PICK-UPS

MAY 1940

The Six-Way Cardioid Directional Microphone

WJSV, CBS Outlet for the Nation's Capital, Steps up to 50 KW

How WOR Operated One Year without a Single Program Break

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PICK-UPS
MAY, 1940

BEING A PERIODICAL DEVOTED TO DEVELOPMENT IN SOUND TRANSMISSION. PUBLISHED BY THE

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School for Announcers

The latest wrinkle at progressive WOR is a school for announcers now being conducted by Edward J. Content, assistant chief engineer. Purpose is to teach announcers proper microphone technique, and it's proving a popular course. The tremendous improvements in microphones (can you blame us for thinking of the 639?) call for complete understanding of the microphone's capabilities, according to Content, and it is to the announcer's advantage if he knows thoroughly just how to use modern mikes.

Spring Gets in Our Hair

Why hasn't some radio station cooked up a good program idea designed especially for automobile and dinner pail radio listeners? For the next couple of months millions of young things will be courting each other in automobiles, on moonlit lakes, park benches and village greens. Their radios will be at their sides. Why not a program that would do the proposing for bashful young men, or the gals since this is leap year? Think what a boon it would be to millions of timid swains, if they knew that at eleven p.m. sharp they could just turn on the radio and let some distant, honey-tongued radio announcer do a "John Alden" for them. Think, too, of the sponsors the station could get for the program. Why the "you furnish the girl, we furnish the ring, furniture, home, etc." stores would fight for the chance to sponsor the program. Note of caution: Before any of you program managers grab the idea, you'd better check your lawyer to see if you would be held legally responsible in case of divorce!

This Issue

Maybe the above will check our spring fever long enough to tell you about this issue. WOR operated all of 1939 without a single program break due to a technical failure. It seems maintenance turns the trick, according to Charlie Singer, who tells you all about it. Of course, a good transmitter and a dash of luck helps too!

* * *

The next time you're in Washington, take a run out to Wheaton, Md., and have a look at the new transmitter plant of WJSV. Housing a 50 KW Western Electric transmitter, it's just about the last word in everything that a modern plant should be. In the meantime, turn the pages to *Pick-Ups'* pictorial presentation.

Bob Marshall, Bell Telephone Laboratories microphone wizard, comes through with another microphone story. This one is on the new 639B, alias the Multi-Mike, or the Six-Way.

Then there's an exciting story of a chase, just like the old movie thrillers, with the Illinois State Police Radio coming through in the nick of time. It's got punch, folks, just like the punch Police Radio takes at crime.

LaGuardia Field is just about the biggest thing in aviation, but it's not too big to keep a Western Electric Public Address System from reaching you, no matter in what part of the huge place you happen to be.

There are quite a few other stories, but you find them for yourself. Right now we'd just rather yawn and let Spring engulf us.

THIS ISSUE

THE NEW SIX-WAY
Cardioid Directional Microphone

By R. N. MARSHALL and W. R. HARRY
Transmission Instruments Engineering,
Bell Telephone Laboratories

The trend to directional microphones has gathered momentum in recent months, as the radio, sound picture, and public address engineers have experimented with the new commercial types. The rapid increase in popularity of the cardioid directional microphone over bidirectional or more sharply directional instruments available, indicates that the cardioid characteristic has been the most useful up to the present time. The cardioid directivity pattern is a heart-shaped curve of sensitivity versus angle of sound approach, showing a broad area of sensitivity in the front falling off to zero sensitivity at 180°.

The cardioid pattern is, however, only one of a family of directivity patterns that may be obtained by the same general means. At casual glance, these companion patterns may not appear to offer any particular additional value, and for this reason they have been slow to take their due position in the art. Yet lurking there all the while have been practical advantages which are now being offered to the field for the first time in the new Western Electric 639B, six-way directional microphone — six-way because it allows selection of six pick-up patterns, three of the new type in addition to the cardioid, the ribbon and dynamic characteristics previously made available in the 639A.

To appreciate the possibilities of these valuable pick-up patterns of the cardioid family, let us review briefly the acoustic conditions that make directional microphones so necessary. Our mechanical ear, the microphone, is often expected to achieve a result which a single human ear is incapable of accomplishing, although our ears are the standard by which the performance of the microphone is eventually judged. This apparent paradox occurs because most sound systems in use today, such as in radio and sound pictures, are monaural. This means that all transmitted sounds come from one source, the loud speaker, and we cannot use the focusing power of our aural senses to disregard unwanted sounds which are transmitted. As a result all undesirable sounds such as incidental noises, echoes, reverberation, and even nonlinear and frequency distortion are in effect exaggerated as compared to what a listener standing at the microphone position would hear.

Upon the microphone in a monaural system, then, falls the responsibility of doing as perfectly as possible what ordinarily requires two ears and a human mind to accomplish. The problem today in the design of a microphone is therefore no longer so much how to pick up sound as how to eliminate in the microphone output all of those unwanted sounds which our aural senses disregard in binaural hearing.

To achieve naturalness of the reproduced sound in a monaural system, reverberation effects, caused by multiple reflections within a room, need to be held to a lower value than that required for direct listening. Directional microphones, by favoring direct sounds, are effective in reducing reverberation effects. But how effective? In an effort to answer that question quantitatively an index has been standardized[1] and defined:

$$\left(\begin{array}{c}\text{Directivity}\\\text{Index}\end{array}\right)\quad I = \frac{\text{efficiency for sound of random incidence}}{\text{efficiency for sound of normal incidence}}$$

By sound of random incidence is meant a condition where sounds are coming from every direction, all directions being equally probable. The reason for choosing this condition is not only because it can be handled analytically, but also because it is a condition that, although extreme, may be realized fairly closely in practice, such as in a highly reverberant auditorium far from the source of sound. By sound of normal incidence is meant a condition where all the sound comes from one direction into the front of the microphone.

For example, consider a random sound field and a single direction sound field of equal total energies. A non-directional microphone will pick up the random sounds from every direction just as well as the normal incidence (front) sound and will have equal output in either field. Hence, its index is 1. A directional microphone on the other hand will discriminate against some of the random sounds and hence will have

1. "Calibration of Microphones" American Standards Association Pamphlet, 1938. For derivation of index see W. P. Mason and R. N. Marshall "A Tubular Directional Microphone" Appendix A, Jl. Acous. Soc. Jan. 1939.


C
0°
-5 DB
-10 DB
-15 DB
-20 DB
90°
90°
I = 1/3
180°
1
0°
-5 DB
-10 DB
-15 DB
-20 DB
90°
90°
I = 1/3.2
150°
150°
180°
D
0°
-5 DB
-10 DB
-15 DB
-20 DB
90°
90°
I = 1
180°
2
0°
-5 DB
-10 DB
-15 DB
-20 DB
90°
90°
I = 1/3.6
130°
130°
180°
R
0°
-5 DB
-10 DB
-15 DB
-20 DB
90°
90°
I = 1/3
180°
3
0°
-5 DB
-10 DB
-15 DB
-20 DB
90°
90°
I = 1/4
110°
110°
180°
R D C 1 2 3

less output in the random field. Therefore, its index will be less than one, and the greater the directivity the smaller the index. The cardioid type has an index of 0.33, but so does the bidirectional ribbon type. Yet we know that these two types are quite different, one is unidirectional, the other bidirectional. Obviously, the standard index, although a valuable aid in determining the effectiveness of a microphone in controlling the ratio of reverberant to direct sound, is not sufficient to specify completely the directional properties.

Looking further into the problem we find that in many cases of sound pick-up either there are a large number of performers as in an orchestra or else a large area of action as in a stage, and if the microphone is made too sharply directional, a large number would be required to cover this area. In general, however, a line can be drawn on one side of which is the area of desired sound sources and on the other the undesired. Thus, the footlights divide the stage from the audience, or in a studio an imaginary line separates the performers from a reflecting wall. This suggests a different index of directivity defined as:

$$J = \frac{\text{average efficiency for all angles of sound incidence in rear hemisphere}}{\text{average efficiency for all angles of sound incidence in front hemisphere}}$$

Thus for nondirectional and bidirectional types $J = 1$ while for the cardioid $J = 1/7$. This index distinguishes between cardioid and bidirectional but not between non- and bidirectional characteristics. Under this system, proposed for the first time, the index is a measure of the effectiveness of a directional microphone in separating the sounds from either side of the dividing line, while the other index I is a measure of the effectiveness in suppressing general reverberation.

Still neither index is helpful in studying how the microphone will handle unwanted sounds from discrete directions. "Slap-back" from a particular reflecting surface may cause annoying interference, or in a sound reinforcement system some particular feedback path may be causing the system to "sing." For analyzing these problems the actual directivity pattern is very helpful. However, a microphone which discriminates against sound direct from the loud speaker will not necessarily give the greatest reduction in feedback. Except for some outdoor installations, the sound fed back may come from many directions, the ratio of the diffused portion to that direct from the loud speaker depending on the nature and location of the reflecting surfaces. A microphone must discriminate against both to reduce feedback effectively. We may conclude that there is no single quantitative criterion that will answer our question "how effective is a directional microphone" and that we must consider a number of factors in judging.

In the discussion so far no mention has been made of the frequency of sound and the fact that in many situations reverberation effects vary with frequency. A room that has unequal reverberation times at different portions of the tonal range may upset the tonal balance of an orchestra playing there, and the overall result depends on the characteristics of both. Furthermore, the program pick-up is also influenced by the way in which the microphone handles direct as well as reflected or reverberant sound. Unequal reverberation effects and unequal handling of them may give a pick-up result that is difficult to distinguish from actual frequency distortion.

This is particularly true in many broadcasting studios at the lower audio frequencies where many forms of sound treatment fail to provide adequate absorption so that a typical studio is considerably more reverberant for bass notes than for those in midscale. Consequently, there is general need for a microphone that is directional at low frequencies, for it provides a control of reverberation effect that may be very expensive or impractical to obtain in any other way. Ideally studio designers strive to obtain uniform[2] reverberation characteristics in small studios, and it is equally important to strive for uniform directivity index in the microphone.

We are now ready to discuss and interpret the various patterns in the cardioid family. In the Western Electric 639A microphone, the cardioid directional characteristic is obtained by combining in series the outputs of a pressure type element and a pressure gradient type element which have equal output voltages. As shown in Fig. 1 when sound arrives at the front of this combination the output voltages of the two elements are in phase and add. However, when sound arrives from the rear, the phase of the ribbon pressure gradient element output reverses while that of the pressure element remains unchanged, and the output of the two elements tend to cancel each other. The operation of this combination gives rise to the equation for the output voltage

$$E = a + a \cos \theta$$

where a = output of the pressure element, independent of angle

$a \cos \theta$ = output of the ribbon element, becomes a, when $\theta = 0°$

θ = angle of sound approach

In polar coordinates this is the equation of a cardioid.

If however, the two elements do not have equal output voltages[3] the equation for the combined output is

$$E = a + b \cos \theta.$$

(*Continued on page 28*)

2. J. P. Maxfield and C. C. Potwin, "Planning Functionally for Good Acoustics," Jl. Acous. Soc. Amer., Vol. II, No. 4, April 1940, p. 390.
3. Other investigators have independently reported on the relation of the index I to the various pick-up patterns in the cardioid family. See H. F. Olson "Broadcast News" May 1939, R. P. Glover, Jl. Acous. Soc., January 1940.

How WOR Operated ONE YEAR Without a Single Program Break

By CHARLES H. SINGER
Technical Supervisor in Charge of
WOR Transmitter and New Jersey Operations

The 1939 "No Program Break" record achieved by WOR can be attributed primarily to two factors — the dependability of the transmitter and a systematized plan of operating and maintenance practices which are followed hour by hour, day and night, year in and year out. These plans have been set down in book form, listing every routine duty to be performed as well as the handling of any emergency which might arise at Carteret, New Jersey. The books are compiled under the headings — Starting Log, Master Operating Log, FCC Log, Day and Night Maintenance, Work-to-be-Done, Special Maintenance and Tube Records. Every procedure is described in the minutest detail. The process of starting and stopping the transmitter, for example, is performed using *one* method and *only* one method. Every piece of equipment is operated, tested, adjusted and cleaned in the prescribed routine manner without variation.

