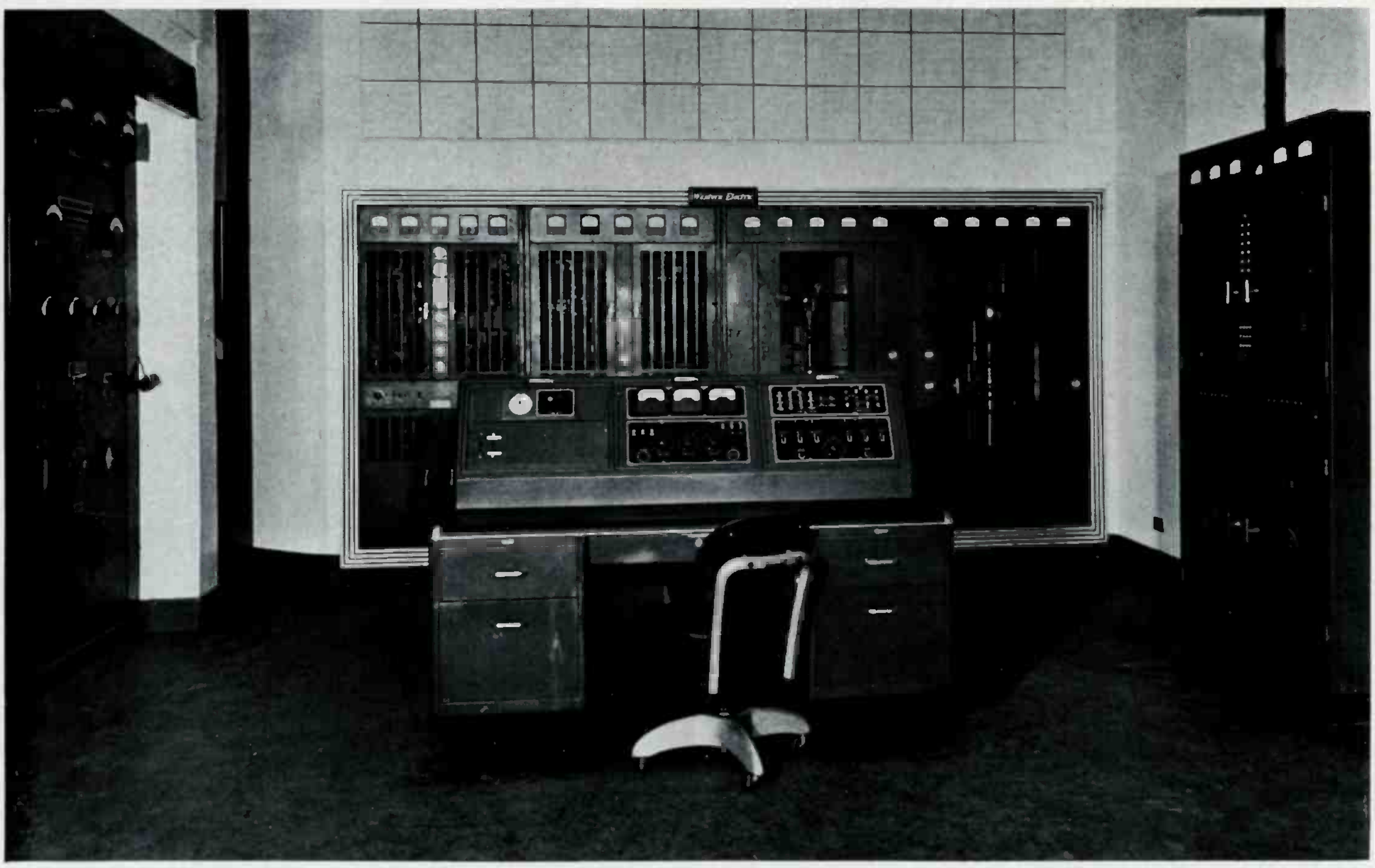
ASSEMBLY — Units of the 10 kw FM transmitter are assembled and wired on the production line. Picture above shows final assembly of driver units; picture on front cover shows the final amplifier and rectifier units on the line. Subassemblies have been wired and tested, are built into frame of transmitter unit at left end of line. Units with all subassemblies in place are moved into position for final wiring, as shown in center of picture above. Preformed cabling is being added to unit to connect all subassemblies. Completed unit at right end of line is ready to be moved to mechanical inspection station.

INSPECTION—Units get a thorough mechanical inspection, covering all soldered connections, tightness of screws, placement of parts, finish, and general over-all assembly check. In picture at right driver units are having soldered connections in subassemblies individually checked. Accessibility of all wiring and components is apparent. After the mechanical inspection of the separate driver, amplifier and rectifier units, they are brought together at the testing position for the electrical test, as shown in picture at upper right.



TESTING — Electrical and operational tests are carried out in specially built test positions, like the one shown above. Permanently installed racks hold the units of completed 10 kw transmitter in normal operating relationship. Water cooled dummy load is seen against wall at left. Mobile test bay at right end holds oscillators, distortion meters, frequency meter, etc. Before shipment each transmitter is tuned to the buyer's assigned frequency and tested at the full rated output. Test data sheets, showing setting of all controls, are furnished with each equipment.





WSB—A DIXIE INSTITUTION

Pioneer southern station installs its fifth Western Electric transmitter

By R. S. Lanier

TO hold the confidence of the community over a twenty-five-year career that includes many historic "firsts" and programming innovations — that is the basic story of a great broadcast station, Atlanta's WSB. In these days of questioning, both from within and without the industry, it is invaluable to have a station like 50,000-watt WSB as a living, growing, *very* healthy example of what broadcasting can mean. A trip to Atlanta to see WSB and meet the men and women who make it go, to learn its history, and to inspect the installation of its new 50 kw Western Electric transmitter, created in the traveler's mind a full picture of the station, one crowded with details of historic beginnings, famous events and remarkable community leadership.

WSB was the first broadcast station in the South, and one of the first in the country. It went on the air in March 1922. It lays claim to a long list of other "firsts" in the South: first newspaper owned station — its owner from the beginning has been the *Atlanta Journal,* a Southern institution itself; first station in the South to broadcast religious services — on the first Sunday of operation, March 19, 1922, the services of First Presbyterian Church of Atlanta were broadcast, and have been regularly ever since; first and only 50,000 watt clear channel station in the area including Georgia, South Carolina, Alabama, and Florida; first station in the South with network affiliation; etc.

Priority in all these matters demonstrates the vision and progressiveness of the men in back of WSB, but even more important is the story of its excellence in programming, its service to the community, and its technical competence, which are the real measures of a station's stature.

The story of WSB's transmitting equipments is a fascinating one in itself. There have been six transmitters at WSB. The original one, a 100-watt amateur rig converted to broadcast use, served from March to June 1922, long enough to form the background for the delightful "publicity shots" shown on page 27. They were taken during the first week of operation. Here we see Rosa Ponselle and her accompanist on a visit to the infant station, listening to the broadcast, with the transmitter on the desk in back of them proudly displaying its open tank coils and shelf-mounted 50-watt "bottles." The picture to the right on page 27 shows the late Henry Ford on a similar visit to the operating bench in the transmitter room, with the leads from the electrolytic rectifier on the high shelf at the right forming a rectilinear pattern on the wall.

Early Visitors

During that first week, many other notables visited the studio, among them Corra Harris, Roger Babson, Ruth Bryan Owen, Alma Gluck, and the actor Otis Skinner, who read a scene from "Blood and Sand," his then current vehicle at the Atlanta Theatre. This attention to newsworthy personalities and emphasis on programs of solidity and wide interest have been characteristic of WSB over its entire career.

WSB's second transmitter, and the four that have followed it, have all been of Western Electric manufacture. In June, 1922, a 500-watt Western Electric transmitter went on the air, one of the first three or four equipments of this power built by the Company. Used until July 1925, this transmitter was then transferred to Station WGHB at Clearwater, Florida, and after years of service there, it was acquired by the Smithsonian Institution in Washington for its industrial exhibit, as an example of early broadcast transmitter design.

WSB went to 1,000 watts in July 1925, with a Western Electric 1A installed in the Hotel Biltmore in Atlanta. The station went to 5 kilowatts with a Western Electric 5C in June 1929, building its first separate transmitter building to house

Above, control room before partitions were removed for new 50 kw equipment. In picture, page 24, the two 50 kw transmitters face each other in new room.

the new rig. It went on the air at 50 kilowatts in July 1933, with a Western Electric transmitter in a new building 10 miles from the center of the city. The 5-kilowatt 5C equipment was kept as an auxiliary until 1946, then stored away in perfect condition.

In December 1947, WSB took to the air with a new Western Electric 50 kilowatt transmitter, a 470A-1, standing cheek by jowl with its old 50 kw equipment, to form a highly modern, flexible transmitting plant. The installation of this new 50 kw transmitter alongside the old one, in a building originally designed for one large transmitter only, provides new light on the adaptability of Western Electric's larger transmitters, and a full description of the solution of this interesting installation problem is given later on in this article.

To understand the real quality of any enterprise, it is necessary to talk to the men who make it go. This has particular pertinence in the case of WSB, because of the remarkable continuity of its policies and personnel over its long career. For instance, consider John M. Outler, Jr., General Manager of WSB, genial, shrewd Southerner who has been with the Atlanta Journal for over 30 years and on the executive staff of WSB for more than 16 years. Mr. Outler explains WSB's general policy in these terms:

"We have never sold time," he says, "we sell programs and a listening audience. Our emphasis from the very beginning has been on programs. WSB has never been aggressively commercial, and we have been rewarded with a faithful listening audience. We operated on a strict non-commercial basis from our beginning in 1922 until the latter part of 1929, with no income from programs, which meant that the cost of our material had to be watched closely. Then it became evident to us that revenue would allow us to expand our service to the community many times over."

Even with the decision to go commercial, WSB did not find it necessary to employ a salesman — and never has employed an outside salesman to this day. From 1931 to 1940, Mr. Outler handled all the commercial activity of the station. Today one man, Frank Gaither, handles all sales activities.

Mr. Outler describes his method of "making sales" as follows:

"Actually, I have more than 60 competent sales people on my staff. They are the clerks, stenographers, musical and dramatic talent, writers, producers, engineers, announcers, department heads, who work together in our studios. They are the ones who have made and kept WSB so attractive to our listeners that we can thoroughly depend on at least 50% of the total tune-in in the city of Atlanta, and a much higher percentage in the outlying areas."

Chief Engineer C. F. Daugherty inspects the completed installation of new 50 kw transmitter.

General Manager John S. Outler, Jr.