It is possible to operate the entire plant efficiently by simply reading and following instructions. The books are readily changeable so that when a suggestion for better procedure is accepted the books can be changed correspondingly. Invariably such suggestions come from the operators themselves. These are put through in the form of office memorandums and later discussed and passed upon at round table meetings attended by the entire staff. Thus the man making the suggestion has an opportunity to advocate his proposal.

There are three types of maintenance at WOR — day, night and special. Day maintenance consists of the work which may be done with the transmitter on the air. Night maintenance entails the necessary and vital work on the transmitter itself. Special maintenance pertains to work which is seasonal or annual.

Today, radio is a new orientation of public service, indispensable in the lives and activities of the people of this modern age.

WOR, since its establishment 18 years ago, has constantly entertained the thought that modern engineering practices provide improved public services. With the combined facilities of all engineering groups, however, transmitting failures invariably occurred during a year's operation, and it was not until last year that a perfectly continuous operation was made possible by engineering maintenance.

Mr. Singer, who is in charge of transmitting operations, is presenting his story how modern maintenance system functions, and illustrates how WOR endeavors to maintain a high standard of operations.

J. R. POPPELE,
Chief Engineer, WOR

But routine maintenance is only half of the requisite for good engineering operation, the other half being a well designed transmitter. Ruggedness, performance and accessibility contribute greatly to the ease of maintenance.

Naturally, successful operation ultimately rests in the hands of the operators. WOR has its own high standards in selecting the men behind the transmitter. Ability, neatness, consideration and cooperation are essential qualifications. Originality, too, rates high for the station lends an eager ear to new ideas. The operator who takes his watch seriously, digging into the job for all he is worth, is the one best fitted to shoulder greater responsibilities later.

Each man stands four weeks of day watch as against two of night watch, working five days or nights a week. By checking the books he brings himself up to date on all operations. The rotation of watches acquaints him with the various procedures of all three working periods. Any changes or out-of-the-ordinary activities which have occurred on one watch are passed along to the incoming men by oral discussion. This gives the man taking over the job an added sense of security. Before an operator signs out he writes a memorandum of the work he has completed. This is checked and filed for future reference. And when a man signs his name below his results he invariably does a good job. As each man works with every one of his fellow employees during some watch period he can weigh his own merits in the light of comparison. He works, too, with each of the supervisors. Thus he is able to talk WOR with greater understanding, all of which tends to develop a sense of pride in his personal job and in the organization as a whole.

Operating WOR's transmitter has long since passed beyond the realm of guessing and half done maintenance. It has become an established routine system of operations which keeps the equipment in A-1 condition at all times. The men realize the value of time and the price of negligence. They know that lost time on the air is costly in more than one way.

To present a more vivid picture of just how this system actually functions, let's join two of the operating engineers as they enter the plant shortly before 8 A.M. to relieve the Maintenance Watch.

Off we go in the wake of the first engineer who proceeds to check the transmitter and asso-

Charles H. Singer displays two of the vacuum tubes which helped make WOR's 1939 record possible. Singer claims that both of these tubes broke all previous records for long life. The larger of the two tubes, a 266B rectifier, burned 33,211 hours before being withdrawn while the 287A had 41,452 hours to its credit. The long life of these, as well as the other tubes in service at WOR, brought this station's 1939 average tube-hour cost down to only $ .34.

ciated equipment before officially taking over the watch.

The control room, where speech input equipment is located, is his first concern. Here he checks filament and plate currents of the speech amplifier stages; operation of the 110A amplifier; fader settings of the program input channels to the transmitter and the emergency channel which feeds programs to Cartaret from New York. He notes any special orders or changes in watch schedules which are posted on a bulletin board.

Next he enters the transmitter room and carefully checks the half-hourly FCC Log and the Master Operating Log with its 85 two-hourly readings. He compares the last readings with previous ones for possible changes which may indicate an imminent breakdown in some part of the 50 KW or associated equipment. On the reverse side of the M.O.L. he finds a complete story of what has transpired in the plant since his previous watch. Here, changes made in the transmitter, repairs or maintenance items performed, are duly logged. He confirms with the outgoing watch maintenance items which were completed and those to be done during the day.

The Starting Log will then be perused. This shows the actual time the transmitter started and any changes in high voltage rectifier tubes.

The next step in the tour takes him to the 50 KW itself. Careful check is made of the meters on the master control panel, water cooled tubes, water cooling connections, the meters which indicate input to the last stages, the antenna extension ammeter readings and antenna coupling unit meter readings. Proceeding down the back of the transmitter unit, all visible parts are scrutinized for even the slightest change from normal.

Now he goes to the basement to check all rotating machinery and important power supply equipment. Here, posted on a bulletin board, he finds orders for the day, the latest information pertaining to transmitting equipment and new rules and regulations issued by the FCC. Here, too, he files his time slip upon which he records the nature of his watch. He looks over the Communications Book in which are posted all inter-office communications such as program corrections and future program arrangements. He initials and dates these notices as he does all other posted orders or information.

While in the basement he must "take the temperature" of the entire plant. First he reads the tel-temp thermometers which record the temperatures of the main breaker switch and the filament and bias generators. Tel-temp thermometers are attached to every piece of machinery or equipment in the plant which may be injured by a temperature rise or in which a temperature rise may indicate a serious fault or breakdown. A red dot marks a maximum allowable point on each tel-temp thus warning the engineer inspecting them.

Now we follow him to the main switch room where power from the Carteret and Rahway mains enter the building and where the main distributing breaker switches are installed. The heating and ventilating system will also be inspected. Enough heat is obtained for heating the entire Plant by forcing filtered air through a series of pipes in which the water used for cooling the large power amplifier tubes circulates before returning to the cooler.

Our next step brings us to the pump room which contains the spray pond pumps, distilled water pumps, electric water still, water softener, storage tank for distilled water, and associated valves. Oil levels, temperature and general operating conditions of the various pumps, tanks and valves are checked. This basement inspection tour also includes a check-up of high voltage transformers, voltmeter multiplier and thyrite protectors.

While our first engineer travels around the basement, his colleague, who stands watch with him, has been going through an identical inspection routine starting from the opposite end. Thus a double check is made of the entire Plant at the beginning of each watch by two men who are rested and alert and responsive to the slightest change. *This is an important point.* More than once, men nearing the end of their watch have overlooked some indication of change which was immediately noted by the incoming operators.

The above inspection tour takes place before the men actually go on watch.

Both engineers now return to the transmitter room to take over the day watch. Any deviations from routine work or operations are thoroughly discussed with the night operators before they sign out.

(*Continued on page 23*)

"DOHERTY AMPLIFIER EXPERIENCES"

BY ORRIN W. TOWNER

ALL SET? FIRE IT UP! AS WE PUT THE FIRST COMMERCIAL DOHERTY AMPLIFIER IN THE UNITED STATES ON THE AIR A LITTLE OVER TWO YEARS AGO AT STATION WHAS, QUESTIONS WERE RAISED WHICH TIME ALONE COULD ANSWER. NOW, SINCE WE HAVE HAD THE OPPORTUNITY DUE TO THE PASSAGE OF TIME AND INCREASED EXPERIENCE, LET US CHECK BACK ON SOME OF THESE QUESTIONS AND SEE WHAT THE ANSWER HAS BEEN.

HOW WOULD MY TECHNICAL STAFF AT THE TRANSMITTER TAKE TO A NEW TUNING METHOD USING CATHODE RAY OSCILLOGRAPH OVALS AND STRAIGHT LINES [1] INSTEAD OF CONVENTIONAL PLATE AND TANK METERS? WOULD THE NINETY DEGREE PHASE SHIFTING NETWORKS SCARE THEM INTO THINKING IT WAS MORE COMPLICATED THAN THE OLD CLASS B AMPLIFIER USED BEFORE? IT WAS A CHALLENGE TO THEIR IMAGINATIONS, AND AS THEY DUG INTO THE CIRCUIT THEY WERE AMAZED AT ITS SIMPLICITY. IT WASN'T AS BAD AS THE THEORY MADE IT SOUND, AND CERTAINLY IT TOOK LESS APPARATUS AND SPACE THAN OUR OLD EQUIPMENT. THEN, DURING THE INSTALLATION TUNE UP PERIOD THEY DISCOVERED THE EASE WITH WHICH THE TUNING OVAL COULD BE MADE HORIZONTAL AND THE ONE HUNDRED-EIGHTY DEGREE OVAL A STRAIGHT LINE, EITHER WITH OR WITHOUT MODULATION. THIS WAS SUCH A DEPARTURE FROM THE USE OF TUNING METERS WHICH VARIED WITH MODULATION, THAT IT MADE A HIT IMMEDIATELY.

SOME QUESTIONED THE STABILITY OF THE AMPLIFIER, ESPECIALLY AS WE PUT IT ON THE AIR WITH ONLY THE CARRIER TUBE NEUTRALIZED. IT IS STILL THAT WAY, ALTHOUGH WE HAVE ANOTHER NEUTRALIZING COIL WHICH FITS IN THE PEAK TUBE COMPARTMENT. THIS AMPLIFIER REFUSES TO MISBEHAVE, SO WHY SHOULD WE SHOW DISTRUST BY INSTALLING ADDITIONAL NEUTRALIZATION? THE AVERAGE NUMBER OF TIMES WE HAVE TUNED THE TRANSMITTER IS ONCE PER YEAR -- SOMETHING WE WERE NEVER ABLE TO DO BEFORE. AT FIRST WE MADE FREQUENT CHECKS OF THE OVALS WHICH, OF COURSE, INDICATED ALL WAS WELL; THEN THE CHECKS WERE MADE MORE SELDOM AS THIS CONDITION CONTINUED. WE HAVE SEEN NO TENDENCY DEVELOPING THAT WOULD CAUSE US TO CHANGE, EXCEPT THE TWO TIMES WHEN WE OURSELVES MADE ADJUSTMENTS NECESSITATING A MINOR FRONT OF THE PANEL TUNING CHANGE. NO FIXED CLIP OR BEHIND THE PANEL ADJUSTMENT HAS EVER BEEN CHANGED SINCE OUR ORIGINAL INSTALLATION TUNE UP, AND WE DO NOT EXPECT IT WILL BE NECESSARY UNTIL WE COME FACE TO FACE WITH OUR AUGUST 1ST FREQUENCY SHIFT.

THERE HAVE BEEN ARCS INSIDE THESE UNITS -- THREE OR FOUR IN ALL -- WHICH WERE IN EACH CASE CAUSED BY SECONDARY INDUCTION FROM SOME OF THE THIRTEEN OR SO DIRECT LIGHTNING BOLTS WHICH HAVE HIT OUR SHUNT EXCITED ANTENNA DURING SUMMER ELECTRICAL STORMS. THE TOTAL DAMAGE TO DATE AMOUNTS TO ONE SMALL BY-PASS CONDENSER. THEN TOO THERE

Early in 1938 WHAS, Louisville, went on the air with the first transmitter incorporating the Doherty circuit, a Western Electric 50 KW. Orrin W. Towner, WHAS Chief Engineer, here tells of his station's experience with this revolutionary circuit, now a standard feature of Western Electric broadcast transmitters.

WAS THE TIME WHEN A SEVERE WIND STORM, COUPLED WITH A COLD WAVE, SNAPPED ONE OF OUR TWO FEED LINE TAPS ON THE TOWER. WITH HALF OF OUR SERIES CAPACITY SUDDENLY DISABLED BY THIS BREAK, THE DOHERTY PROTECTIVE CIRCUIT [2] IMMEDIATELY KICKED THE TRANSMITTER OFF THE AIR DUE TO THE DE-TUNING EFFECT OF THE FEED LINE CIRCUIT. QUICKLY THE PROTECTIVE CIRCUIT WAS DISABLED AS THE CAUSE WAS DISCOVERED, AND THE TRANSMITTER PUT BACK ON THE AIR WITH FULL VOLTAGE ON THE TUBES. ANYONE INSIDE THE TRANSMITTER BUILDING WOULD NOT HAVE GUESSED THE TRANSMITTER WAS OPERATING OTHER THAN NORMALLY, UNLESS HE LOOKED AT THE "WOULD-BE" NINETY DEGREE PLATE-TO-PLATE OVAL OF THE DOHERTY AMPLIFIER, WHICH SHOWED THE EXTENT OF THE DE-TUNING, AS THE OVAL AXIS WAS STANDING NEARLY FORTY-FIVE DEGREES FROM HORIZONTAL. OPERATION UNDER THIS CONDITION WAS CONTINUED THROUGHOUT THE DAY AND EVENING WITHOUT EVENT, INDICATING TO US IN SOME MEASURE WHAT EXCELLENT STABILITY REALLY IS INHERENT IN THIS DOHERTY AMPLIFIER.