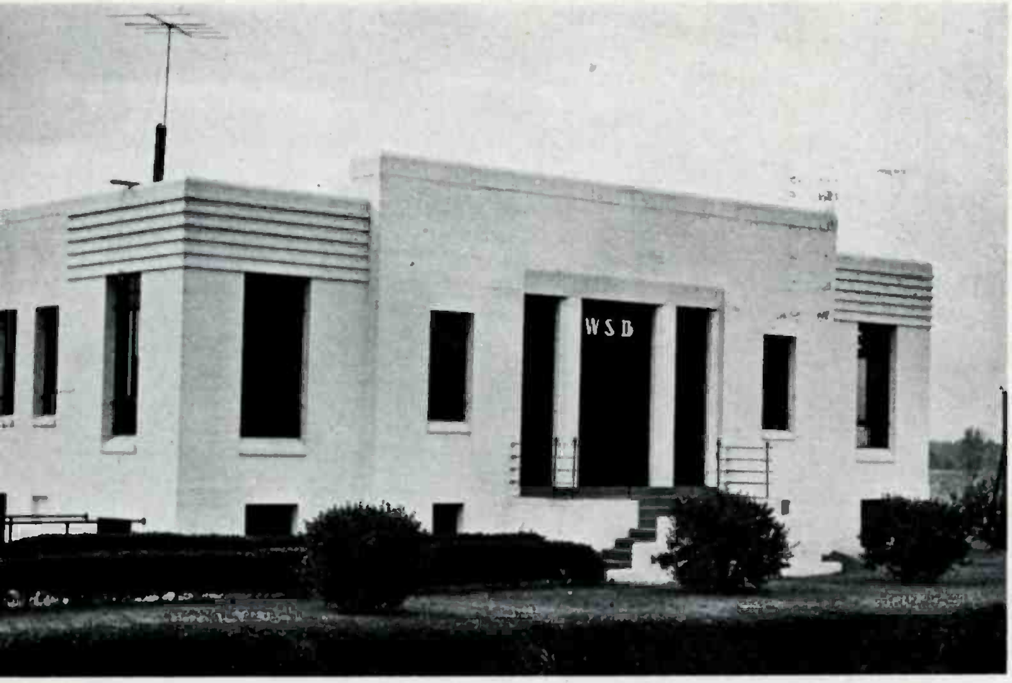
Rural Coverage

Speaking of WSB's high acceptance in rural areas, Mr. Outler corrected any idea that it was won with programs especially tailored to a theoretical "hillbilly" or "rural" mentality.

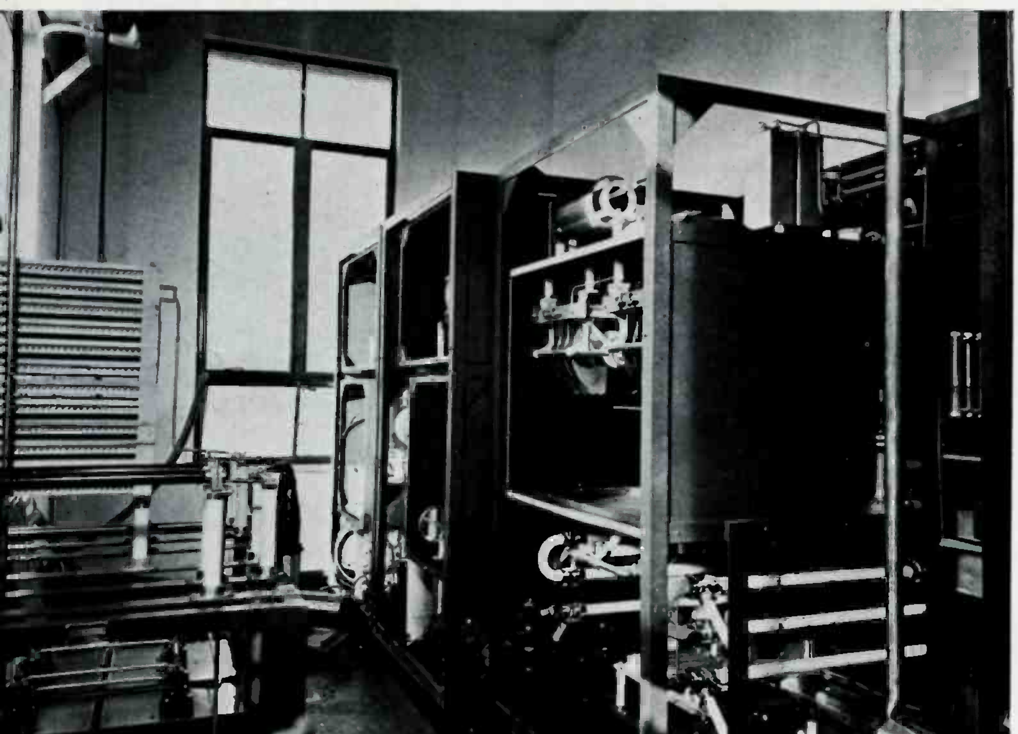
"We find that people in the country like the same programs as the city people and vice versa," he says. "We have a daily farm program — but we believe that this has about as many listeners in Atlanta as in the country. And our weekly 'Barn Dance,' broadcast from a local theatre, which might be considered strictly 'hillbilly' in musical character, has the highest listener rating in the city of Atlanta of any program we produce. The other side of it is that *all* our programs, including those that could be described as sophisticated or city-bred, have ratings in the hill counties equal to or higher than those in Atlanta."

Mr. Outler summed up the description of WSB's general approach to programming in this way: "We like our present policy, as it is a continuation of our whole tradition of programming and service to the community; the South likes it, which proves that it is a practical policy — it works! Any skeptic has merely to look at our Hooper ratings."

Miss Jean Hendrix, WSB's young and decidedly attractive publicity director,



Exterior of transmitter building. Window at extreme right looks into rear of new 50 kw equipment.



Rear of main units, new 50 kw transmitter, has ample servicing space, accessibility to all components.

talked about some of the programs that have expressed the station's leadership in the community, a leadership that could be exercised only on the basis of thorough respect on both sides. She was particularly proud of the dramatic series, written by Brad Crandall of the WSB staff, titled "The Harbour We Seek," in which WSB spoke out on the race problem in a way that amazed many critics of the South, and fought a very effective battle against the Columbians, that short-lived Georgia-grown Blackshirt movement. And in the "Battle of the Governors," the struggle over Herman Talmadge's accession to the Governorship to succeed his father, WSB attacked the Talmadge methods with everything in its arsenal.

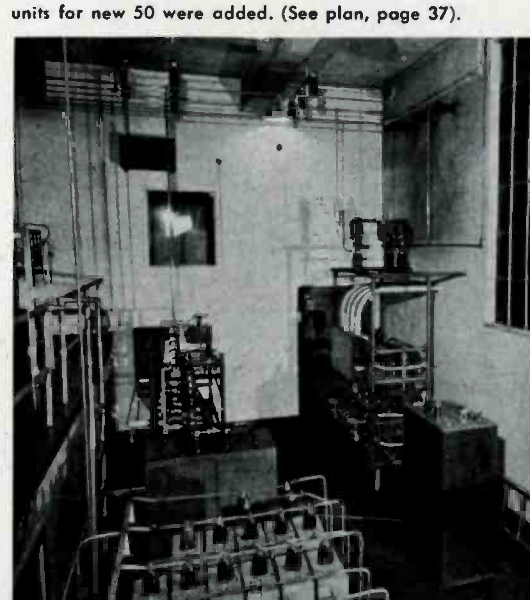
Such programs as these have won a glittering string of awards for WSB in recent years: the Variety Award, in 1940, 1942, 1944, 1946; American Cancer Society Citation; four U. S. Treasury Citations; United War Fund Citation, 1944; George Foster Peabody Citation, 1940 and 1946; National Conference of Christians and Jews Award, 1946; Billboard Award, 1946.

Miss Hendrix told how Atlantans have learned to turn to the station for help in emergencies. When the tragic Winecoff Hotel fire broke out in December 1946, the staff as though by common consent assembled at the studios and worked through the night and next day, assembling lists of the injured and missing, answering hundreds of phone calls from anxious relatives, and acting as a clearing house for the Red Cross and local hospitals. That the city should have automatically considered WSB as a prime source of help in time of trouble seemed to Miss Hendrix the best possible testimony to the confidence that the station has won in its community.

A station with the technical quality and progressiveness of WSB implies an engineering executive of real talent and vision. This man is C. F. ("Harry") Daugherty, the friendly, able chief engineer of WSB, who has had much to do with building the station to its present eminence. He is the oldest member of the staff in point of service, joining in September, 1922, after his service as a Naval radio operator in the 1st World War. He has been Chief Engineer since 1925. He is a man who in a very short time makes an impression of sureness, comprehensive technical ability, and open, attractive personality.

He has done much more for WSB than keep it at the highest pitch of technical excellence. In the early days, for instance, he toured the Georgia hill towns in a truck, equipped with one of the early radio receivers and whole banks of storage batteries, to demonstrate the new miracle of broadcasting to people at fairs, meetings, wherever there were assemblies of any kind. The job was to teach people to listen, even to prove to them that the thing worked, for skeptical listeners often searched the truck for a concealed phonograph as the source of the music issuing from the loudspeaker.

High-voltage area, rear of old transmitter, before units for new 50 were added. (See plan, page 37).



Mr. Daugherty tells the story, in this connection, of one elderly cotton planter, who followed the program for some time in a spirit of open disbelief. He was asked whether or not he went to the telegraph office for the cotton reports every day at 2:30, as did every cotton operator of the period.

"You'll get those same reports right out of this loudspeaker," announced Mr. Daugherty, "at the same time that they reach the telegraph office." When this feat was carried out on schedule, the skeptic was forced to admit that broadcasting "worked."

Chief Engineer Daugherty has supervised each of WSB's increases in power, the construction of its steadily enlarging series of studios, and of the two transmitter buildings used to date. He is now engaged in planning WSB's future in FM, television, and facsimile. Thus Harry Daugherty has had the experience of pioneering with one of the earliest stations in the country, building it up through the growth of broadcasting as a powerful national instrument, and now is deeply involved in bringing in the much wider and more varied future of the new technical developments in broadcasting.

Two 50's In One Building

When it was decided that WSB's transmitting plant was to be modernized by the installation of a new 50-kilowatt transmitter, with the old 50-kilowatt left in place as a standby, Chief Engineer Daugherty surveyed the problem of a housing for the new equipment. The most efficient and economical solution obviously was the fitting of the new transmitter into the existing transmitter building, without any disturbance of the old equipment that would interrupt air time, and without extensive additions to the building.

This straightforward, economical, but at first glance improbable housing arrangement turned out to be a practical one for Western Electric's 50-KW 407A-1 transmitter. A study by WSB's engineering staff showed that the new "50" in the Western Electric line of high power transmitters could be fitted into the transmitter building alongside the old equipment with a minimum of alteration to the building interior and very little relocation of existing equipment. The plan on page 37 shows in detail how the new units were added in the building. The photographs on pages 24 and 25 give a "before and after" story on the new installation.

As can be seen in the photographs and the plan, a partition was removed which had divided the space in front of the old transmitter into a control space and an entry space. With the removal of this partition, a much larger control area was available. Then an office area at the right front of the building was split up, part of it being added to the new control area, and part of it reserved for installation of the main units of the new 50 kw equipment. These changes created an ample control area with the old transmitter across the back and the new one at right angles to it at the right end of the area, as can be seen in the photographs.

It should be interesting to point out the actual dimensions of the new room, shown at the right front of the plan, in which the new rig is installed. All of the main units have been fitted into a space approximately 16′ x 10′, with ample room in the rear for movement of the engineer who must do maintenance or servicing. The Doherty high-efficiency amplifier should be given great credit for the compactness that makes possible an installation of this kind. The relatively small size of the final amplifier and associated components such as the power transformers, cooling system, filament supply, etc., are prerequisite to installation of a complete 50-kilowatt broadcast transmitter in a space of this size. The photograph at left center of page 26 shows the rear of the new transmitter.

The rectifier, choke coil and thyrite protector for the new transmitter were fitted into the high-voltage area in back of the old rig by moving certain of the corresponding units of the old transmitter a few feet toward the left wall of the area. Similarly, the plate voltage regulator and power transformers for the new transmitter were installed in the area already set aside for the corresponding units of the old transmitter. It was only necessary to add a new chain link fence around the somewhat enlarged area for these latter units.