TUBE LIFE MAKES INTERESTING SPECULATION, ESPECIALLY IF THE TUBE IS WORTH THE PRICE OF A HIGH GRADE AUTOMOBILE. WELL, WE STILL DON'T KNOW WHAT OUR 100 KW TUBES WILL DO. OUR VETERAN HAS ACCUMULATED SOME 14,000 HOURS AND STILL DOES NOT NEED TO BE OPERATED AT RATED FILAMENT VOLTAGE IN ORDER TO GET SUFFICIENT EMISSION. ITS COMPANION HAS HAD ABOUT 6,000 HOURS AND IS STILL GOING STRONG. AT THIS RATE IT WILL TAKE US SIX OR EIGHT YEARS TO ANSWER ANOTHER QUESTION — WHICH TUBE OF THE DOHERTY AMPLIFIER WILL INHERENTLY LAST THE LONGER? OUR VETERAN, INCIDENTALLY, IS IN THE CARRIER TUBE POSITION.[3]

THE FINAL CRITERION OF COMMERCIAL SUCCESS IS THE POWER SAVINGS. IT SOUNDED GOOD ON PAPER, AND THEN THE BILLS STARTED COMING IN. THE FIGURES WERE CORRECT.

AS COMPARED WITH OUR OLD EQUIPMENT, WE ARE SAVING SOMETHING OVER $5,000 PER YEAR ON POWER, IN SPITE OF AN EXPANDED SCHEDULE. THIS WITHOUT MENTION OF THE $500 SAVINGS OBTAINED BY THE USE OF THE WASTE HEAT IN OUR COOLING SYSTEM TO TAKE CARE OF OUR TRANSMITTER BUILDING'S WINTER HEAT REQUIREMENTS.

NOTHING INTERESTING (?) EVER SEEMS TO HAPPEN IN THE TRANSMITTER ANY MORE, SO BEFORE WE FORGET HOW TO LOOK FOR TROUBLE, WE HAVE DECIDED TO HOLD AN OCCASIONAL FIRE DRILL DURING THOSE WEE SMALL HOURS WHEN ANYTHING GOES — THAT IS EXCEPT FREQUENCY DEVIATION. THE FACT IS, AS YOU MAY HAVE GUESSED, WE AT STATION WHAS ARE PROUD OF OUR DOHERTY AMPLIFIER.

ANNOTATIONS BY W. H. DOHERTY

[1] Oscillograph tuning, as explained in the Doherty-Towner I.R.E. paper of September, 1939, is the ideal method of adjusting amplifiers of any type. It is particularly useful with the Doherty circuit because of the 90-degree phase relations, which give an oval pattern.

[2] This is a balanced device which instantly detects any accidental de-tuning of the output or antenna circuits, such as might result from a flashover or a mechanical failure.

[3] The No. 1 "carrier" tube in this circuit supplies all of the output except when modulation occurs. In neither tube, however, are the operating conditions as severe as in conventional circuits.

ILLINOIS STATE POLICE R

By RALPH JOHNSON

Illinois State troopers have been topping records in police history since radio first rode the highways with them in 1936. During the past three years the percentage of "stolen cars recovered," valued at nearly three million dollars, skyrocketted from 13 to 83. "Criminal apprehensions" jumped from 37 to 65 per cent while figures on "missing persons located" climbed from 57 to 86 per cent.

Back of these achievements are the hours of planning and training which have gone into the job of making Illinois troopers such a hard and fast hitting unit. The 350 officers who comprise the unit have a far flung area to patrol. Their travels take them over 13,000 miles of paved roads scattered throughout 56,000 square miles of territory which is populated by more than six million people.

With this electrically controlled map Superintendent Walter Williams directs police activities anywhere in the state. Upper left: Central control station WQPS, Springfield. Left: E. Swaringen, senior operator (right) and C. L. Hopper, supervisor, at the zone and interzone telegraph console, Springfield. One of the fleet of field service trunks which facilitates maintenance work throughout the entire police radio division in Illinois.

So important has radio become to the Illinois police that precautions are being taken to prevent the network from being off the air even during temporary power failure. Emergency power plants are being installed at all transmitter stations which will go into action the moment the regular lines fail. According to latest statistics which cover the first ten months of 1939, the system was on the air 2,745 hours with a total of 276,479 transmissions.

When a crime conference called by Governor Horner some years ago recommended that the state police utilize radio, there was no headlong plunge to get on the air. Instead, state officials ordered that a scientific field survey be made to determine the logical number, location and power of the stations required. Plans which had been submitted by commercial and amateur radio technicians showed arrangements varying all the way from three 2,000 watt stations to thirteen 50 watt stations. The field survey showed that in order to send messages strong enough to be picked up above the roar of a speeding squad car with a limited battery powered receiver, six 1,000 watt stations would be required. Because this arrangement did not take into consideration a control station at headquarters, the plan

ADIO SYSTEM

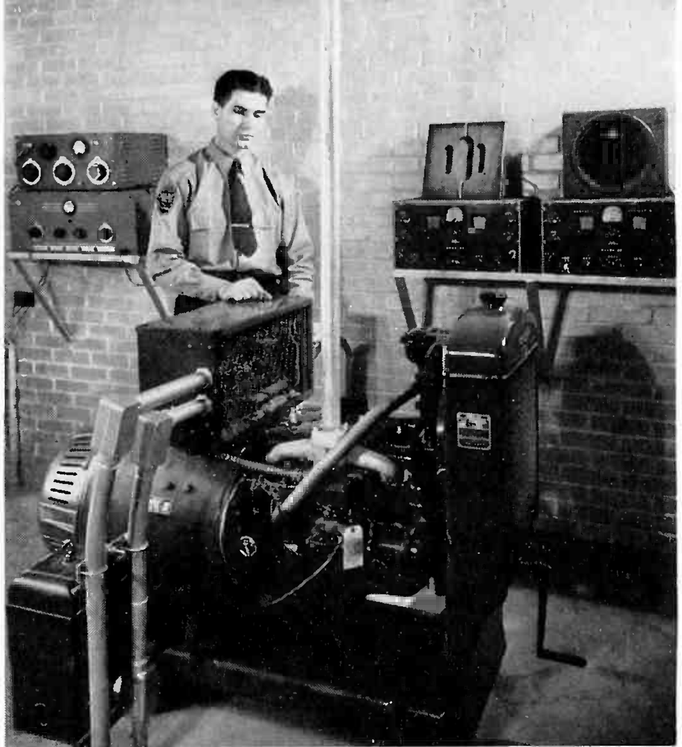
adopted covered seven 1,000 watt stations with equipment built to give unfailing service 24 hours a day, year in and year out.

Western Electric was awarded the contract for the broadcasting equipment. The network consists of seven stations which are located at Springfield, Chicago, Pontiac, Sterling, Macomb, Effingham and DuQuoin.

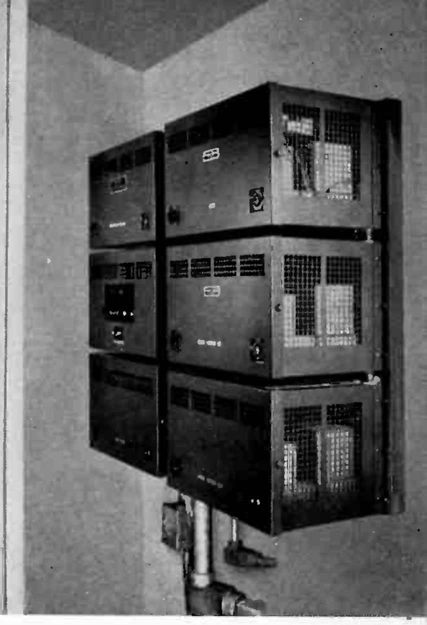
Among the many interesting features of the network are the control facilities provided in the office of Superintendent Walter Williams, chief officer of the state's police force. An eight-ball microphone at his elbow enables him to direct any one or all squads in the state from his own desk.

On one of the walls of his office hangs a huge map of the state, so wired that the chief may light

(*Continued on page 34*)



Emergency power and mobile equipment kept in readiness at all Illinois State radio stations, shown at top. Heart of the network is this operating room with Western Electric transmitter, zone telegraph desk, interzone telegraph and radio telephone control desks. Close-up of radio telephone control desk with Operator Henry Trapp broadcasting a message over the network. Supervisor Hopper at the 1000 watt transmitter.



The great length of the loading platform is evident in this photo taken during opening ceremonies. Center: An American Airlines ticket agent announces time of plane departure. Right: All amplifying equipment is mounted in a small closet.

LaGuardia Field Sound System Has 15 Microphones, 85 Speakers

Every one of the millions of people who have visited the New York Municipal Airport at LaGuardia Field is unconsciously a witness to the efficiency of the public address system in the Administration Building. No matter where passenger or visitor may wander about this huge bulding, ever and anon a quiet "attention please" intrudes upon thought or conversation with an announcement that "Mr. Jones is wanted at the American Airlines ticket office" or "the Skysleeper for Miami will leave from Gate 9 in five minutes."

Wherever the person for whom the message is intended may be, he will hear it. For in dining rooms or barber shop, in the main rotunda or at the loading platform, in every public room to which a waiting passenger may stray, there is a loudspeaker to seek him out.

Most of the visitors to the airport accept this phenomenon as just another convenience of modern life and, unless an announcement directly concerns them, pay no attention to it. If, however, one of these visitors should have an inquisitive nature or be endowed with an enlarged "bump of curiosity," an hour or two of diligent search will disclose to him all of the physical means which have made the announcements possible.

If such a curious visitor should make a complete tour of the building with eyes and ears alert, he will find in every room open to the public, one or more wall mounted loudspeakers hidden behind inconspicuous metal grillwork. There are 52 of these small units scattered throughout the Administration Building. In the vast rotunda, with its airlines ticket offices and circular information counter, the words which he hears so clearly and distinctly come from three small Western Electric "cobra" horns, fitted unobtrusively into the decorations of the huge circular dome.

To find the other loudspeakers the inquisitive visitor will have to go outside of the building to the loading platform, that long, semi-circular enclosure facing directly on the landing field, before which incoming and outgoing planes stop to pick up and unload both passengers and baggage. Here, protected from wind and rain by glass panelled walls, passengers walking to and from the planes hear the announcements from circular loudspeakers fastened to the I-beams of the ceiling. Thirty of these units, non-directional in sound distribution, are spaced 50 feet apart, so that the quiet words of the announcers form a veritable zone of sound, seeking out every nook and cranny of the long enclosure.

When he reaches the end of the loading platform, our visitor will have seen all of the loudspeakers, the immediate source of the announcements he hears, and he can then start his search for the initial source of those words — the microphones. There are 15 of these in all, simple, compact 632A units, which look like desk type telephones with small streamlined microphones.

Nine of these microphones are used at the loading platform. Our guest probably has already noticed that this platform is divided into fourteen sections or "gates." At each of these gates there is a small glassed-in enclosure or "office" from which the airlines' employees supervise the departure of planes and the loading, unloading and checking of passengers

Left: While dispatcher (seated) talks by radio to incoming plane, control operator announces its arrival time over the P. A. system. Center: Three "cobra" horns in the circular dome bring announcements to passengers in the great rotunda. Right: Fastened to ceiling at 50-foot intervals, thirty 360-degree loudspeakers completely cover the loading platform.

and baggage. By peeking through the glass panels of these offices, our seeker-after-knowledge will discover microphones in nine of them, standing on small counters amidst telephones, card files, pads and pencils. They are most often used, he will find, to call for taxis and porters, and to page missing passengers.

The next group of microphones is inside the building in the rotunda. Here five more can be seen, at the ticket counters of each of the four airlines —American, United, T.W.A., and Canadian Colonial —and at the information counter in the center of the room. If our visitor has any trouble finding these microphones, a little patience will help in his search. For here they are used to announce the impending departure of planes and to page passengers, and therefore are kept fairly busy. A quick glance around the room during each announcement will disclose one after another of the five units in the hands of trim-uniformed airline or airport employees.

So far our inquisitive visitor has found 14 of the 15 public address microphones. To see the last one in operation he will have to do more than just find out its location, for it is in one of those places ordinarily closed to visitors and he must secure a pass from the officials of the airport before he will be admitted. If he can secure that pass, and a guide to show him the way, he will be led through hallways and up stairs, up and up, until after going through a door marked "keep out," he will find himself in the topmost room of the building, a circular, glass-enclosed crow's nest — the control tower.

A bewildering array of radio and weather reporting equipment meets his eye as he steps into this room and his ears are struck by a curious mixture of sound as the voices of two, three or perhaps even four transport pilots, emerging simultaneously from a bank of loudspeakers, blend with the constant clicking of a teletype machine. There are only two occupants of this airport traffic tower. One is the dispatcher, who sits before the huge glass windows with a microphone in his hand, conversing by radio with the pilots of the great ships which are constantly landing and taking off from the smooth concrete runways. The other, the control operator, is seated at a desk in the middle of the room, entering on a large, many-columned sheet, data concerning the arrival and departure of these planes.

Our guest might be momentarily confused in his search for the fifteenth public address microphone, thinking it is the one which the dispatcher is using; but not for long. For suddenly the control operator lays down his pencil, picks up from his desk one of the now familiar 632A microphones and in a quiet voice says: "Attention, please. The Skyliner from Chicago will arrive at Gate 11 in three minutes."

This ends his microphone hunt, but our visitor will undoubtedly delay his exit as long as possible, following the glance of the dispatcher around the sky as tiny specks in the distance grow into silvery liners of the air, to circle slowly about and then glide to rest on the airport floor. He listens as the dispatcher converses with planes still out of sight in the distance, telling the pilots of wind direction and velocity, ordering one plane to come down and another to take off. But, finally it is time to leave, and our visitor and his guide pass back down the steps to mingle once more with the crowd in the great rotunda.

By now he must realize that there is something else to this announcing system, and he will probably ask his guide what it is that controls the quiet voices of the announcers at the microphones so that only one comes out at a time, amplifies and distributes them to the loudspeakers. In answer his guide will take him to a little closet in a corner behind one of the ticket counters.

In this small enclosure, cooled by a wall mounted ventilating fan, six gray, perforated metal cabinets are fastened to the wall. On one of these is a small metal plate, engraved with the words "Western Electric Sound System — Engineered and Installed by Langevin Company, Inc." Although our guest might not thoroughly understand him, the guide will explain that one of the cabinets contains two 116A pre-amplifiers and a 119A line amplifier which take the voice

(*Continued on page 27*)

First Western Electric Synchronized FM Transmitter Features Carrier Stability

Use of Single Unit Construction in New 1 KW Reduces Size and Increases Accessibility

Preliminary information has just been released on Western Eletric's first, standard frequency modulated broadcast transmitter. Known as the 503A-1, this 1 KW transmitter is contained within a single cabinet similar in appearance to Western Electric's latest amplitude modulated transmitter, the 1,000 watt 443A-1. All of the apparatus necessary to take a program signal and input primary power and to deliver a frequency modulated carrier wave to a transmission line is included in this one unit.

In this new transmitter a really dependable system of carrier wave frequency stabilization has been incorporated. This system, unique in the 503A-1, is known as synchronized frequency modulation and provides a carrier wave frequency stability equal to any well designed transmitter operating at the lower broadcast frequencies. The present requirement of the Federal Communications Commission for frequency stability is .01 per cent or an allowed variation of 4300 c.p.s. at a carrier assignment of 43 megacycles. The 503A-1 transmitter has a stability of better than .0025 per cent — at least four times better than that required.

This stability, maintained without the use of temperature control anywhere in the system, is independent of circuit variations. Moreover, since the frequency synchronizer is external to the transmission path, no interruption in operation can be caused by failure of a vacuum tube or any other component in the synchronizing circuit.

Frequency modulation is produced directly without the intervening step of first generating a predistorted phase of modulated wave. The circuit employs constant values of direct current voltages independent of the synchronizing action, giving the best conditions for modulation at any audio frequency within the range from 30 to 20,000 c.p.s.

The frequency response of the 503A-1 is flat within ± 1 db from 30 to 15,000 cycles per second. It employs a program level about zero vu for full modulation of ± 100,000 c.p.s. carrier excursion and a single frequency level of + 8 vu for the same excursion.

Typical measurements of r.m.s. audio frequency harmonic distortion with a distortionless FM audio monitor in the frequency range of 30 to 15,000 cycles per second show less than 2 per cent at a modulation corresponding to ± 100,000 c.p.s. excursion of the carrier. Distortion measurements include all audio frequency harmonics up to 30,000 c.p.s.

Typical measurements of modulation capability show that the transmitter modulates to a degree corresponding to more than ± 100 kc per second at any frequency within the range of 30 to 20,000 c.p.s. The modulation action of this transmitter is independent of any carrier frequency stabilizing action and is also unrestricted as to the degree of modulation possible at any frequency, including the extreme low end of the audio frequency range. The modulation capability of this transmitter, therefore, is unique among FM broadcasting equipments.

The circuit employed is not sensitive to noise producing action of any character, either of the amplitude or phase variation types. Typical measurements show that, without special precautions against mechanical vibrations or electrical balances, under conditions encountered in day-by-day commercial broadcasting, the phase noise carried by the transmitted wave is well below 70 db down unweighted from 100 per cent modulation.

The 503A-1 transmitter operates from a 230 volt, single phase, 60 cycle power source and requires an input of 4 kilowatts for full power output. The power factor is approximately 90 per cent. An installed voltage regulator can be adjusted to take any primary voltage over the range of 190 to 250 volts.

Any output power up to a maximum of 1.2 kilowatts can be delivered to the transmission line input terminals. The design is based on connection to a 65 ohm, 7/8 inch coaxial line, although arrangements can be made to connect to other types of lines if desired.

The mechanical arrangement of the new 503A-1 transmitter follows the modern design of the 443A-1 in that all electrical components are located on a central structure of vertically mounted steel plates. When all connections have been made an attractively finished cabinet is simply slipped over the apparatus and fastened in place.

Both interior arrangement and outer cabinet have been designed to provide a maximum of accessibility. All tuning and operating controls are reached through two small side doors. One full length door on the front, electrically interlocked, provides access to the apparatus on the front of the frame. Two large doors in the rear open for complete access to the apparatus located on the rear side of the frame and to the heavy power supply transformers and coils and blower mounted on the frame base.

CBS Outlet for the Nation's Capital

WJSV-50 KW

WJSV steps up to 50 KW

Joins Ranks of Nation's Finest Stations

October 20, 1932, the Columbia Broadcasting System purchased a local broadcasting station in Washington, D. C., known as WJSV. It had few listeners and was of little significance in the Washington radio picture.

March 7, 1940, WJSV added new power to signal and prestige by inaugurating its 50 KW Western Electric transmitter. Today, WJSV is one of the country's top stations. As Columbia's outlet for the Nation's capital, it originates approximately 1,000 network programs annually, and plays a tremendous part in the lives of a million people who live within the radius of its signal.

This tremendous growth in power and prestige of WJSV is tribute both to the American system of broadcasting and to the men who have been directly responsible for it. It requires brains and relentless energy to accomplish such a job.

The District of Columbia probably presents the toughest broadcasting problems of any similar population in the country. Many of its inhabitants are transients whose roots and interests go back to some other part of the nation. Providing programs which will score with such a heterogeneous population offers problems never dreamed of by managers in more static communities.

An even more ticklish problem confronts a broadcaster in the Nation's capital which is headquarters for countless organizations looking for free time on the air. How to refuse time, how to give time to events and causes that are deserving, how to maintain the good will of all and yet operate a station for the greatest benefit of the majority, calls for super qualities in any broadcaster. WJSV is fortunate in having men on its staff who know how to handle such problems admirably — such men as Harry C. Butcher, vice-president of CBS in charge of the Washington area, and A. D. Willard, Jr., general manager.

WJSV has an outstanding record as a public servant. At Christmas time each year, in cooperation with a local newspaper, it conducts a drive to provide shoes for needy children. Last year it raised $7,800 in this drive. When the Children's Hospital needed funds for modernization, the station raised more than $6,000. Such cases are mentioned simply because they are typical of the services rendered by the station.

The new transmitter plant of WJSV represents an investment of more than a quarter of a million dollars in equipment and building. Columbia has spared nothing in either talent or funds to make it the finest tool for the job of broadcasting known to the art. And as such it may be regarded as a contribution to the entire industry in promoting the interests of broadcasting.

Opening week, daily luncheons were held at the transmitter for representative and influential groups of business, civic and governmental leaders. And now the station stands open to the public day and night as a place to be seen as well as heard. In the months and years to come the public as well as broadcasters everywhere will visit the station and go away with a new respect for an industry which contributes so much to the better living and understanding of a nation and its people.

Here Are the Men Who Direct Activities at WJSV

Under their leadership WJSV has reached an outstanding position in American broadcasting. Left to right: Clyde M. Hunt, chief engineer; A. D. Willard, Jr., general manager; Harry C. Butcher, vice-president of CBS in charge of the Washington office; William D. Murdock, commercial manager and Lloyd W. Dennis, program director.

In the little town of Wheaton, Maryland, 11 miles from Washington, is the new transmitter plant of WJSV. Housing a 50 kilowatt Western Electric Doherty transmitter, the plant probably is the industry's finest expression of what a modern radio station should be.

Architect and engineer have conspired to achieve a perfect wedding of building and equipment. The result is a building beautiful in appearance and completely functional in operation. A credit to the entire industry, it is rapidly becoming a showplace for the public and the nation's broadcasters.

The exterior and interior design of the building is carried out in a modern functional expression. The lines of the exterior are severely plain, the architectural effect being obtained by careful use of proportion of masses and relation between plain wall areas and openings.

Principal feature of the exterior is the group of buttresses at the right end, which not only supports the coaxial lines but expresses architecturally the flow of energy from the transmitter to the three radiators.

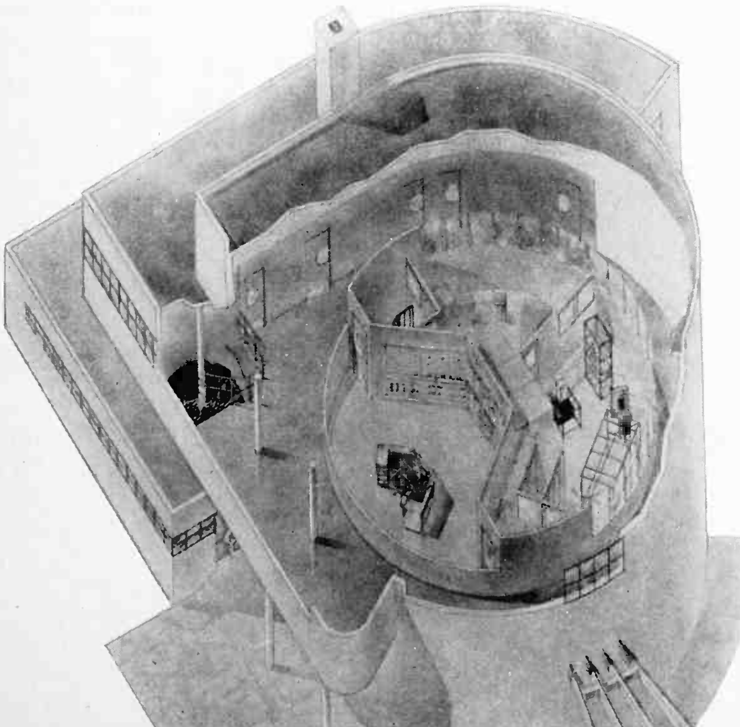
The main portion of the building is a circle, 50 feet in diameter, inside, housing the transmitter equipment. Entrance to the building is on the ground floor with a circular stairway ascending to the main floor. On this ground floor are the boiler room, a two-car garage and the heavy equipment.

By means of the circular stairway, visitors enter the main floor on the spectator's gallery which continues completely around the transmitter. This equipment, including the control desk, is depressed below the gallery level. The passageway around the equipment affords complete visibility of the entire equipment through a plate glass screen.