Spray Pond for Cooling

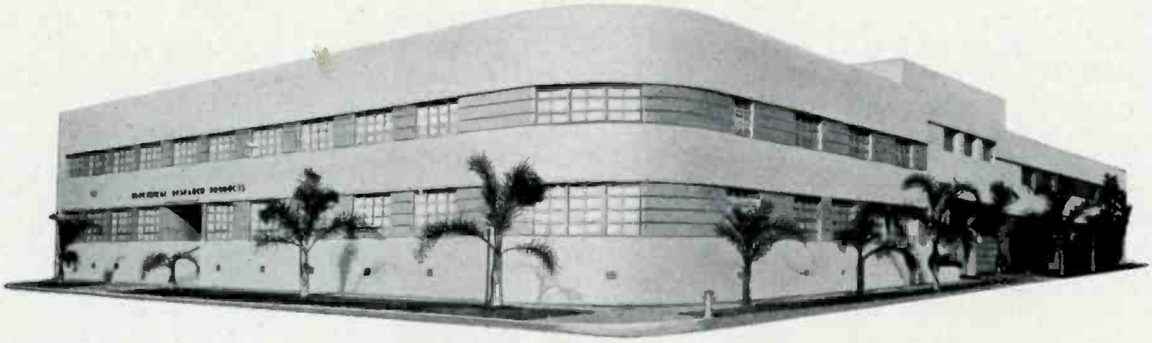
The water cooling system for the new transmitter uses a basement area directly under the transmitter. It proved to be economical and technically efficient to use the spray pond installed with the old transmitter as the basic cooling agent for the new one. A new circulating system brings the cold spray pond water into the basement. There it receives, in a set of small heat exchangers, the heat carried by the distilled water that circulates over the tube anodes, through the heat exchangers, into a tank, and back again, in a closed system. It occupies in the basement a 16′ x 10′ space corresponding to the similar space for the transmitter just above it, with ample room for servicing, since a good part of the equipment is on the walls of the room.

A further and most important way in which the new transmitter has fitted in beside the old one without disturbance is in its connection to the original two-wire open transmission line. The WSB staff wanted, if possible, to use their transmission and radiation system, without extensive changes, for the new equipment as well as the old. The new transmitter has

(*Continued on page 37*)

Rosa Ponselle samples WSB's program during first week on the air, March, 1922, with the original 100-watt transmitter in background.

Henry Ford was another early visitor to the transmitter room, pronouncing his interest in and approval of new art of broadcasting.



CUSTOM BUILDERS FOR BROADCASTING

How specialists in high quality motion picture sound recording apply their unique skills to audio systems for radio broadcasting

By F. L. Hopper

Electrical Research Products Division
Western Electric Company

THE Electrical Research Products Division of Western Electric—commonly referred to as ERP Division—is not as well known to the broadcaster as to the motion picture industry. Electrical Research Products, Incorporated, was formed in 1926 as a subsidiary of Western Electric, to handle by-products of research by Bell Telephone Laboratories having application in other than the telephone field. These organizations produced sound for the first really successful talking motion picture, premiered at that time, and the interest aroused by this event established sound recording and reproduction as ERPI's chief activity. In 1941 ERPI was merged into Western Electric, becoming a Division of Western Electric with its headquarters in New York but carrying on some of its former functions.

The Products Division maintains offices and a laboratory in Hollywood for carrying out the design, manufacture and application of recording equipment for moving picture studios, calling upon Bell Laboratories for fundamental development. Indication of the widespread use of Western Electric sound recording equipment may be found in the screen title credit at the beginning of motion pictures released by M.G.M., Fox, Paramount, Columbia, Universal, Goldwyn, Vanguard, J. Arthur Rank Organization, United Artists, and other important producers. In addition, the Westrex Corporation, a subsidiary of Western Electric, distributes motion picture recording and reproducing equipment in all countries outside the United States and Canada.

Techniques Applied to Broadcasting

While the mechanisms for recording sound on film, and for reproducing it, are peculiar to motion pictures, the transmission and control apparatus involved in such systems bears a close resemblance to the audio facility equipments required by broadcasters.

Performance requirements are comparable: high-signal-to-noise ratio for normal conditions of input and output, minimum absolute noise at the grid of the first preamplifier tube, wide frequency response, minimum harmonic distortion, and minimum crosstalk between circuits. Control of systems grounding and shielding is such as to preserve the individual performance of each of the various components which comprise the whole system.

Film recording divides into two main categories and requires several types of system assemblies:

1. Original Recording.
   (a) Dialogue recording on set during picture filming requires a portable mixer on the set with the remainder of the system located in central recording rooms, or in a truck. Portable equipment is also required for dialogue and, infrequently, musical recording "on location," i.e., remote from the motion picture studio in either outdoor or indoor settings. This latter operation corresponds to remotes or nemos in broadcasting, except that the sound is usually recorded at the location rather than being transmitted to the studio. Sound recording systems for location work are, in general, less elaborate than studio installations and the pickup and control equipment is more comparable to portable speech input equipment for broadcasting.
   (b) Musical Recording. This requires

a much more elaborate mixing console, and is a fixed installation. Such consoles require a minimum of two men for operation.

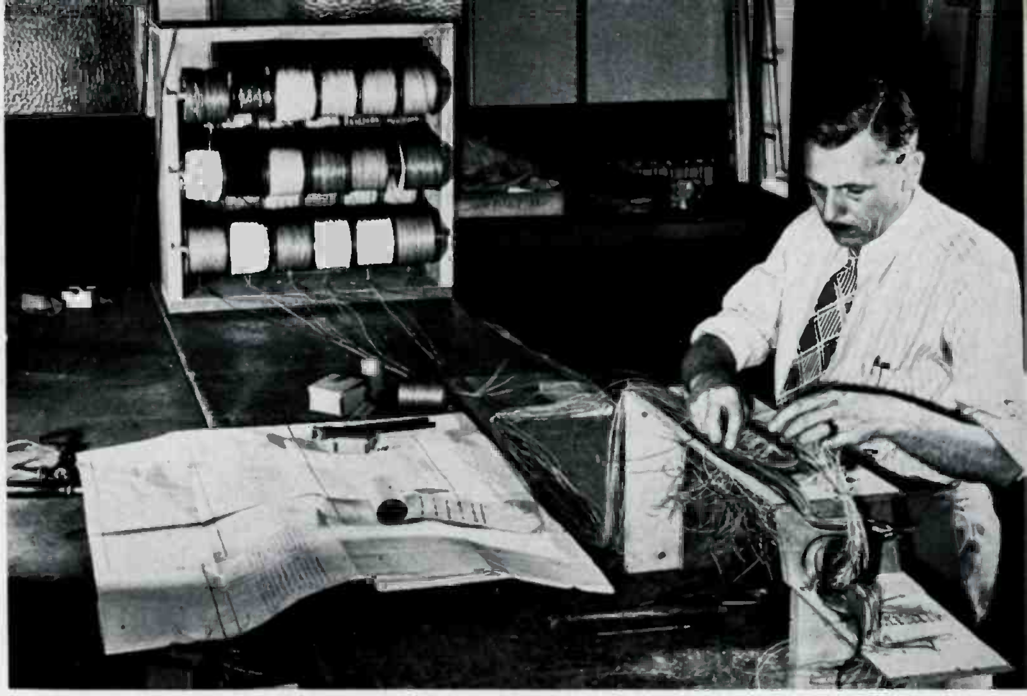
(c) A composite type of system. This may be used for dialogue and musical recording in a fixed installation, or for rerecording.

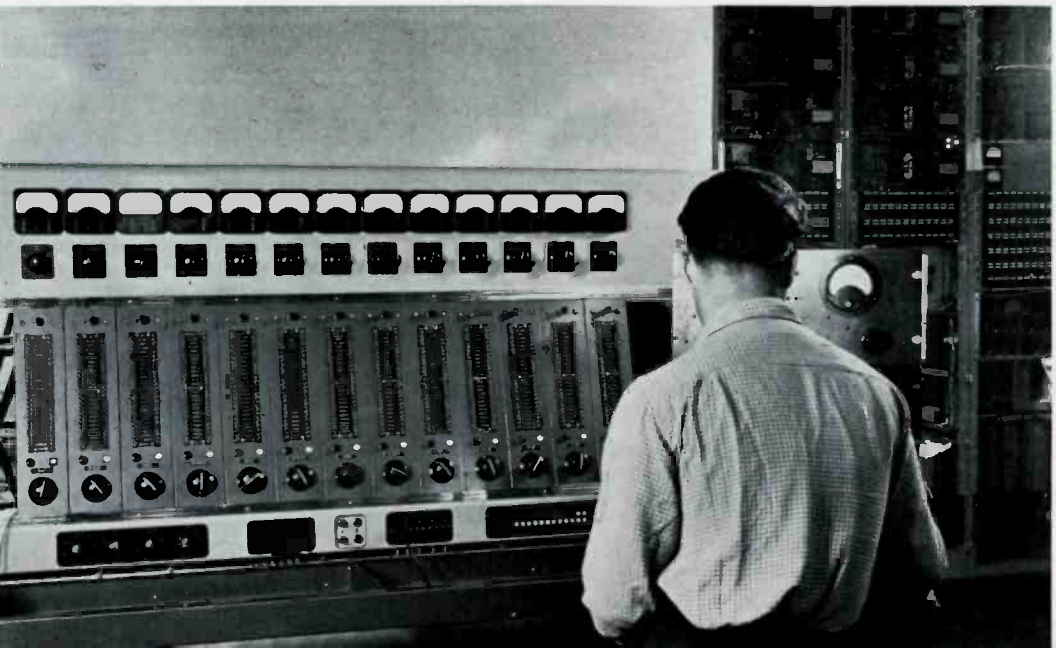
2. Rerecording.

This process precedes the preparation of a release print and combines the outputs of a number of sound records such as original dialogue, music, and sound effects. The rerecording console has facilities for mixing as many as twenty sound tracks, and, in addition, contains a variety of equalizers and filters for simulating sound effects or for compensation for acoustical conditions existing on the set. Such a console may require four to eight men for its operation, and is, consequently, a large and complex structure.

The typical custom built audio facility console for broadcasting corresponds most closely to the motion picture musical or scoring recording console, the chief difference being the fact that operation for radio is by one man and for motion pictures by more than one man. The output of these consoles supplies either a transmitter or network for radio broadcasting, or film recorders in motion pictures. Both industries utilize disc recording, the radio industry for transcriptions and the motion picture industry for immediate playback for checking musical recording.

It can be appreciated that a background of some twenty years in the design and application of transmission systems for motion picture use has much to offer when applied to the radio broadcast and television sound fields. It is not surprising, therefore, that the Radio Division of Western Electric employs the facilities of the Electrical Research Products Division in





TOP: First of three typical operations in the construction of audio facilities for broadcasting use — a wiring form for master dispatching line channel cables.

CENTER: Wiring master control equipment for Mutual — Don Lee's KHJ, another vital operation in the construction of audio facilities for broadcasting.

BOTTOM: Testing a master control panel for KHJ — a final step in preparation of audio facilities for broadcasting use by Electrical Research Products Division.

the production of custom built audio facilities for broadcasting use.

After consultation with a prospective customer on his requirements for custom built audio facilities, a proposal is prepared by the Radio Division. This proposal outlines briefly the type of equipment to be furnished, its physical characteristics, operational characteristics and guaranteed performance. Drawings are included covering the physical dimensions of the proposed consoles and power cabinets. Location of equipment controls and a jack field layout are also included. A block circuit schematic indicates the operating and transmission features of the system. Usually a description of the functional operation of keys and relays is included, since it may not be obvious from the block schematic what sequence of switching operations is initiated by the operation of a key. Lists of standard equipment items to be supplied are also included. The methods used to measure the transmission characteristics are given, together with a statement of performance. The proposal also serves the Products Division as an introduction to the project and serves as a basis for the estimation of shop costs.

With the signing of a contract with the customer by Graybar, orders are placed by the Radio Division, and specific engineering and drafting to enable construction of the equipment is begun by the Products Division. Engineering may be divided into mechanical, involving the sheet metal consoles and cabinets; and electrical, involving circuit schematics and wiring information. Shop drawings are prepared covering the construction of the main console components, as well as all the necessary mechanical details. The latter include various mounting details carrying pads, relays, coils and similar items, and various types of plug-in drawers to accommodate amplifier and rectifier components. The art work from which the photo-etched mats are made must also be prepared.

42,000 Square Feet of Blueprints

The magnitude of the drafting program for such a job as KHJ's new Hollywood studios and dispatching center for Mutual —Don Lee may be appreciated by the following facts: for the Studio Consoles, 100 original tracings and 151 running sheets were required, and the total area of the issued blueprints was 12,000 square feet; for the Master Control Room equipment, 192 original tracings and 288 running sheets were required, and the total area of the issued blueprints was 30,000 square feet. The total weight of all blueprints used was 660 pounds.

Circuit information to be developed includes a system two-wire schematic. This covers all equipment items, even though they may be distributed between a console, power cabinet, or rack. Running sheets are compiled which indicate to the wireman and customer necessary interconnections between major units. Unless the consoles to be wired bear resemblance to others for which wiring forms have been designed, it is necessary to lay out such forms and to make forming boards for the use of the wiremen. Such work involves a proper segregation of high and low level speech circuits, signal circuits, various d-c circuits, and power. Where necessary, shielded pairs must be specified and the treatment of transmission and shield grounds indicated.

After this information is available, and upon completion of the console furniture, assembly and wiring may be started. As a final step before delivery all individual components and the system as a whole are given operational and transmission tests. The latter include gain, frequency, noise, distortion, and crosstalk checks. In addition, key or relay clicks are removed by suitable means, with the result that the customer receives a completely tested and operating system, which can then be installed with a minimum of effort.

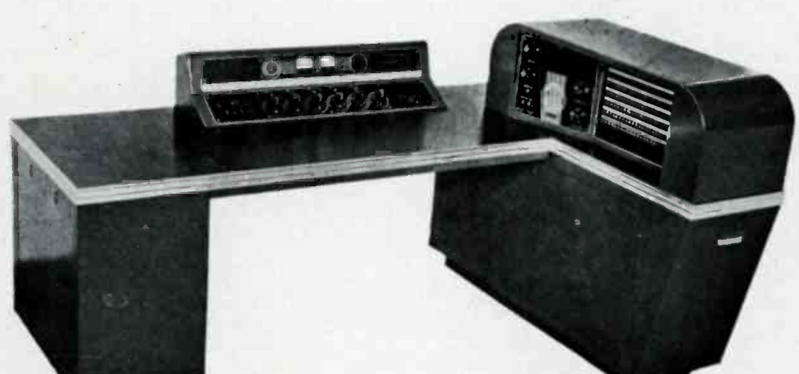
The philosophy behind an all-inclusive structure, such as a console, which houses all items from the microphone preamplifiers to the line amplifiers as well as monitoring and talkback amplifiers, is that it permits the completion and testing by the supplier of a complete system. Hence the cost of the console normally includes the expense of assembly and testing which would with other special designs be assumed by the customer. The components normally housed in a console may, of course, be redistributed between a simple mixing desk and various relay racks and wall cabinets. In this form, however, more space is required for a given facility and more expense is involved for customer installation and supervision, and the responsibility for the ultimate system performance must of necessity be assumed by the customer.

Manufacture of such custom built apparatus is not, of course, restricted to studio type audio facilities. Master dispatching room systems have been designed and manufactured following essentially the methods outlined. The master dispatching

(*Continued on page 35*)

Operations for motion picture recording system are similar to those required in constructing audio facilities for broadcasting. Here is wiring form.

Another operation in ERP Division's work for motion pictures. This is a console assembly for recording console designed for MGM International.



Completed recording control console designed for MGM International. Console is typical of ERP Division's quality work for the motion picture field.

FM'ING AROUND THE CLOCK

The Fort Industry's WJBK-FM Detroit is on the air 24 hours a day — its 1KW transmitter has not been turned off since October 10, 1947

DETROIT'S WJBK-FM is one of the nation's first FM stations to go on the swing shift. In order to give both day and night service, the station is planning a careful separate programming schedule, but at present all programs are similar to those broadcast over WJBK, the sister AM station.

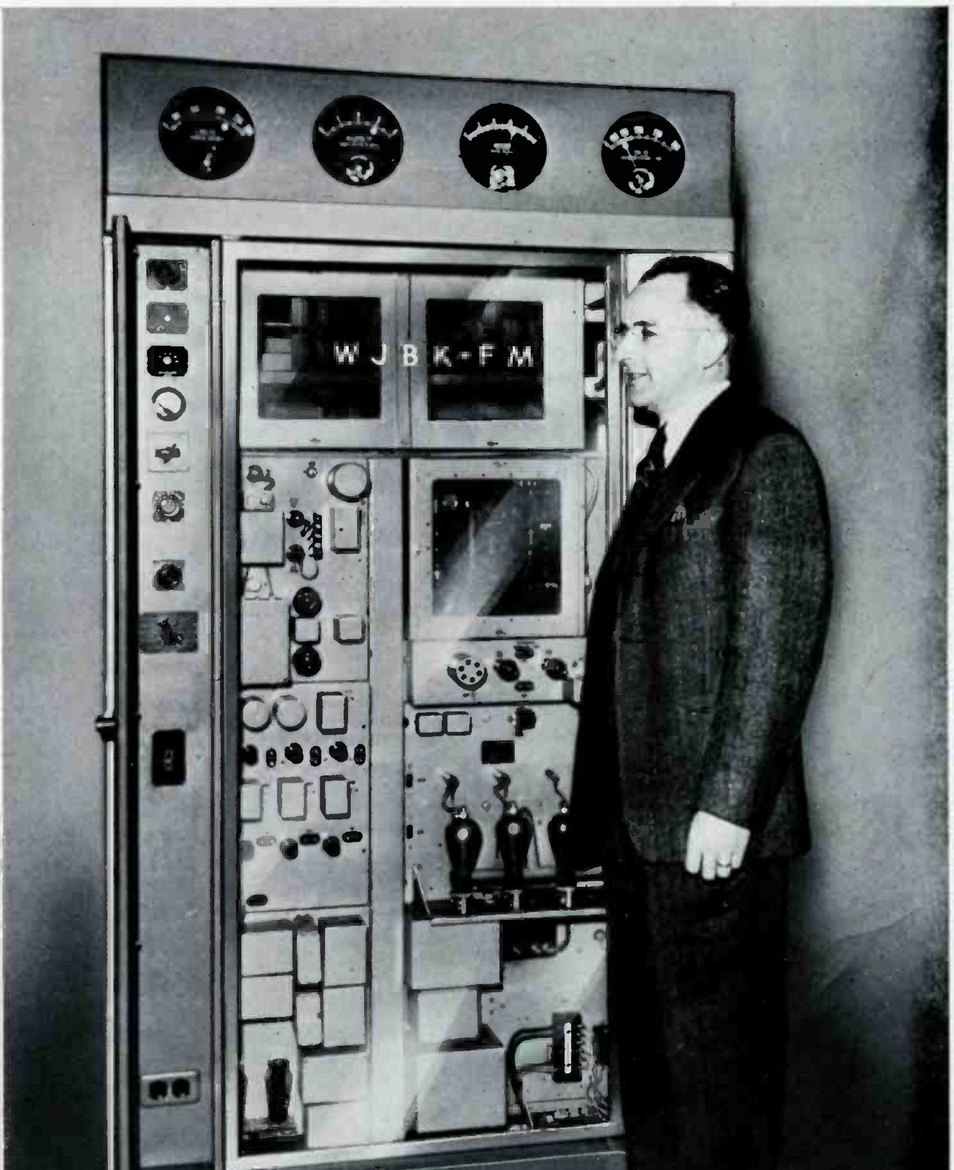
The station is now operating with a 1 kw Western Electric 503B-2 transmitter. When equipment on order is installed, the station's power will be boosted to 10 kw and its effective radiated power, authorized at 33 kw, will make it one of the most powerful FM stations in the state.

Periodic checks made by a commercial frequency checking service since the station went on the air June 19, 1947, show that the WJBK-FM transmitter stays on frequency; in fact, many of the checks show zero variation from its assigned frequency.

Program reception has been reported at distances of well over 100 miles. Chief Engineer Paul Frincke, who supervises both the AM and FM operations, has received DX reports from as far away as Zanesville, Ohio—approximately 150 airline miles.

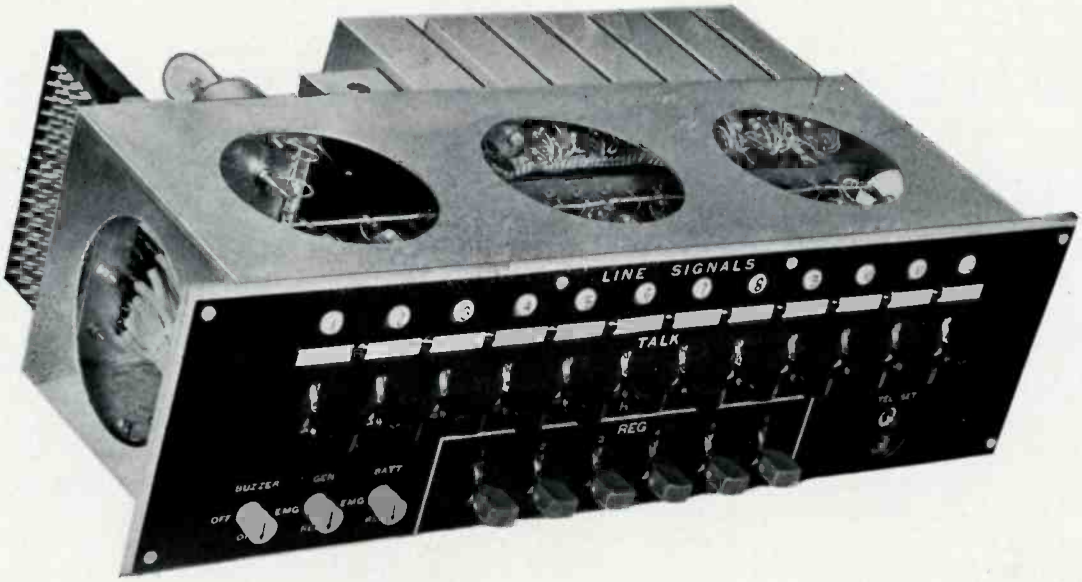
WJBK-FM is owned by the Fort Industry Company; President, George B. Storer; Vice President and Treasurer, J. Harold Ryan; General Manager, Lee B. Wailes; Chief Engineer, Glen C. Boundy. The Fort Industry Company has a total of seven AM and six FM stations. The company has on order three Western Electric 10 kw FM transmitters for Atlanta, Georgia, Miami, Florida and Lima, Ohio.

In addition to WJBK and WJBK-FM, the Fort Industries organization owns or has an interest in such stations as WSPO, Toledo, Ohio; WWVA, Wheeling, West Virginia; WMMN, Fairmont, West Virginia; WLOK, Lima, Ohio; WAGA, Atlanta, Georgia; WGBS, Miami, Florida and KIRO, Seattle, Washington.



RIGHT: WJBK-FM Chief Engineer Paul Frincke stands before the Western Electric 1 kw FM transmitter.

BELOW: Ralph Elvin, managing director of WJBK and WJBK-FM, in charge of both AM and FM operations.



NEW ORDER WIRE PANEL FOR BROADCASTERS

Simple, compact, ring down and lamp indication panel has termination facilities for 12 order wire lines—including operator's subset

THE new Western Electric RD-101 Order Wire Panel is a small switchboard unit for the telephone transmission of operating orders between broadcasting station control rooms and remote operating points. It is a compact, flexible, complete and very useful operating unit for serving a maximum of twelve order wire lines. Two or more units may be used together to handle a greater number of lines.