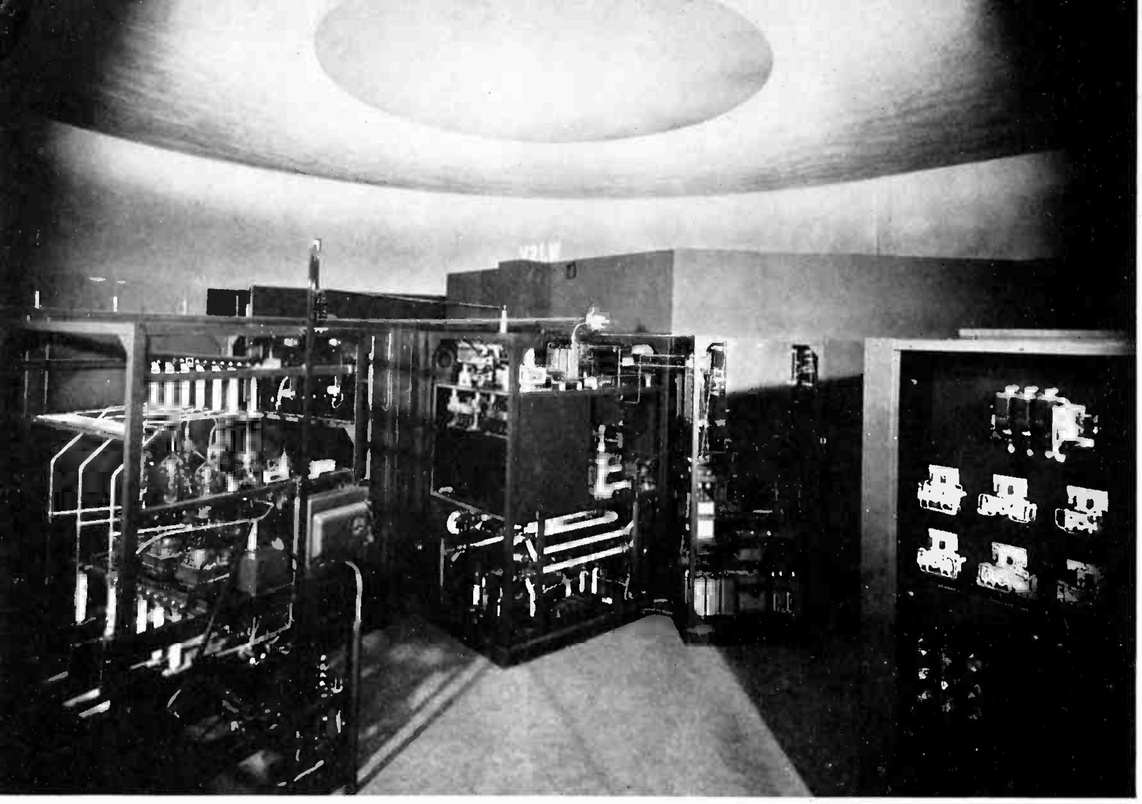
Grouped around the main circle on one side are the general offices, operator's apartment and rest rooms.

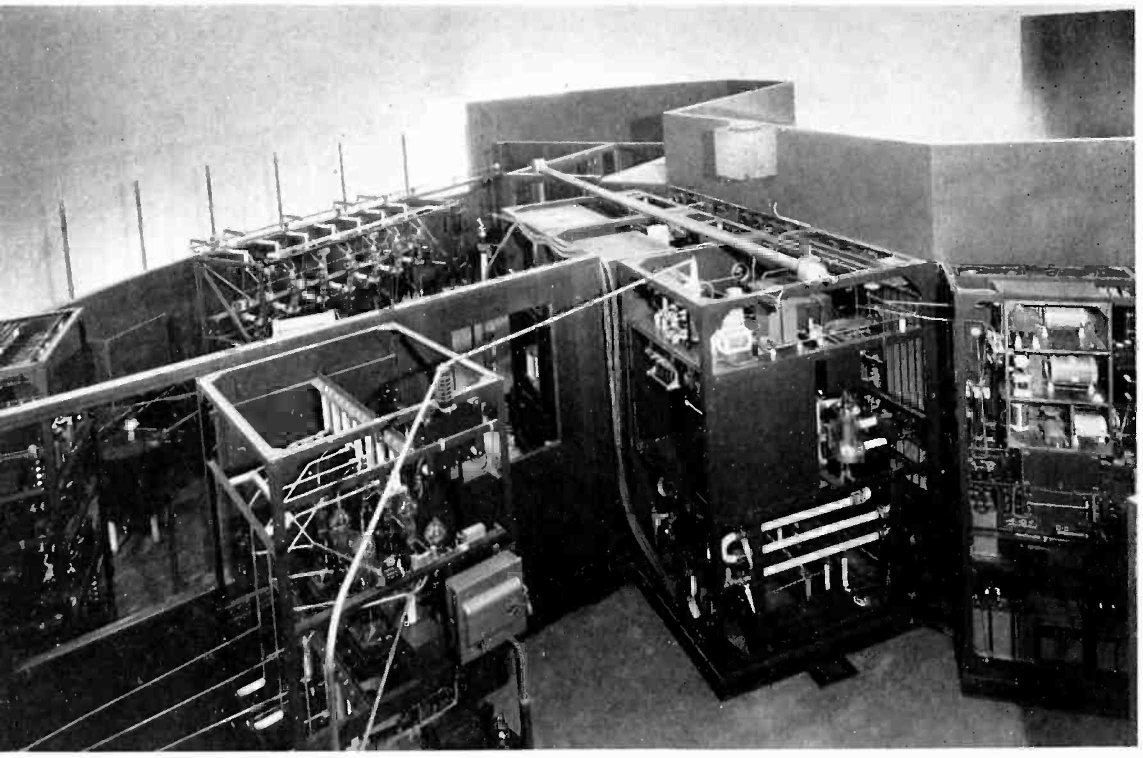
The floor of the entrance vestibule and the stairway are black terrazzo with stainless steel handrails. The walls here and extending up into the main story are covered with blue linoleum. The floor in the transmitter room is of gray marbleized linoleum. A portion of the walls in the transmitter room is covered with blue linoleum and the remainder is of an oyster-white acoustic plaster.

The building is constructed entirely of reinforced concrete. The exterior surfaces have a smooth finish obtained by the use of plywood forms. Exterior surfaces are finished with a cement paint in a Spanish white color. Window sashes, lettering, and other ornamental features are painted blue.

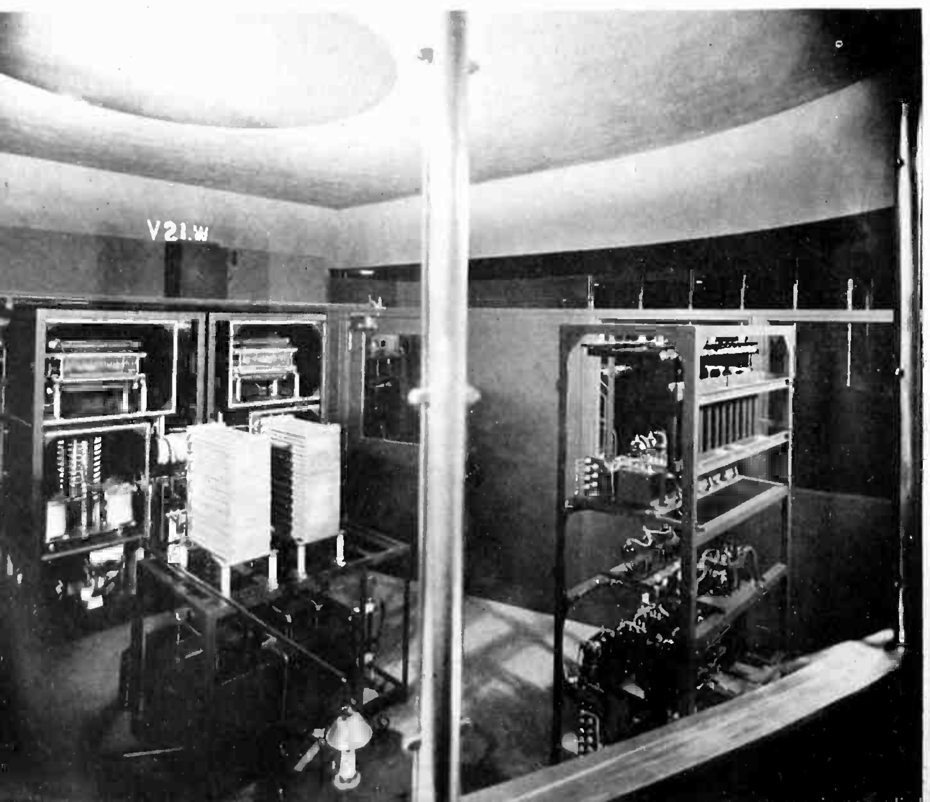


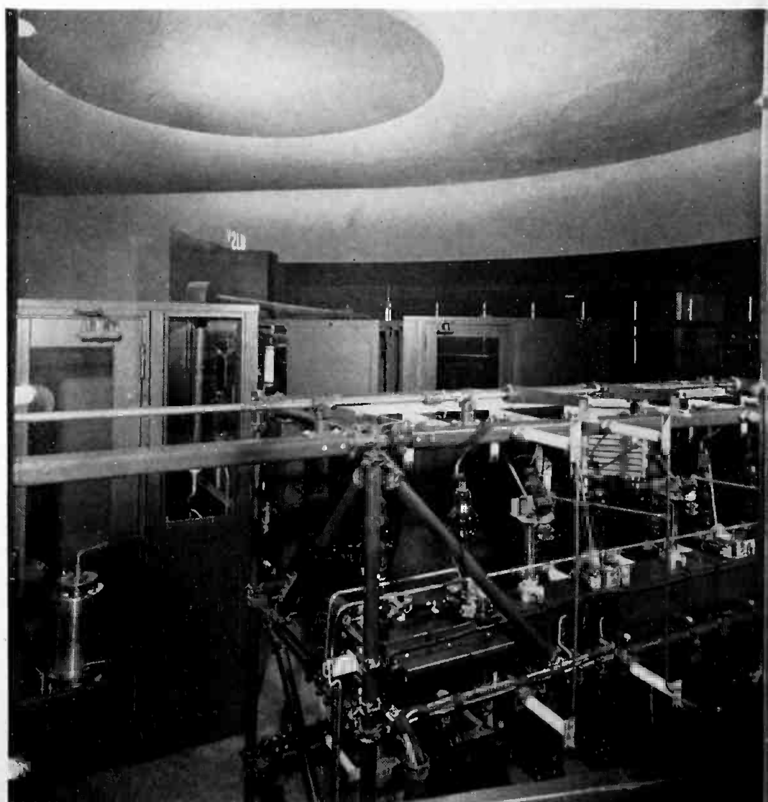
Artist's drawing, E. BURTON CORNING, Architect