Ring down, relay lamp indication is provided for each of the twelve order wire line circuits. The relays and lamps are part of the unit assembly, as are an operator's subset equipment of the preferred anti-sidetone type, an alarm buzzer, a set of six program-line transfer keys, also regular and emergency battery and ringing source transfer keys. All of this equipment occupies only 5¼ inches of panel space on a standard 19-inch rack cabinet or desk unit.

Production and dispatching of programs for broadcasting and like services frequently involve, of course, intercommunication between two or more operators. Ready communication between them is essential for proper program coordination, especially in the case of remote "pickups" where programs are produced at points outside studio locations and transmitted to a studio or to master control for distribution to AM or FM transmitters or network feed lines.

Order wire line circuits used for this service are primarily of the "local battery" or magneto type in which a single pair of wires to each remote point is used for talking and signaling. Talking current is generated at each station by means of a local battery, a carbon type transmitter element and an induction coil so arranged that only the alternating (voice) currents reach the line. The telephone receiver is connected to the induction coil circuit in such a way as to make it fully sensitive to voice currents coming in over the line but relatively insensitive to much stronger voice currents from the local transmitter element. (This briefly is the "anti-sidetone" feature.) Signaling is done by ringing on the line using 20-cycle alternating current as in telephone practice.

By use of magneto type line circuits for communication, the standby program line circuits can at times be used for communication service when not transmitting programs. The program line transfer keys assist in this interchange.

Unusually Compact

The whole unit has an unusually compact construction, as may be seen in the photograph above, and its operation is not impaired by tilting to the rear as would be convenient in a desk panel mounting. Instead of requiring a separate "Telephone Panel" for the operator's subset equipment, adequate subset equipment has been included, and the only telephone set equipment which must be provided externally is a suitable hand telephone instrument and switch hook such as the Western Electric 214AW-3F Hand Telephone set. If an operator's head telephone set such as the new Western Electric 52AW or 52BW is available, it can be plugged into the "Tel Set" jacks seen in the lower right corner of the front panel, and the panel operated whether or not the hand telephone set is connected.

External power to operate the panel is also to be supplied. A maximum of 50 watts of 12 or 24-volt quiet direct current will supply talking battery and power for locking up the line relays and illuminating the lamps. Five to ten watts of standard 20-cycle ringing current is usually adequate. Two of the rotating type keys seen near the lower left of the front panel are for transfers between regular and emergency battery and ringing supplies. A set of dry cells is adequate for the emergency battery and a hand generator of the three or five bar type can be used for these standby sources. The third rotating type key is a cutoff key for the alarm buzzer supplied in the panel to sound an audible indication of an incoming call.

The twelve line keys with their associated indicator lamps and designation strips are arrayed across the top half of the front panel. The line relays can be seen at the rear of the panel, where they are mounted on a hinged panel which can be dropped back for access to the wiring side of all apparatus. The terminal strip at the left rear is not hinged and serves for all connections to external circuits.

One of the features of this order wire panel is the facility for transfer between regular and emergency order wire line circuits. The six line transfer keys seen in the central portion of the lower half of the face panel are arranged for connection during installation to jacks on the incoming lines rack so that they can be patched to line circuits as required. The circuit for each of these two position keys is shown in Figure 2 in the normal or unoperated key position — "regular line in" feeds "regular line out" and "emergency line in" feeds "emergency line out." With the key operated, the lines are transposed so that "regular line in" feeds "emergency line out" and "emergency line in" feeds "regular line out."

Simple to Operate

The operation of this order wire panel unit is simplicity itself. As soon as ringing current comes in to any one of the twelve incoming order wire line circuits, the relay associated with this circuit closes and in doing so illuminates its associated indicator lamp and also sounds the buzzer, if desired. The control room operator, noting the illumination of one of the order wire line indicating lamps, operates the associated order wire line key upward to the TALK position, which releases the relay, extinguishes the line indicating lamp and buzzer and connects the control room order wire subset to the line over which the incoming call is being received. Conversation between the operator at the panel and at the remote point can then be carried on. When conversation has been completed, the operator simply restores the operated line key to its "signal" position, so as to make possible receipt of the next incoming call over its associated incoming line.

Whenever the operator wishes to place an outgoing call over one of the order wire lines, he needs only to press the appropriate line key to the downward "nonlocking" RING position. As will be noted on the Figure 1 schematic, this disconnects all relay and subset apparatus from the line circuit and connects it to the 20-cycle ringing bus. A resistance lamp connected in series with the 20-cycle ringing circuit prevents a defective (grounded or shorted) line from disabling the ringing source by abnormal drain.

The call signal buzzer is a convenience when the operator does not happen to be near the order wire panel position. This buzzer sounds whenever any of the twelve order wire line relay units responds to an incoming call. A cutoff key mounted on the control apparatus panel assembly provides a means of disconnecting the buzzer whenever it is not needed.

While not primarily designed for interconnection between two or more order wire line circuits, it is possible to make such connection by operating the associated line keys to the TALK position. This connects the lines to the talking bus in the panel, and not only can the panel operator talk with the remote points but the remote points so connected can hear and talk with each other. As with all multiple connections, the transmission level falls as more and more lines are connected in multiple, but it is entirely possible under the line conditions usually encountered, for all twelve lines and the panel operator to be interconnected without falling below an adequate communication level. The exact levels, of course, depend on the length, type, impedance and noise level of lines and the efficiency and impedance of the telephone set equipment used both at the panel and at the remote points.

For incoming ringing signals, the relays are sensitive enough to respond to about 35 volts of 20-cycle current at the relay terminals which should be well within the capabilities of both three and five bar generators used on the remote telephone sets for 1400 to 2000 ohm lines.

The battery supply to the panel can be either 24-volt (20 to 28-volt range) or 12-volt (10 to 14 volt range). As shipped, the panel is connected and equipped with lamps for 24-volt operation. For 12-volt operation, a few straps need to be connected and the Western Electric type 2J Switchboard Lamps replaced by 2F Switchboard Lamps.

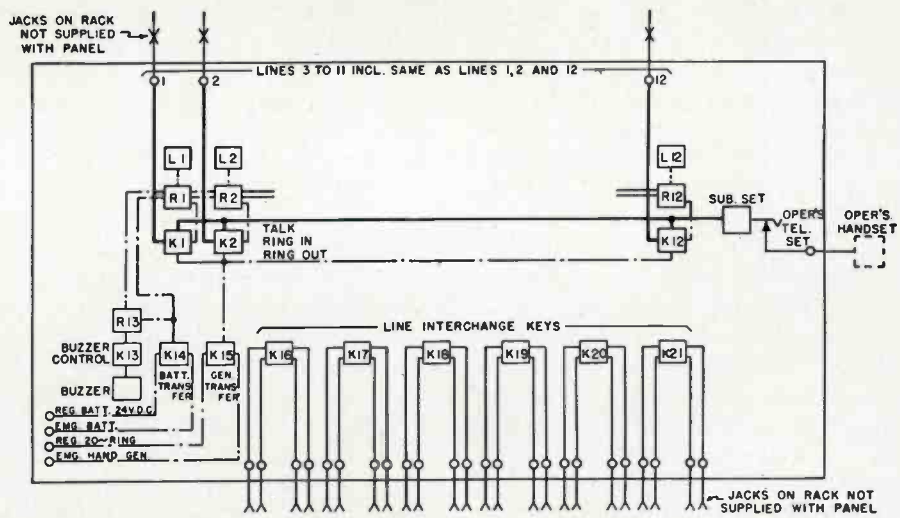
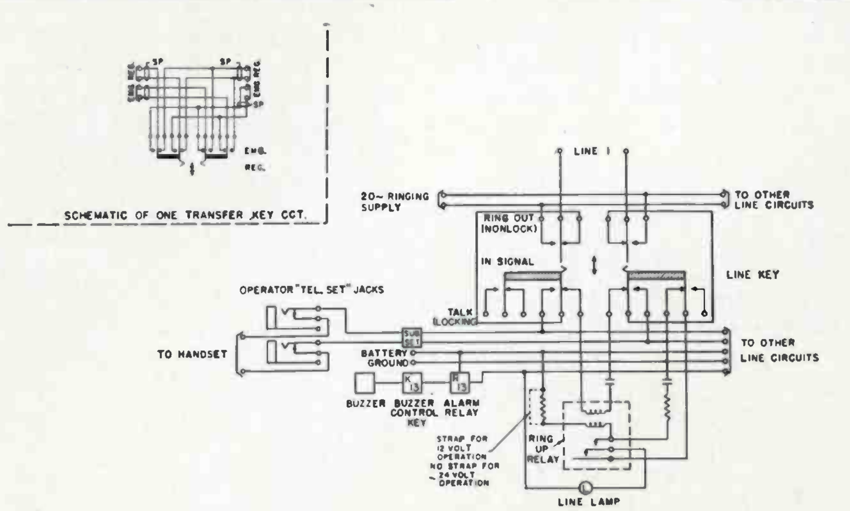


Figure 1 — Block layout of RD-101 Order Wire Panel, showing keys, relays, lamps for each of 12 lines.



SCHEMATIC OF ONE LINE CCT.

Figure 2 — Detailed schematic of one line circuit equipment and (insert upper left) a line transfer key.

"Protected Networks"–
A New Technique in Hearing Aids

In the field of sound reproduction, an important modern application is the hearing aid. These tiny audio amplifiers interest technical men because of the techniques used to provide ample amplification, power output, and fidelity in a unit as small and light as possible. Western Electric recently introduced two new hearing aids with self-contained batteries, Models 65 and 66, that are smaller and lighter than previous designs. They include new developments that solve the problem of protecting critical components from moisture, dust, and dirt, and make for easier, more rapid servicing.

"Protected networks" is a feature applied to hearing aid construction for the first time. This principle includes the sealing of circuit elements in moistureproof blocks of plastic, the provision of a special plastic-coated metal foil membrane as a moisture-resistant cover across the face of the Rochelle salt crystal microphone, and the mounting of a tone control network inside the metal microphone case for physical protection and electrical shielding.

The provision of two models instead of one resulted from studies which indicated that one instrument could not conveniently and economically supply the needs of all who use hearing aids. Accordingly, Bell Laboratories designed one model (the 65) for those who have moderate hearing losses, and a second (the 66) with greater power output for those having severe losses and with extra fidelity for those desiring maximum acoustical performance.

Model 65 weighs only six ounces and is about four and one-third inches long. Its resistance-coupled amplifier is powered by a miniature 15-volt "B" battery and 1.5-volt "A" battery and has a frequency response with a gradually rising characteristic that effectively covers the range that contributes most to speech intelligibility. A tone control permits tilting the frequency response upward toward the higher frequencies at an additional 4 or 8 db per octave. This allows the user to discriminate against unwanted sounds such as street noises, etc., or to change the response to that most pleasing to the individual.

The condensers, resistors, and tubes of the three-stage amplifier are connected together with the elements' own leads and molded into one compact, moistureproof unit, $1\frac{5}{8}$ by $1\frac{1}{2}$ by $\frac{3}{8}$ inches. Delays in servicing are eliminated by the simple and rapid replacement of the entire unit. The transformer-coupled output of the amplifier is connected by a cord to a midget type receiver worn in the ear. Output capabilities of the 65 make it suitable for compensating hearing losses up to 65 db, with an operating cost well under a cent an hour.