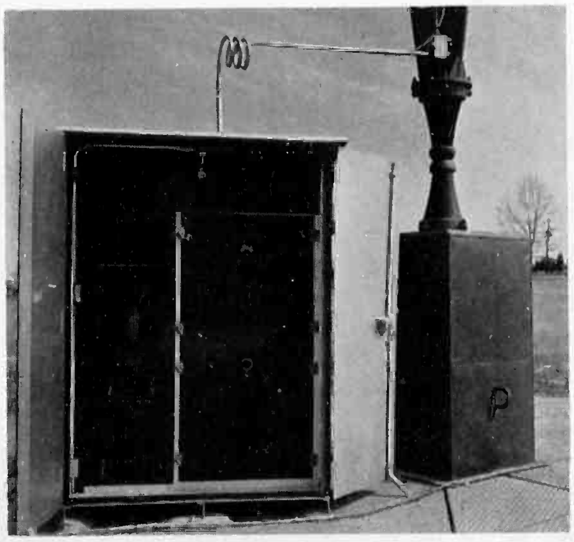




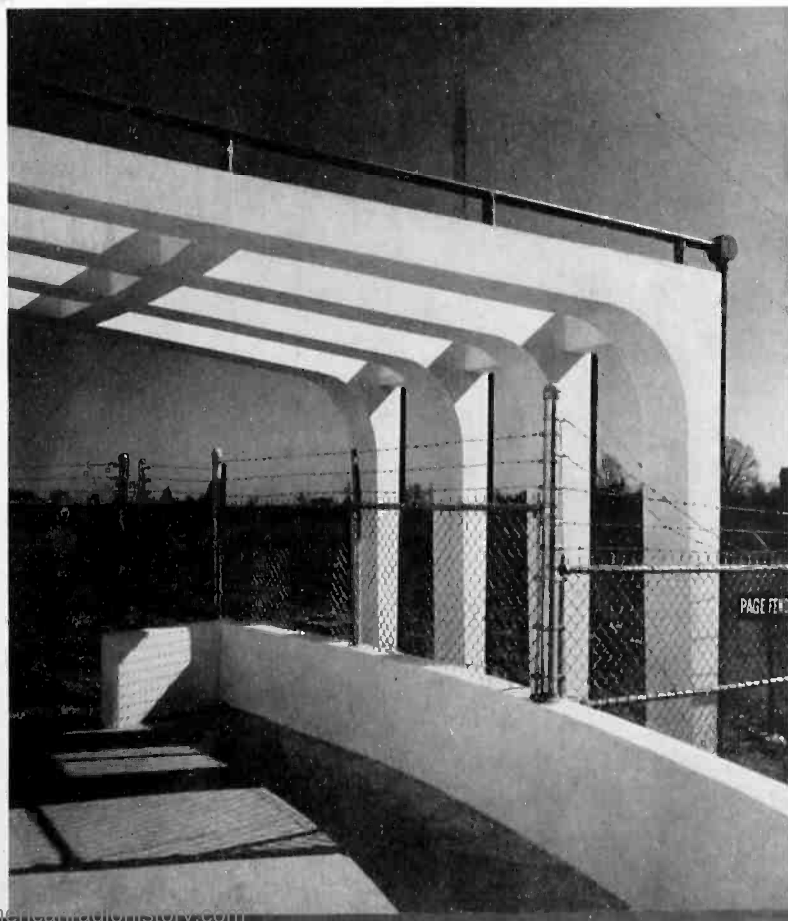
Interior views of WJSV's Western Electric 50 KW transmitter. Photograph at top shows the 5 kilowatt stage which can be operated independently of the 50 kilowatt amplifier. Left: Divided and interlocked section between the 5 and 50 kilowatt units. Lower left: A part of the 50 kilowatt section. Below: Line-up of mercury vapor rectifier tubes.

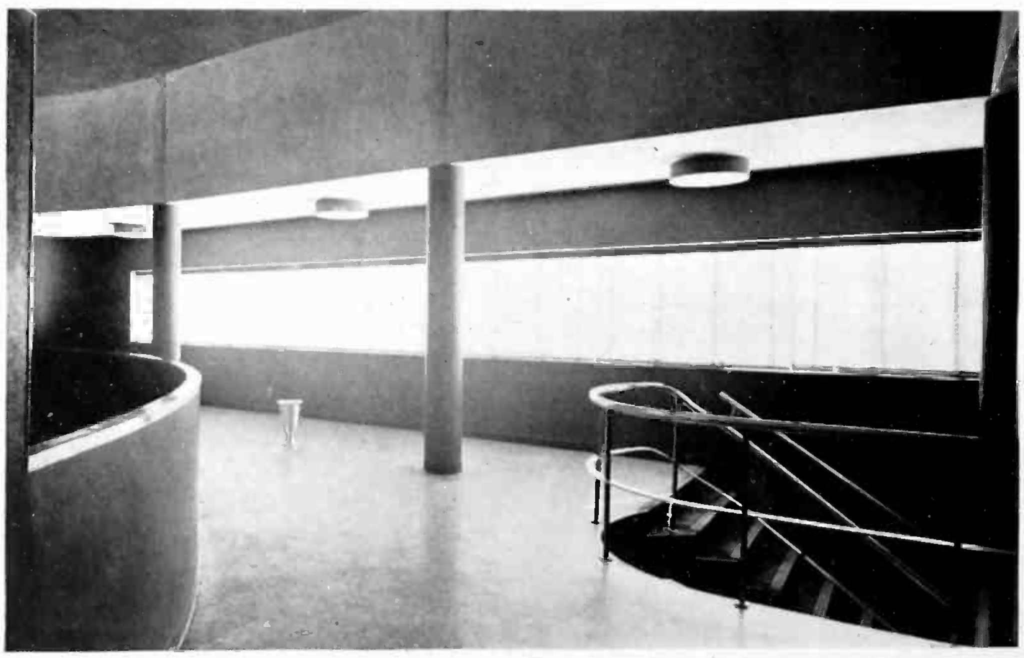






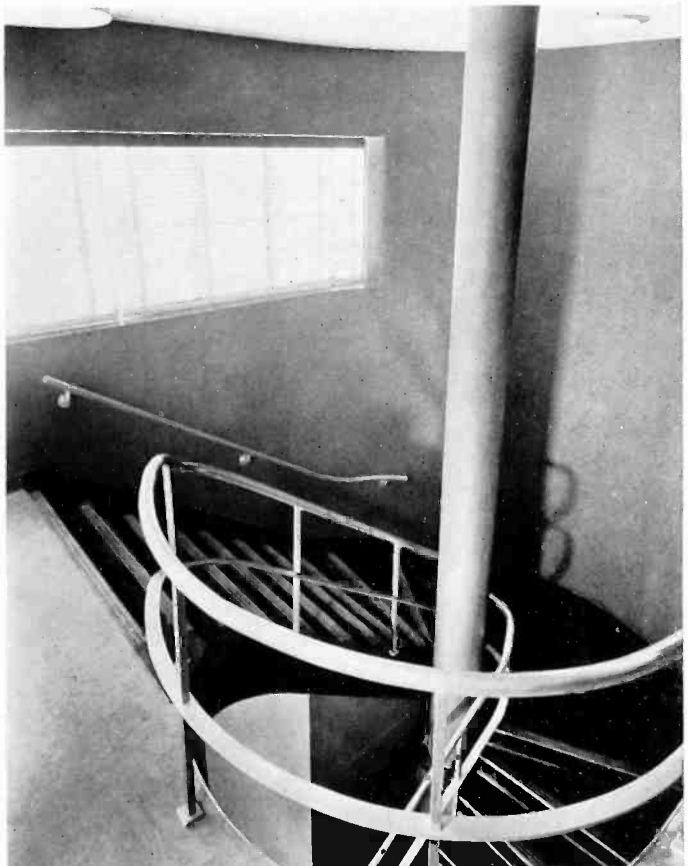
Home of the first 50,000 watt broadcasting station in the nation's capital situated at Wheaton, Maryland. Left: Coupling house at the base of one of the vertical antennas. Lower left: Even a shadow goes ultra-modern as it creeps over the entrance to the transmitter plant. Below: Coaxial cables leading to the three antennas are firmly supported and nicely camouflaged by these arched columns located at back of plant.

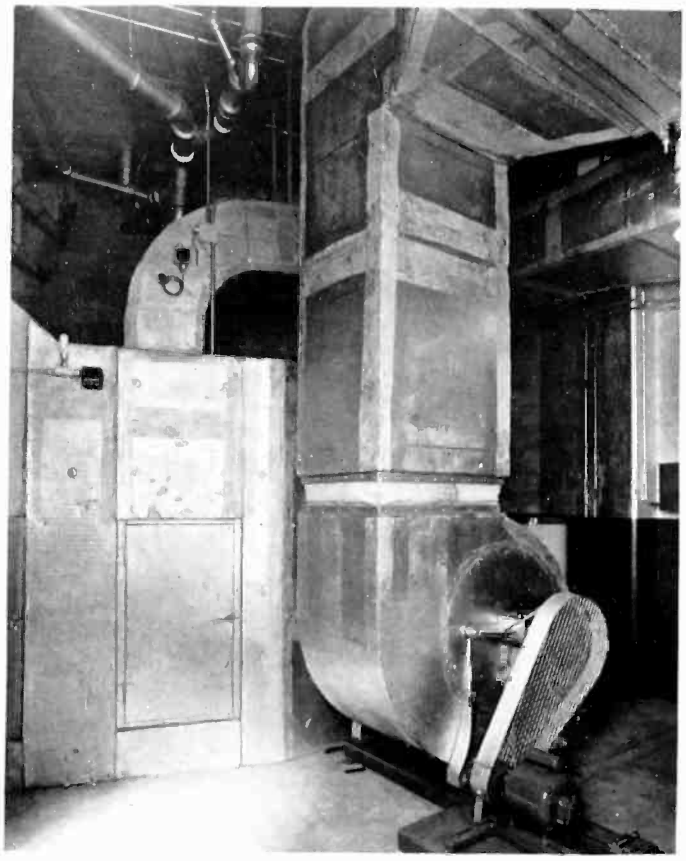




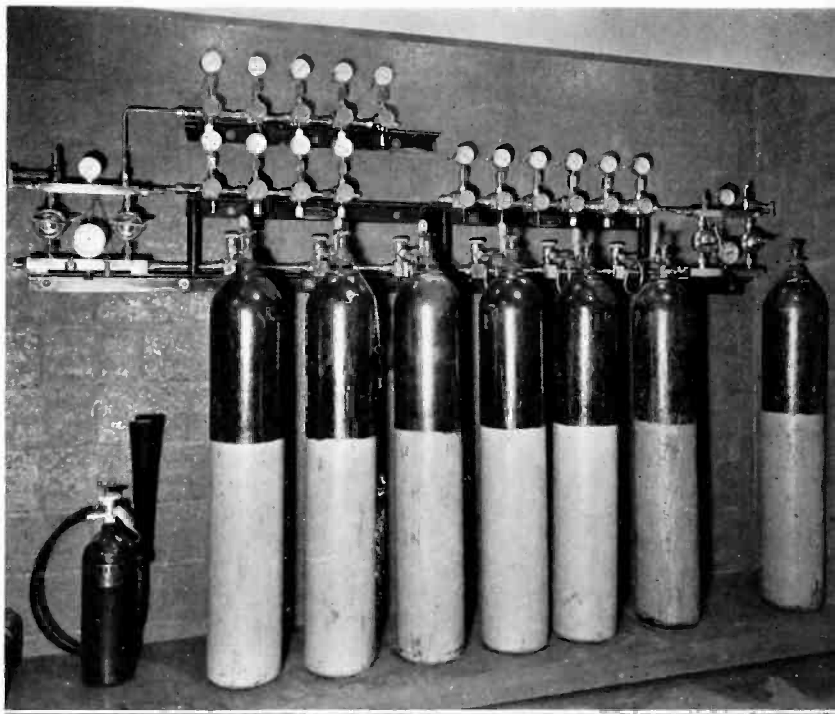
Modern interior settings form the luxurious frame for WJSV's powerful new voice. Top view shows the work shop with testing and measuring equipment. Center: Office, rest room and wash room corridor taken from head of stairway. Left: Section of the circular passage surrounding the 50,000 watt transmitter.

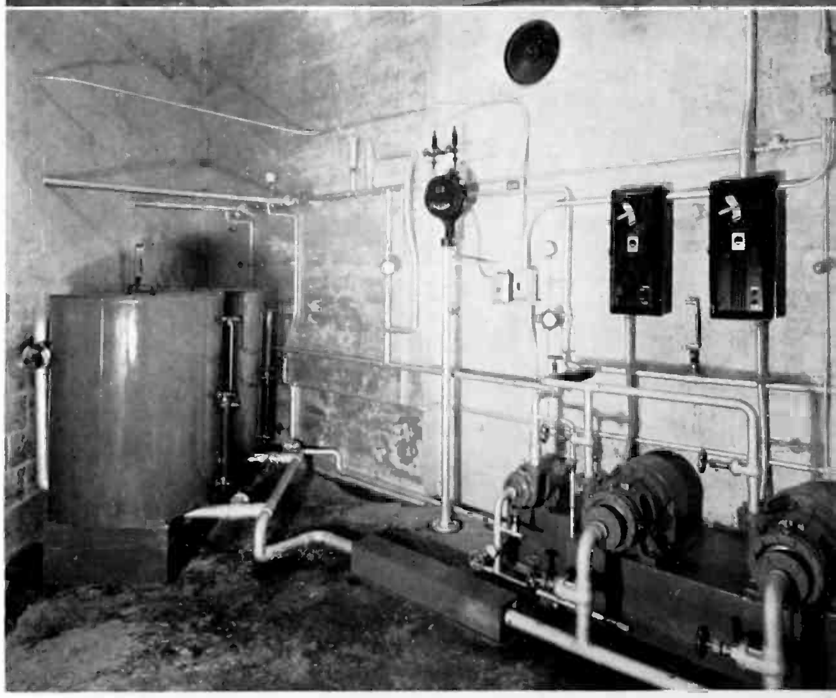
Left: Office of one of the station's most important members, the chief engineer. Two lower left pictures show views of the lounge—the center, revealing a most up-to-date kitchenette. Doors on either side conceal a bath and built-in bed. Below: Circular stairway leading from main floor to operating room and view of corridor at head of stairs on the operating floor.





The new WJSV is completely air-conditioned—picture at left shows part of the air conditioning plant. The main power switchboard and spiral staircase leading to the operating room is shown at lower left. Below: Gas equipment for keeping transmission lines under pressure. Lower photograph shows part of the water pump and storage tank assembly which is used to cool the high powered tubes of the new 50 KW transmitter.





How WOR Achieved Record

(*Continued from page 7*)

Suggestions for better operation have frequently resulted from these informal chats.

The engineer designated as transmitter engineer has immediate supervision of the 50 KW. Primarily his duties consist of taking half-hour readings for the FCC Log; seeing that proper levels are fed from the New York studios; noting quality of outgoing programs; checking the start and finish of each program as scheduled by the program sheet; making sure that the auxiliary transmitter crystal heating units function properly and taking readings and recording them on the M.O,L. every two hours.

As previously mentioned, there are 85 readings to be recorded on the M.O.L. These include every meter on the 50 KW and its associated equipment. Any deviations from regular readings are immediately noted and steps taken to prevent possible program or transmitter breaks. After taking over the watch the transmitter engineer makes an inspection of the transmitter. Then, leaving his colleague in the transmitter room he makes the second inspection tour of the basement. This duplicates the previous tour — but this time all readings are recorded in the M.O.L. instead of merely making mental note of them. The readings completed, he returns to resume his duties at the transmitter.

Meanwhile his colleague, designated as control engineer, lists maintenance items to be done this particular day. Let us suppose that the day is Friday and he finds Items 1 and 2 have been performed. During his watch and the following one, Friday Day Maintenance Items 3, 4, 5, 6, 7 and 8 must be completed. As taken from a page of Carteret's Day Maintenance Book, Item 3, for example, reads "All measuring equipment and test oscillator to be serviced," Item 4 "Test all short wave equipment," Item 5 "Check all loudspeakers internally." Each item is clearly specified and its performance unmistakably described in the book. This might well be termed WOR's bible, for the commandments therein must be obeyed to the letter. Men of longer service on the job come to know many of the routine procedures by heart while newer employees can easily follow instructions which are set down in the minutest detail. Some procedures are described in a few sentences — others fill two or three pages.

The routine for testing and repairing every piece of equipment at Carteret is indicated in the Day Book. Each piece, with no exception whatsoever, undergoes inspection during one of the seven days of the week. Thus, an endless chain of maintenance keeps all equipment in top condition. WOR contends that a transmitter is only as good as it is maintained — even with the advantage of operating Western Electric equipment. The station's motto reads: "If you notice something going out of order — do something about it — NOW."

A tribute to WOR's engineering staff for broadcasting 8221 hours without a program break due to a technical failure — Fred R. Lack, manager of Western's Specialty Products Division, presents the trophy to Chief Engineer Jack Poppele.

While the control engineer attends to these maintenance items the transmitter engineer keeps guard at the 50 KW and the voice of WOR flows smoothly on from one daytime program to another.

At 3.50 P.M. the four to midnight watch arrives. The same routine checking, prior to taking over the watch, is carried out.

As darkness approaches, the transmitter engineer keeps glancing at a sign over his desk reading, "Aviation Lights." Suddenly, a red light blinks on beneath the sign. And all is okay along WOR's skyline. For the crimson sentinel signals that the rotary beacon light on the roof and the tower lights have begun their long night vigil, safeguarding the air lanes around Carteret. Building flood lights are turned on manually but beacon and tower lights automatically appear when light in the North sky falls to 36 foot candles. In the morning they automatically go off when light reaches 70 foot candles. A photo-electric cell, installed on the roof, is the magic hand guiding this lighting system. Should a white light appear under the desk sign the engineer knows that the regular beacon light has burned out and that the rotary beacon is operating on an emergency light installed in the beacon.

The clock is the commanding officer at WOR. Practically from minute to minute its dictates must be obeyed. Now its hands point to 8.15 P.M. — time for testing the 5 KW auxiliary transmitter. The transmitter engineer proceeds to carry out the order by first checking the oscillator and low power stages. After shutting these down he checks the final power amplifier and H.V. rectifier tubes. This method of testing is

WOR NIGHT MAINTENANCE ITEMS

Sunday

1. Feel condensers in "H" — "I" and "J" units.
2. Read filament currents of all 232-B and 342-A Tubes.
3. Check filament voltage of second and third P.A.
4. Check bias voltage at tubes for 2nd and 3rd P.A.

4-A. Clean and grease dosserts of 232-B — 342-A and 266-B tubes.

5. Feel condensers in outside coupling houses and clean all end seals in outside coupling houses.
6. Check and tighten all connections in outside coupling houses and measure bleeder resistance in same.
7. After shut down inspect all parts, feel condensers and inspect all resistors, mainly R1G and R2G.
8. Clean underneath units "A" — "D" — "E" — "I" and "J".
   In "J" unit polish coil with Noxon and meters with Stafford's. Tighten all connections of every condenser.
9. Wipe off all tubes and glasses, check clamping rings, wipe off R.F. busses and check for corrosion of hose nipples.
10. Tighten filament transfer switches and filament connections.
11. Check 5 KW transmitter crystal heaters hourly.
12. Clean basement work bench.

Monday

1. Feel condensers in "H" — "I" and "J" units.
2. Feel all condensers and equipment in outside coupling houses.
3. Clean high voltage rectifier unit and busses.
4. Clean and polish second and third P.A. meters.
5. Clean all busses of 50 KW transmitter.
6. Check 5 KW transmitter crystal heaters hourly.
7. Wipe off tubes and glasses, check clamping rings. Wipe off R.F. busses and check for corrosion of hose nipples.
8. Clean basement work bench.

Tuesday

1. Feel all condensers in "H" — "I" and "J" units after shut down.
2. Inspect all parts, feel all condensers, inspect all resistors, mainly R1G and R2G, after shut down.
3. Clean transformer vault, polish all insulators etc.
4. Clean DIP switch.
5. Wipe off all tubes and glasses, check clamping rings, wipe off R.F. busses and check for corrosion of hose nipples.
6. Check 5 KW transmitter crystal heaters hourly.
7. Clean basement work bench.

Wednesday

1. Take 25.4 ampere readings inside and outside and at conclusion feel condensers in center coupling house.
2. Feel condensers in "H" — "I" and "J" units after shut down.
3. Inspect all resistors after shut down, mainly R1G and R2G. Tighten all screws and connections on same.
4. Take readings of east and west concentric line gas pressures.
5. Clean units "A" — "D" — "E" — "F" — "G" and "H" and polish busses in each of these units.
6. Wipe off all tubes and glasses, check clamping rings, wipe off R.F. busses and check for corrosion of hose nipples.
7. Check 5 KW transmitter crystal heaters hourly.
8. Clean basement work bench.
9. Clean faders in control room with Carbon-Tet (1st Wednesday each month).
10. Clean contacts of all rheostats in both transmitters. (1st Wednesday each month.)
11. Check hose nipples for electrolytic disintegration. (2nd Wednesday each month.)
12. Tighten covers on transformers in high voltage transformer vault. (3rd Wednesday each month.)
13. Inspect high voltage transformers for oil level (3rd Wednesday each month.)
14. Clean blades of bias generator selector switch. (4th Wednesday each month.)
15. Check connections in 50 KW and 5 KW transmitters. (4th Wednesday each month.)
16. Clean inside of "D" — "E" — "F" — "G" and "H" units with vacuum cleaner. Include top of racks and walls above transmitter. (5th Wednesday each month.)

Thursday

1-A. Feel all condensers and equipment in outside coupling houses immediately after sign-off.

1-B. Clean end seals in all coupling houses with Carbon-Tet.

1-C. Tighten all connections, polish coil in all coupling houses.

2. Clean contacts of antenna relays at coupling houses.
3. Immediately after shut down feel condensers in "H" — "I" and "J" units.
4. Outside antenna lead-in bowls to be inspected and cleaned.
5. Inspect all parts, feel all condensers after shut down and inspect all resistors, mainly R1G and R2G.
6. Wipe off distilled water hose troughs, hoses and insulators.
7. Wipe off all tubes and glasses, check clamping rings, wipe off R.F. busses and check for corrosion of hose nipples.
8. Check 5 KW transmitter crystal heaters hourly.
9. Clean basement work bench.
10. Check plate currents of 1640 volt rectifier tubes. (1st Thursday each month.)
11. Measure 50 KW crystal heater tube plate currents. (1st Thursday each month.)
12. Measure resistance of R1G and R2G ohmspuns. (1st Thursday each month.)
13. Measure resistance of thyrites in 50 KW transmitter and one in transformer vault. (1st Thursday each month.)
14. Check time delay adjustment of S6A, S5A, S4B and S5B. (2nd Thursday each month.)
15. Clean contacts of S4B and S5B. (2nd Thursday each month.)
16. Clean all plug connectors from plates of 266-B rectifier tubes. (4th Thursday each month.)
17. Feel all condensers in outside coupling houses, also equipment immediately after sign-off. Inspect all equipment and clean all parts. Tighten connections, all very thoroughly. (5th Thursday each month.)

Friday

1. Polish turrets in control room.
2. Feed 400 cycle tone into 50 KW transmitter at 25.4 amperes single concentric transmission line input.
3. Immediately after shut down feel all condensers in "H" — "I" and "J" units.
4. Feel all condensers and equipment in outside coupling houses right after sign-off.
5. Feel all relay field coils, particularly S4B, S5B and S1L.
6. Wipe off all tubes and glasses, check clamping rings, inspect hose nipples for corrosion.
7. Clean all high voltage capacitors in 50 KW transmitter.
8. Check 5 KW crystal heaters hourly.
9. Clean all end seals within building.

Saturday

1. Immediately after shut down feel all condensers in "H" — "I" and "J" units.
2. Wheel 50 KW fuse and test wagon into tube room.
3. Clean in "I" unit, coil, condensers, and insulators.
4. Clean all isolantite slabs, condensers and insulators. Clean porcelain tubes in 50 KW distilled water system.
5. Check every insulator in and out of plant, report condition.
6. Check 5 KW crystal heaters hourly.

used only while the 50 KW remains on the air. If further testing becomes necessary while the 50 is operating the auxiliary can be tested on a phantom antenna made available by simply throwing the transmitter output switch from the antenna side to the phantom antenna side.

Meanwhile the control engineer continues the maintenance work of the day. If the transmitter engineer needs relief he summons his colleague from the basement by means of the Morse sounder or private phone line which connects all parts of the Plant as well as every other department at WOR.

Another phase of the transmitter engineer's work involves making comments on the more important shows and special broadcasts. He switches from engineer to dramatic critic, frankly expressing his opinion of the broadcast as to entertainment value, direction, technical setup and handling. He also is requested to report on any show which does not conform to standards.

Now the hands of the clock point to midnight and the 12 to 8.00 A.M. watch takes its place on the Carteret stage. This watch is the backbone of plant maintenance work. The responsibility of keeping the powerful transmitter in the pink of condition day after day falls upon the shoulders of these men. Since the advent of Facsimile, there remains but two hours each morning, with the exception of Sunday and Monday mornings, for carrying on important maintenance jobs.

Let us skip ahead to Sunday night when three men are assigned to duty — the remainder of the week two keep watch. This maintenance watch is headed by George D. Robinson, assistant supervisor, the only man always assigned to night duty. As the men switch from day to night Robinson acquaints them with any new procedures.

At 2.05 A.M. WOR signs off the air. Robinson, standing by the input control, slowly increases the input until a current proper for 50 KW registers on the concentric transmission line input ammeter. The engineer stationed at the ammeter checks readings through a co-ordinated signal. The third engineer now takes a complete set of readings on the M.O.L. while the input to the concentric line is kept rigidly at 50 KW carrier output.