The Super 66

The Super 66 is slightly larger than the 65 and weighs eight ounces, including self-contained batteries. The two interstage coupling networks are sealed in separate blocks of moistureproof microcrystalline wax and installed in the amplifier unit as indicated in Figure 2; tubes are not sealed in as they are in the 65. This contributes to the versatility of the 66, where twelve different fitting combinations are made available (in order to meet varying power requirements) by the choice of two output tubes, self-contained or separate batteries, and four receivers (three air conduction and one bone conduction) for each tube and battery combination. The tone control provides three different frequency response variations for each fitting combination. Operating cost, with self-contained batteries, is less than a cent an hour. The battery compartment may be detached and replaced with a separate battery pack connected through a cord to provide extra power and even lower operating cost.

Held in the right hand is Hearing Aid Model 65, designed for persons with moderate hearing losses; in left hand is the Super 66 with a high power output for persons with severe hearing losses.

Frequency response of the 66 is uniform within ± 6 db from 250 to 4000 cycles when used with a 724C midget receiver. Other receivers can be used for higher output with some reduction in response above 3000 cycles. The 66 has the lowest distortion and the best frequency response of any aid that has been tested by Bell Laboratories. It is capable of delivering a sound pressure level as high as 136 db

(*Continued on page 38*)

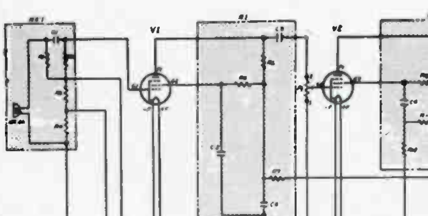


Figure 1 — Simplified schematic of Super 66 Hearing Aid Amplifier. Protected networks are shown by shaded areas. MK 1 (left) is tone control network and microphone. N1 and N2 are interstage coupling networks in moistureproof blocks.

Figure 2 — Two views of amplifier chassis of Model 66 Hearing Aid. Left are moistureproof blocks containing interstage coupling networks, one tube, tone and volume controls; at the right are microphone, two tubes and transformer.

WTPS-FM, New Orleans

(Continued from page 11)

progressive and experienced in communications media.

President of the Times-Picayune Publishing Company is Leonard K. Nicholson, a prominent New Orleans business man who has been associated with the paper since 1902. He has been President of the Company since 1918, four years after the *Picayune* merged with the *Times Democrat*.

Also on the policy-making staff of the station is Vice President and Business Manager of the Times-Picayune Publishing Company John F. Tims, Jr. Associated with the company since 1908, Mr. Tims became business manager in 1923, treasurer in 1932 and vice president in 1939.

The Men Who Run It

The actual operation and direction of the station are in the capable hands of Henry F. (Bob) Wehrmann, General Manager of WTPS-FM and WTPS. Bob Wehrmann graduated from Tulane University School of Engineering and was a ham operator from way back with call letters 5SZ. For 13 years, he acted as purchasing agent for the Times-Picayune Pub. Co. and was instrumental in guiding the papers into radio broadcasting. He has devoted the past two years exclusively to the organization and building of WTPS-FM and its AM sister.

Commercial Manager of WTPS-FM is John R. O'Meallie, another graduate of the *Times-Picayune* staff. John served for 13 years as an account executive, handling major retail accounts for the *Times-Picayune* and the *New Orleans States*. He brings to WTPS-FM 25 years' experience in the advertising field.

For the important position of Program Manager, the Station has Bill Seymour, who has a wide experience as writer, actor, news writer, announcer and supervisor at such stations as WLW, Cincinnati; WKRC, Cincinnati, and WBBM, Chicago.

The engineering force is headed by Transmitter Supervisor George W. DeBlieux and Studio Supervisor Edward Holmes. George began his career as an engineer in the Electric Service Section of the New Orleans Public Service. In the Navy in World War II, he was Aviation Radio Technician, and for the last year has been assisting in the planning, construction and maintenance of the studio transmitting equipment at WTPS-FM.

Studio Supervisor Edward G. Holmes is a graduate of Tulane University's Electrical Engineering School. A Radar Officer in World War II, he received his first-class phone ticket in 1946 and went to work for WTPS-FM installing the FM transmitter and later changing its frequency and installing all studio equipment.

On the Air Since January 1947

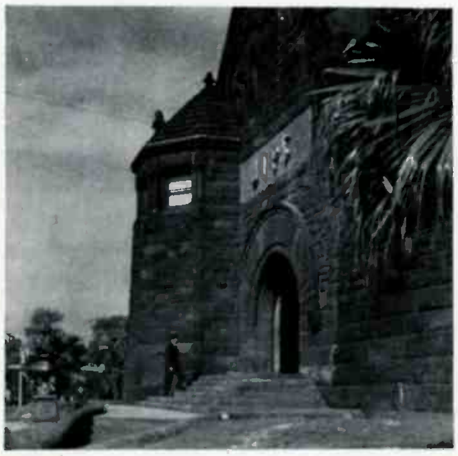
The Station has been on the air since January 3, 1947. It is Western Electric-equipped from microphone to transmitter.

In the early part of that year, the station broadcast entirely from its studios, the transmitter being set up in a special room there while the transmitter building and antenna were being erected at Gretna, across the river.

The studios are on an elaborate scale. In the two-story fortress-like edifice on Lee Circle are main lobby, business, executive, production and sales offices and the large and handsome Studio A, the ceiling of which is two stories high. On the second floor are Studios B, C and D lined up along a luxurious viewing lobby. The basement itself contains a lobby and demonstration and assembly rooms as well as space for the electrical and air conditioning equipment and for storage. The layout of these elaborate studios is shown on page 10.

Across the river in Gretna is the transmitter site within view of the skyscrapers of New Orleans about two miles away. The transmitter building is a large 60 by 40-foot Quonset hut. Inside this building, the two Western Electric transmitters stand in the main area at right angles to each other, the 1 kw AM unit with space for expansion to a higher power on the left as you enter and the 1 kw FM with space for the 10 and 50 kw units to the rear center. Speech input equipment is placed on the right.

When the station is complete, its Western Electric equipment will include in addition to its FM transmitter, a 10 kw AM transmitter, 23C speech input and two 25B speech input assemblies, 639B and 633A microphones, eight transcription turntables, two 22D remote amplifiers, ten 753C loudspeakers (cabinet type), seven 124F amplifiers and other studio and transmitter building equipment.



Gen. Mgr. H. F. Wehrmann enters WTPS Studios.

No story of an FM station which places its expectations in good programming and good coverage would be complete without some comment from the listeners themselves. To provide this element, we did a little doorbell ringing of our own. We secured a few names from dealers in FM receiving sets and went around to visit these FM set owners to see what they had to say about FM and the stations which provide it. Of course, with a sample as small as the one we were able to secure, it would be too much to make any major generalizations, but some of the comments might prove of interest.

Listeners' Comments

All of the set owners replied that they preferred FM to AM reception, giving as reasons the clarity, quality and freedom from static. All set owners found the musical programs most interesting, enjoyed the relative freedom from too much advertising and counted short news reports repeated fairly frequently as valuable. The set owners interviewed asserted that they listened on an average of three hours per day. They complained chiefly of the lack of good "live" programs, comedy and specialty shows and the elaborate type of major program that AM can afford. They complained that the stations were on too short a time each day, although one owner remarked with approval on WTPS' morning programs. One set owner concluded with a remark which should warm any FM station owner's heart:

"After getting used to our FM radio," he said, "my wife and I find the other kind seems sort of noisy and off-beat. You find you kind of get to expect a better quality. I don't know exactly what it is, but if they'd give us as good stuff as the other type of radio does, we wouldn't want to get our programs any other way."

Custom Builders

(Continued from page 30)

system for WHDH in Boston, and a standardized master dispatching system, both described in recent issues of the *Oscillator*, were constructed by the Products Division. The latter system, together with custom audio facilities consoles for WHAM in Rochester, and KHJ, Mutual—Don Lee in Los Angeles, were exhibited at the Institute of Radio Engineers Spring Convention in New York City in March, 1947. The original consoles constructed at the beginning of this cooperative effort are those installed at WOR, New York.

It has been found possible to utilize major furniture items rather interchangeably for radio and motion picture projects. Basically, an audio facilities console consists of pedestals which house amplifier equipment on a plug-in basis. Turrets, or console sections, which may be mounted upon the pedestals, contain panels carrying auxiliary controls and jack fields. The pedestals are connected together by a table structure which carries a mixer. This table may be of nearly any desired length and can, of course, support more than one mixer housing if required. Other versions of a table can be supplied having a compartment underneath the top, and at the rear, which will accommodate amplifiers or various electrical networks such as filters and equalizers. While some of the described components are standardized, great flexibility is insured, since many variations of structure are possible by the assembly of different basic items.

Techniques in Two Industries

Circuit features commonly used in both industries include the so-called split-mixer, use of inclusive volume controls controlling the output of several individual mixer attenuators, and various means of introducing reverberation by by-passing part of the program through a reverberation chamber or some type of device which simulates reverberation.

The radio and motion picture fields have developed independently, and there are many ideas which are peculiar to each. Since the Products Division has been participating in both types of project, there has been an increasing transfer of ideas from one field to the other, so that each custom project has had the benefit of engineering experience gained from the combined fields. As an example, equalizer or filter designs have been developed for motion picture requirements giving nearly any conceivable variation in transmission characteristic. The hearing aid type of receiver, 724C, has supplanted in movie sound monitoring (when loundspeakers cannot be used), the usual type of high quality head set receiver for monitoring, due to its comfort, improvement in low frequency response resulting from better coupling to the ear, and greater exclusion of external sounds. Such receivers might find application in the radio field for monitoring of remote pickups. Current transcribed radio programs which utilize as the final transcription a disc which has been rerecorded from several originals, indicate that the techniques developed in the motion picture field involving rerecording processes would undoubtedly find use when applied to such radio problems.

Elaborate devices for the investigation and measurement of film speed variations have been developed by movie technicians, and the speed variations (flutter) of film devices have been reduced to a minimum. Similar techniques could probably be applied by broadcast operating people to disc recording and reproduction as used in radio. The measurement of harmonic distortion from a recorded film is often limited by film noise. In order to obviate this limitation, two-frequency tests were devised, and if the system was non-linear the side band products could be measured by the use of a band pass filter, eliminating much of the film noise. This method is called an intermodulation test, and while originating in the motion picture field, is now being used in radio. Here it may be used to check distortion in audio equipment, and it is an excellent way to study distortion in disc recording.

The individual performance of microphones used in motion picture sound recording must be as nearly identical in response as possible. This follows since a given actor's voice may in the course of a picture be recorded with different microphones, and in the subsequent assembly of the film record, the sound quality must match. While radio does not have at present a similar problem, its problems will more nearly approach the motion picture field with the coming of television. Numerous other examples might be cited, but these will illustrate the point, that knowledge developed in one field may often prove useful in another.

Future Cooperation

With the coming of television the radio industry will in the future become more familiar with many motion picture techniques. While undoubtedly many programs will be televised from live action, storage of programs on film for latter transmission will also be necessary, due to the same factors which have made transcribed sound programs necessary. In addition, the advantages of preparation of suitable programs, taking the necessary time to insure good story and action continuity, certainly suggest that much regular program material be taken on film, and subsequently edited before release on the air. Since Western Electric has been a pioneer in the motion picture industry it can be of considerable aid to radio, in helping to adapt motion picture techniques to television.

The experiments and demonstrations by Bell Telephone Laboratories in the field of "Stereophonic" auditory perspective are well known. It is not perhaps as well known that the Products Division has spent considerable time in the study of such methods of recording as applied to motion pictures. While it may be entirely too early to consider multi-channel transmission in radio, the quality improvement afforded by such transmission is great, and might well be considered as one of the advances of the future.

The cooperative efforts of the Radio Division and the Products Division of Western Electric provide a wider field of knowledge and experience which will be helpful to the broadcaster. This, coupled with the fundamental research developments of the Bell Laboratories provides a team difficult to match. Such teamwork between organizations insures the broadcaster custom built audio facilities second to none.

Power Amplifiers

(Continued from page 17)

being operated Class C so that it consumes power only in proportion to the amount the modulation exceeds the no-modulation level.

The constants are such that at the peak of 100% modulation, each tube is delivering half of the power to the load. The system is self-adjusting to maximum efficiency at all levels of modulation: Tube No. 1 operates with the r-f plate voltage swing constantly near maximum, whereas Tube No. 2 operates under Class C conditions. The combination forms a high-efficiency amplifier that divides the load at the peak of 100% modulation equally between the two tubes.

The beauty of the Doherty circuit is that the *first of these actions, the variation of the load facing Tube No. 1, is produced by the second action, the drawing of power by Tube No. 2, through the medium of the network connecting the output of the two tubes.* As shown in Figure 1, Tube No. 2 is connected directly to the output load; Tube No. 1 is connected to the load through an impedance-inverting network. The action of this circuit is that as Tube No. 2 is made to act as a generator and hence deliver power to the load, the impedance into which Tube No. 1 "looks" is correspondingly reduced.

To understand the effectiveness of the circuit, consider first the following simple example showing the effect of connecting a *second* source of voltage in parallel with one already pushing current through a load: battery "A" is delivering current "I" into resistive load "R". If another battery "B" be connected in parallel with "A", of identical voltage, the current which "A" will deliver is then "½ I" — the voltage across "R" has not changed, but there are now *two* sources of power. Thus it will appear to battery "A" that the load has suddenly doubled to "2 R"!

This principle is used in the Doherty amplifier as follows:

(a) With two tubes in parallel working into the same load, the increase of current through Tube No. 2 would be an effective increase in the load impedance facing the other tube;

(b) The simple impedance inverting network has the property that the change of impedance looking into one end is the *inverse* of the change of impedance at the other end, so that the net result at Tube No. 1 is a *decrease* in impedance when Tube No. 2 draws current.

Thus, in proportion as the modulation level increases, forcing Tube No. 2 to draw current, the impedance presented to Tube No. 2 is *increased,* and the impedance into which Tube No. 1 works is *decreased*. The inverting network produces a 90° phase shift, a characteristic of all such networks, so the grid drive to Tube No. 1 is made to pass through a network giving a compensating 90-degree shift as shown in Figure 1. *The signals from the two tubes are then in phase at the load.*

Simple Modulation System

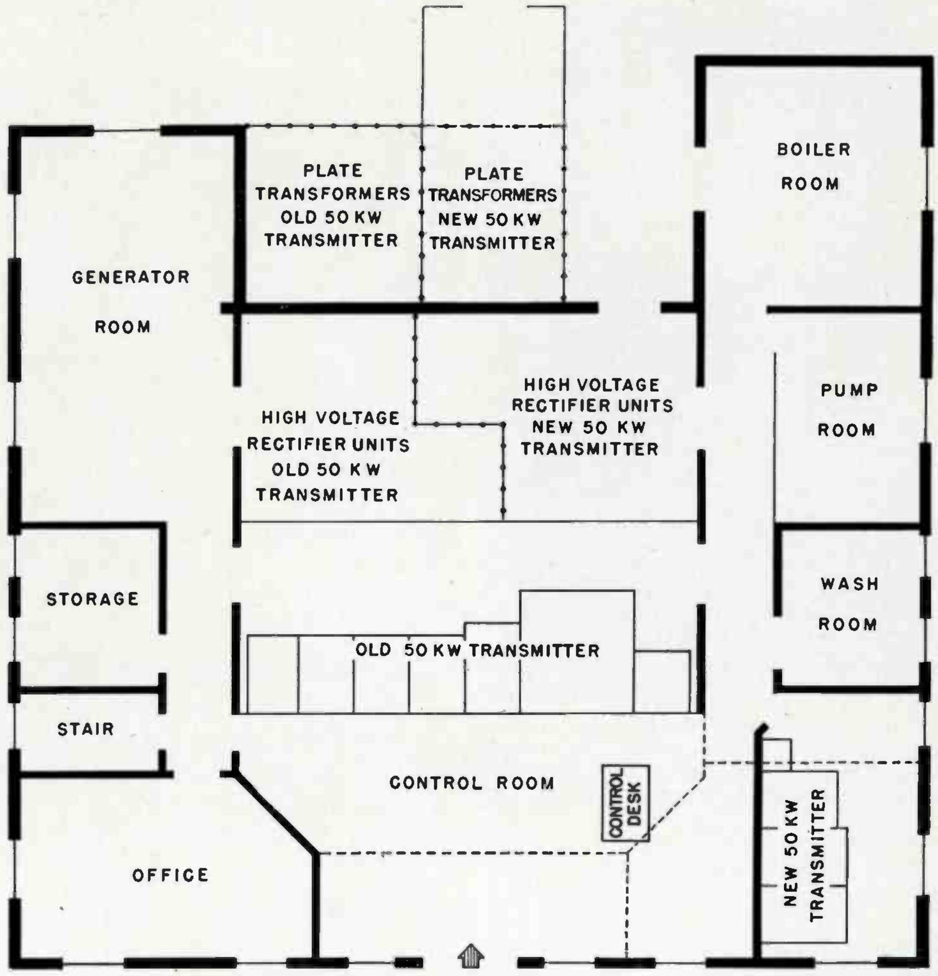
Grid-bias modulation of the power amplifier tubes themselves, as used in Western Electric's 1 kw 443A-1 equipment, is accomplished with the audio voltage from a two stage amplifier added in series to the bias on each of the four tubes in the high-efficiency amplifier. (In the 1 kw, "Tube No. 1" and "Tube No. 2" are each formed by two tubes in parallel.)

Maintaining the simplicity of the design, the elements of the grid phasing network do double duty and are used to feed the audio modulating voltage to the grids of the output tubes, while maintaining the proper d-c, audio, and r-f separations and phase relations. The modulating system thus takes full advantage of the simplicity inherent in grid-modulating the final stage of the transmitter.

As the circuit is simple in operation, it is correspondingly simple in adjustment. The number of adjustable elements in the output circuits of the amplifier is reduced to a minimum by combining the shunt elements of the impedance inverting network with the shunt elements in the tuned loads of the two tubes. The only additional element then required to form the network is a series inductance connected between the plates of Tube No. 1 and Tube No. 2.

Neutralization is adjusted in a conventional manner. The loads on Tube No. 1 and Tube No. 2 are adjusted to the proper resistive and reactive values at the station's operating frequency, using an r-f bridge, as with any high-power r-f amplifier. The proper phase relations in the power amplifier are set in a simple manner with front panel controls. Sampling jacks are provided for determining the phase relations at the proper points with an oscilloscope, as shown in the photographs on page 16. Other adjustments correspond closely to those used with any high-power r-f amplifier to get the excitation, modulation, etc., etc., "on the nose," with full power into the antenna.

And when tuning and adjustment of the high-efficiency amplifier have been completed, it is stable. The experience of the many broadcasters who have used it for periods up to ten years is — it stays put!



Main floor plan of WSB's transmitter building shows how the new 50 kw transmitter was fitted in beside the old one, with a minimum of alteration. Dotted lines indicate partitions that were removed.

WSB—Atlanta

(Continued from page 27)

been matched to the original open-wire line, with a changeover switch which permits instant change from one transmitter to the other without tuning or other adjustment. The old equipment can be cut back to 5-kilowatt output in case of any emergency reducing the power available or putting the high-voltage equipment out of operation.

Chief Engineer Daugherty surveys his completed dual-transmitter installation with satisfaction.

"The installation pleases us very much," he says, "especially the Doherty amplifier in the transmitter, which simplified the cooling system greatly by reducing the heat load. I believe that we have the only dual-50-kw transmitter installation in the country. Our success with this installation ought to throw some new light on the general problems of high power transmitter installation and operation."

Riding with Harry Daugherty over the pine-wooded, red-clay Georgia hills, on an Indian Summer afternoon, to see the transmitter building and its combination of equipments, was a wonderfully pleasant finish to the tour of discovery of WSB. Broadcasting has its finest champions in such stations as this tradition-strong but forward-looking Voice of the South.

W. H. Doherty of Bell Telephone Laboratories at the International Congress for the 50th Anniversary of Marconi's development of radio, Rome, Italy, held from September 28 to October 5, 1947.

Hearing Aids

(Continued from page 34)

and is adaptable to the needs of most persons who can be helped by a hearing aid.

The two new aids are housed in molded cases made of a carefully-selected inert plastic, ethyl cellulose, that is tough and durable and has a very low coefficient of friction that serves to reduce clothing and frictional noises. Background noises are further reduced by the resilient mounting of the microphones. New colors are also an innovation: French gray for the 65 and two-tone gray for the 66. Both are also available in flesh tint.

In order to provide improved servicing facilities, which have always been an important consideration, Western Electric engineers developed two new instruments, the Servicemaster and the Gainmaster, and a visually-indexed, rapid reference card file of simplified, easy-to-follow repair diagrams and instructions. This new system makes it possible for non-technical personnel, with nominal training, to quickly and easily service all models of Western Electric hearing aids.

The new hearing aids are available in the United States through nearly 300 dealers, authorized by the distributor of other Western Electric commercial products—Graybar Electric Company. In Canada, these aids are distributed by Northern Electric Co., Ltd., and in other countries by Westrex Corporation.

This Is the Life

(Continued from page 21)

key relay. Must be something the matter with power supply. Will have to be fixed.

At noon runs into the Cannery foreman, already looking for him. "How in h - - l can ve can fish when you take all the yuice? Tell me that. This morning ve vas running the can shop and the can line and the fillers and the seamers and the machine shop and a few other things and the fish elevator just to try dem out vithout any fish in dem and then you started that %#&$ vireless radio and the whole vorks stopped. 80 amps you vas drawing! Tink of it! Yust tink of it!"

Eighty amps at 100 volts equals 8 KW! Motor-generator couldn't have possibly drawn over 10 amps the way it was running, which only equalled one kilowatt. "There must be a mistake", he ventures. "Mistake h - - l," answers cannery foreman. "Yust have a look for yourself."

New operator decides to go to bottom of matter. Goes to engine house with foreman. Looks more closely at meter, then at voltmeter which registers 110 volts. Strange, an 80 amp load should pull voltage down. Looks at meter again. Notices that pointer instead of varying slightly is perfectly stationary. Thought strikes him.

"There's nothing the matter" he tells the foreman, "except that your old rusty meter is stuck." To prove point further, new operator pulls all the switches on the board: the meter sticks at 80. "You're not so smart," says the foreman with a haughty air. "Dat &%#$* vireless radio is not on a svitch. Dat feller last year dat vas here used to get sore when ve vould pull his svitch, so he come down and fixed the &$%* vireless radio right off the yenerator vithout a svitch." New operator too busy to notice the generator before, but thought strikes him it looks awfully small for 100 amp. generator. Goes over, scrapes off several coats of old paint with pocket-knife, gets down to numbers on name-plate. Reads; Volts 110 Amps. 20. Shows cannery foreman. "Dat don't mean a &%$#* thing. Here is vhat ve go by," foreman says, pointing in direction of big ammeter with pointer stuck at 80. "If I knew vhich vires vas your radio, I vould cut dem to pieces! Ve vill see about dat too," foreman adds, as he barges away.

Operator decides spend rest of day repairing gas engine. Has hard time with governor as parts broken and missing. Finally gets engine ready to run.

Engine starts after much coaxing. Belt won't stay on. Takes belt to machine shop to cut piece out and make repair. Puts on belt, starts engine again. Goes to radio station. Closes switch. Nothing happens. Increasing "Pop-Pop-Pop-Pop-Pop-" from engine house tells operator things not going so good up there. Dashes madly to engine house. Belt wrapped around flywheel whirring like airplane propellor. Old engine jumping up and down like it is ready to take flying jump to moon! Operator's first impulse, get out quick before she leaves. Remembers operator supposed to stay with ship. Ignition switch on other side of engine. Operator grabs first thing handy, an old rusty axe with broken handle, throws this at ignition battery, knocks it off shelf. One of wires break. Engine stops.

Operator looks at rusty mass of junk—weeps. Pulls himself together, tries again. Hunts all over place for piece of same width belting to repair belt. Ends up by carving down piece of wider belt found in machine shop. Builds framework around belt so can't come off this time. Installs ignition switch in radio house to forestall catastrophe like the last. No wire. Only alternative string. Asks storekeeper for ball of string. Storekeeper wants to know if operator going to fly kite.

Gets new rig fixed. Works perfectly. Can pull one string if engine goes too fast, cut off ignition, pulls other string and circuit closes again.

Starts engine. A flash inside set, a curl of smoke, generator groans, lights go out. Operator fears worst. Lights candle, repairs blown fuse, gropes way out to engine house. Finds no damage there. Starts up again for lights.

Finds transmitter damage quite extensive. Has to disconnect all 16 wires, take out 38 screws. Two tubes shot. Finds flash-over down inside, inaccessible without tearing set completely apart. Seems a shame—nice new set. Decides to trace out wiring. Finds it different than blueprint. Decides to take bull by horns, start over. Tears out defective wiring, replaces with whatever handy. Has been at cannery nearly a week—no communication yet; has the Supt and cannery foreman sore at him; nearly wrecked engine and engine house trying to get power. Now nice transmitter all shot. Weeps.

After three days gets set back together. It doesn't look the same. Has temporary wiring all over it now. Sits out at an angle like the old one used to, so operator can watch insides for signs of smoke while operating. Operator gets schedule going with "WXX". Rush message from home office three days old.

Now decides to try and get stand-in with Supt by giving him good service on message. Raises "WXX" on morning schedule but "WXX" too busy, says "If it's a NL hold until PM schedule." Starts to explain but "WXX" is gone, working next station. Evening schedule operator gets engine warmed up early, be sure all set when chance comes to clear traffic to "WXX". Waits patiently until "WXX" clears other stations, comes to him. "WXX" calls, operator closes switch to answer. Engine dies.

Up next morning hour early. Guy with "Jits" on watch and worse than ever this morning. ". . . . . . Why don't you keep your skeds . . . . . . called you five minutes yesterday . . . Where do you get idea you can come on anytime . . . skeds are for you to keep, see . . . . here's No. 1 rush . . . . from Seattle . . . . etc." Operator does best, with induction and the "Jits." Delivers to Supt who has answer back, also in code for evening schedule. Operator puts in several hours in afternoon cleaning up engine, getting it to run better. Engine holds OK on evening schedule, code message goes through OK.

. . . .

Down in Seattle next morning one of the big cannery executives twerps the dial on his desk phone, and the party answers. "Say," he says, "we just got a long wire from our Supt up in—. Says that fellow you sent up as operator is no good. Says he got into trouble with the Cannery foreman, and that he can't make the set work, says he had that new radio all apart that you sent up - - - - - etc., etc. . . . ."

This is the life!

Ventilating System

(Continued from page 19)

In locations where low temperatures are encountered during the winter months, the intake air should be tempered by mixing it with the hot exhaust air in a sheet metal chamber, or in a basement or storage room. In this way the mercury vapor rectifier tubes and quartz plate unit for frequency control will not be affected. Air no lower in temperature than 40° F. should be supplied to the transmitter. In winter some of the hot air from the transmitter may be utilized for auxiliary room heating purposes by diverting air from the exhaust duct by means of a damper.

There is one additional feature of interest. Mercury vapor rectifier tubes are generally adversely affected by wide variations in temperature. As mentioned in the preceding paragraph, temperatures in the equipment below 40° F. may be avoided by tempering the incoming air. Temperatures above the tube limits are avoided by employing a small blower in the rectifier unit which is thermostatically controlled. If the air surrounding the rectifier tubes exceeds the recommended ambient temperature, the blower in this unit operates and directs a small blast of air at the neck of each tube. This condenses mercury at this point and prevents arc-backs. This blower also sweeps any hot air which may have risen to the ceiling of the cabinet and under the shelf immediately above the power transformers toward the amplifier where it is mixed with the cool air and exhausted through the main blower.

The ventilation system designed for the new FM transmitters should give broadcasters the kind of service they have been looking for — low cabinet temperatures for minimum load on air-conditioning systems, maximum life of apparatus components, freedom from movement of dust from the room into the cabinet, and increased operator comfort, which is especially needed in transmitter installations where space is limited.

Microwaves in Harness

(Continued from page 7)

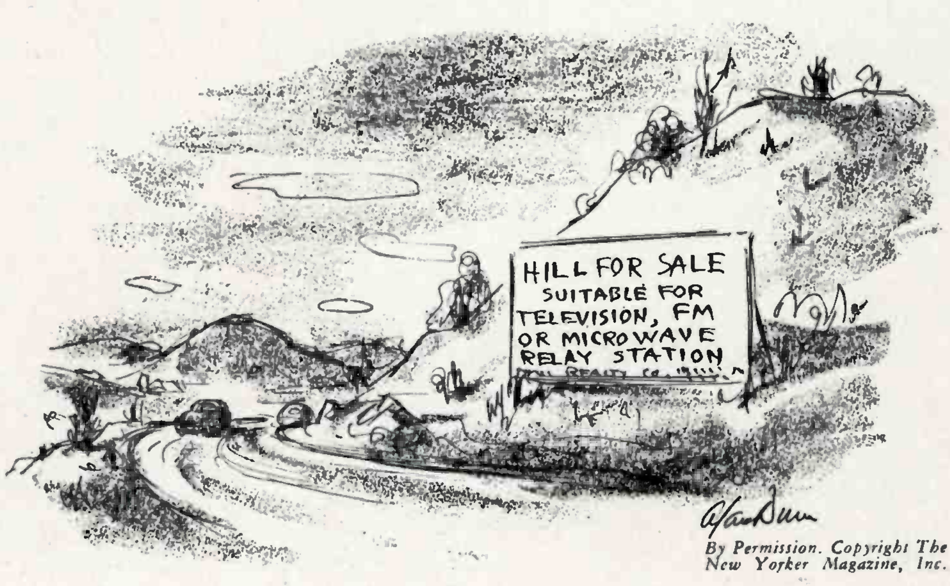
oscillators. Since the output of the monitoring receiver is proportional to frequency, direct comparison of the frequencies of the two oscillators can be made on the screen of the oscilloscope of the picture monitoring set. In practice, the two traces representing the individual outputs of the two amplifiers in the electronic switch are made to appear superimposed upon the screen, one trace including the wave form of the modulation taking place in the transmitting oscillator, and the other a horizontal line which moves up or down as the frequency of the calibrating oscillator is raised or lowered. In this way, the frequency excursions of the transmitted wave can be accurately adjusted within the proper limits. These observations can be made continuously without interrupting normal service.

The 1948 I.R.E. Convention will include a large exhibit of products available to the broadcast and communications industries through the Bell Laboratories-Western Electric-Graybar team. Don't miss it!

The scopes for video monitoring and for the frequency calibrations can be seen in the third and fifth bays in the photograph of the terminal equipment on page 5.

The transmitter-receiver combination in the lower part of the third diagram in Figure 1 is connected for the distortion test. In this test the transmitter and receiver for a single channel are looped as shown, and the distortion of the whole system is measured by impressing a saw-tooth wave on the transmitter and comparing it with the output of the receiver on the screen of the monitoring oscilloscope.

Although the New York to Boston project as a whole is described as "experimental," the system is suitable for commercial use and is expected to provide reliable and satisfactory service. In this sense, the new relay link represents the successful harnessing of the microwaves into a system with great present utility and important potentialities for the future.



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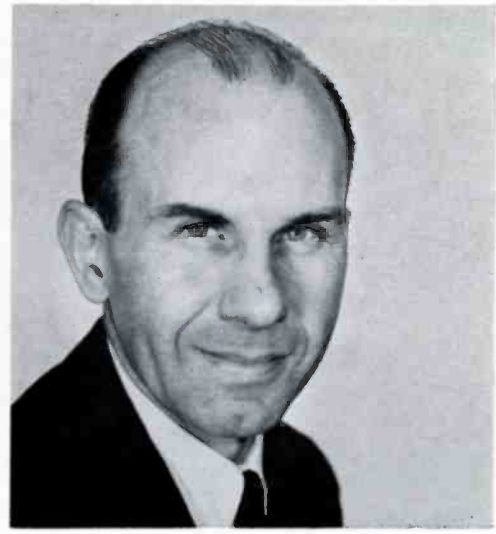
AUTHORS

F. L. Hopper



Arnold K. Bohren

CONTRIBUTORS TO THIS ISSUE

F. L. HOPPER, author of *Custom Builders for Broadcasting* (page 28), was graduated from the California Institute of Technology in 1922 with a B.S. in physics and engineering. He joined the Bell System after graduation, in the office of the Chief Engineer of the Pacific Telephone and Telegraph Company.

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In 1945 he began work in conjunction with the Radio Division of Western Electric in the design and development of custom built audio facilities for broadcast applications. Mr. Hopper is a member of the I.R.E., the Society of Motion Picture Engineers, and the Acoustical Society of America.

ARNOLD K. BOHREN, author of *A New Ventilating System Adds Reliability to FM Transmitters* (page 18), was graduated from Oregon State College in 1930 with a B.S. in Mechanical Engineering. He joined the Bell Telephone Laboratories in 1930 and for four years was engaged in the mechanical design of panel dial central office equipment. In 1934 he was transferred to the Commercial Products Development Department where he designed radio communication transmitters and receivers for marine, police and aircraft services. During the war he designed the FM communication set for armored vehicles, and supervised a group working on the mechanical design of Navy radar equipments. He is now in charge of the design of transmitters and antennas for broadcasting. He is the author of *A Clover-Leaf Goes Up*, in the *Oscillator*, July 1946.

Mr. Bohren is a Senior Member of the I.R.E. and a member of Tau Beta Pi, Sigma Tau, and Phi Kappa Phi, national honorary societies.

J. A. JOHNSON, author of *This is the Life* (page 20), studied electrical engineering at the University of Washington from 1924 to 1928. During college vacations he made several trips to Alaska as radio operator, his first one in 1924, when he installed a spark transmitter at Kenai. Since then he has made 21 trips to Alaska. *This is the Life* was written after his return from Alaska in the fall of 1927.

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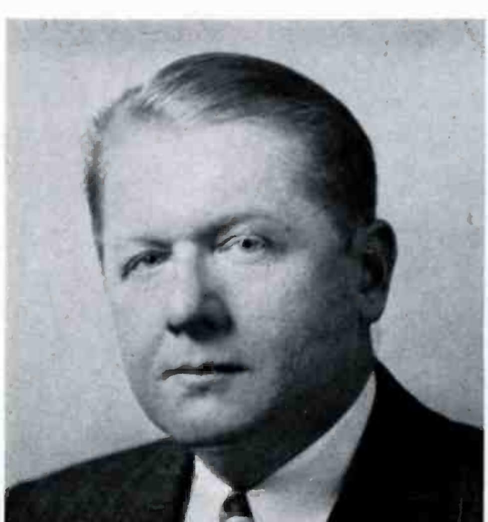

J. A. Johnson

E. E. Selover