After the readings two engineers go out to the towers — one takes his stand at the East tower, the other at the West tower. The third remains at the transmitter. He checks the input of the concentric line and when the meter indicates 50 KW power he phones the tower men in turn to read and report the antenna currents at their respective positions. These readings he records in the M.O.L. One of the tower men returns to the Plant — the other makes the rounds of the three coupling houses, reads the antenna currents and phones them back to the transmitter room. He stands by at the center coupling house until he is advised that the 50 KW is completely shut down. Now he moves quickly—feeling all condensers for warm or hot spots. From the center coupling house he hurries over to the two other towers to test for hot spots in the equipment in these units.

Meanwhile the engineers in the building test all condensers for excessive heat and place the auxiliary transmitter on pre-heat. Their next job is to measure filament currents, filament voltages and bias voltage as per the Sunday night maintenance list, while the tower man returns to take charge of the auxiliary transmitter. After putting it on the air and adjusting it for proper power he notifies New York that he is ready for a program test. New York makes the proper announcement and feeds 15 minutes of electrical transcriptions. As this is coming through, the auxiliary transmitter engineer takes a complete set of readings of various meters as well as readings required for the FCC Log. At the conclusion of the test he shuts off the transmitter, goes inside the enclosure and makes a general inspection.

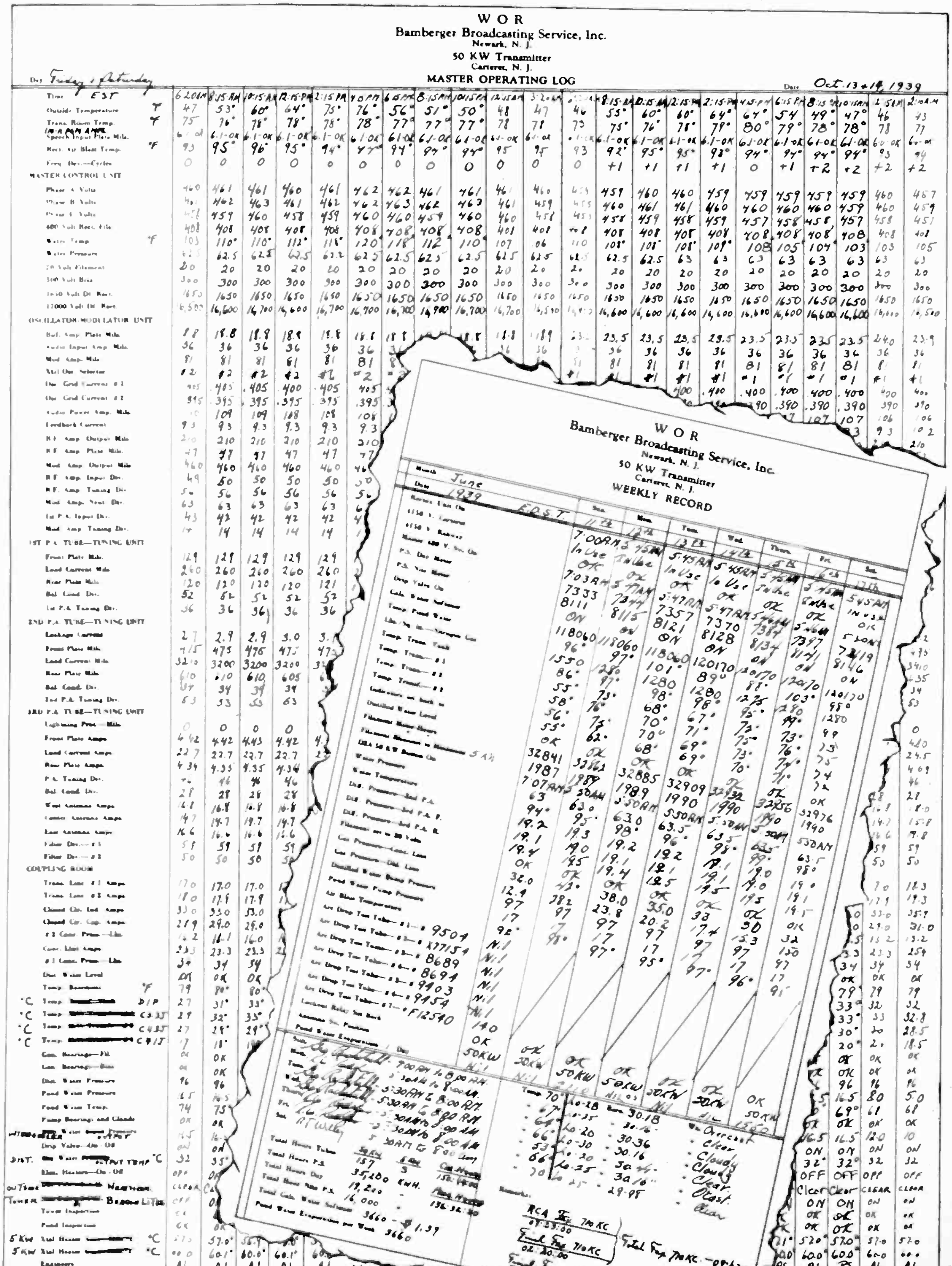
His colleagues have been taking measurements of the filament currents of each of the water cooled tubes used in the 50 KW transmitter. A permanent record is kept of each tube's current reading so that comparisons can be made from week to week. From past records the approximate end of the tube's useful life can be predicted. Thus, instead of risking tube failures on the air, the tube is removed from service before complete failure can occur. X-rays taken of tubes help the operators to understand more clearly just what happens when a tube fails. The average tube life at WOR is 10,485 hours with a maximum tube life of 33,485 hours.

When tube readings are completed the transmitter is shut down and the remainder of the Sunday night maintenance items performed.

At 5.30 A.M. the ritual of placing the big 50,000 watter on the air begins. The transmitter engineer refers to his Starting Log in which are listed the 44 steps of operation which launch WOR's powerful voice each morning. As he performs each step he checks it on the log. While the filaments of tubes are pre-heating, he steps inside the transmitter enclosure to make a general check. A second engineer makes a similar check. Now all three engineers stand together at the transmitter to avoid any mishaps.

Making sure that the antenna is switched to the 50 KW by checking the antenna transfer switch indicator light on the control turret, the transmitter engineer puts the transmitter on the air for two minutes on low power. During these two minutes he takes FCC Log readings and checks crystal deviation. When the two minutes have elapsed the 50 KW is shut down. Two engineers go inside the enclosure to quickly check the unit there while the third man throws the H.V. switch from 10 K.V. to the 17 K.V. side. Both men leave the enclosure and shut the door.

Next 17,000 volts are applied to the



These pages taken from WOR's Master Operating Log and Weekly Record give some idea of the detailed maintenance practices carried on at Carteret. The original size of the MOL page is 15¼ by 21½ inches—the Weekly Record 8½ by 14.

water-cooled P.A. plates without any drive, for a degassing test. This lasts five minutes. Any flash-arc or arc-backs during the test are logged on the back of the FCC Log. If none occurs, this too is recorded.

While the transmitter engineer goes through the degassing tests, his colleagues make a line and volume indicator test with master control, the latter feeding tone signals at a steady level. Results are recorded on the M.O.L. Any deficiency in either of the two channels or in any of the amplifiers at either end will be revealed by this test and a possible program failure prevented.

Now the transmitter engineer puts the 50 KW carrier on the air, regulating the input at the first P.A. so that a proper current for 50 KW will be read at the concentric line input ammeter. During the process one engineer stands by the concentric line input ammeter. When it reads correctly he signals, whereupon the transmitter engineer takes a reading of all three extension antenna ammeters and records this on the back of the FCC Log. He also takes a complete set of readings on the M.O.L. with no modulation on carrier.

A double check is made of the input, output, monitor and vu keys on the control room turret. Since an engineer's mind does not function at its highest efficiency after a long night watch, WOR insists on this double check procedure. By this means the possibility of an error is greatly lessened.

At 6:14:30 A.M. the first chimes come over the loudspeaker. The engineer at Carteret flashes an "OK" signal on the Morse sounder to master control, signifying that all is ready. And WOR is on the air.

P. A. at LaGuardia Field

(*Continued from page 13*)

currents from the microphones and increase them greatly in strength. These amplified voice currents then go through four of the other cabinets which contain 118A power amplifiers — one for the three cobra horns in the rotunda, one for the 52 administration building loudspeakers, and the other two for the speakers at the loading platform.

In the last cabinet there is an intricate system of relays and switches, forming an automatic interlocking switching system. This so controls the equipment that when any announcer places his thumb on the "press-to-talk" switch of his microphone, the words he utters come out of all of the loudspeakers at once. As long as he holds this switch closed he cannot be interrupted by any other announcer using a microphone. When he releases the switch the system returns to normal, and is ready for the next announcement.

The use of high quality equipment and the wide distribution of loudspeakers permit clear, lifelike reproduction of the human voice at a moderate volume level, which never becomes objectionable to either visitors or employees.

22D Speech Input Equipment Has Important New Features

Controlling a remote broadcast with new portable equipment.

Retaining all of the features which have made previous 22 type units so popular with broadcast engineers, the new 22D portable speech input equipment recently announced by the Western Electric Company has a number of important and valuable improvements. Like the former models, the 22D provides complete pick-up facilities for remote broadcast programs and serves exceptionally well as a permanent console in smaller broadcast stations.

The most noticeable of the improvements to the 22D is the new volume indicator, calibrated in vu, which has been adopted as standard by the Bell System and the major networks. This volume indicator is available with either the "A" scale, marked for —20 to +3 vu above the arc of the meter pointer, with an arbitrary voltage scale 0 to 100 in small letters below the arc, or the "B" scale, in which the 0 to 100 markings are in large letters above the line of the meter arc with a corresponding —20 to +3 vu indication below the line.

Another important change is the provision of two output lines instead of one, with keys for connecting either the amplifier or the order wire telephone set to either line. This arrangement permits instantaneous interchange of program and order wire lines in emergencies. These output lines are equipped with contacts to short-circuit outgoing lines and enable the station operator to test the loops from master control and make certain that the lines are in order.

The equipment as a whole consists of a combination amplifier-control unit and a power unit, together with the necessary interconnecting and power cords. The two carrying cases in which these units are contained are approximately 14 inches high, 17 inches long and 8 inches deep. Each case, when fully equipped, weighs about 30 pounds — light enough to be carried with ease and convenience.

New Cardioid Microphone

(*Continued from page 5*)

This is the equation of a family of polar curves depending on the values which are assigned to a and b. For our purposes the most useful curves are obtained when a is equal to or less than b, that is, when the pressure element output is less than that of the pressure gradient element. In the case where $a = b$ the two elements are equal and out-of-phase for sound incident at 180° so that cancellation occurs at this angle. As the value of a is reduced the two outputs are equal and out-of-phase at two angles symmetrically disposed around 180° so that cancellation results at these two angles. The exact manner in which the directional patterns of the two elements combine to yield new patterns which have two dead zones symmetrically disposed about the 180° axis is shown in Fig. 2. It is apparent that by merely adjusting the output of the pressure element with respect to the pressure gradient element the zones of minimum sensitivity may be shifted to any point between 90° and 180°, and this feature may be very useful in eliminating particular "slap-back" reflections and feedback paths.

Up to this point the directional patterns have for the sake of simplicity been discussed on the basis of some plane selected at random through the axis of the combined microphone. However, the directional characteristics should actually be represented in three dimensional space, in which case they take the form of surfaces of revolution generated when their respective plane representations are revolved about their axes of symmetry. One of these three dimensional surfaces is shown in Fig. 3 for a representative pattern, and from this it is seen that the pattern holds for vertical and horizontal planes as well as intermediate ones.

To evaluate these patterns, let us consider the directivity indices I and J, which have been plotted in Fig. 4 against percentage combinations of the ribbon and dynamic elements. This throws light on the crux of the matter. Although I is ⅓ for 100% bidirectional ribbon and also for the cardioid combination of 50% each, yet at a point in between for 25% dynamic the index I is ¼, indicating that this condition will handle random reverberation effects best of all. Similarly J has a minimum for 40% dynamic indicating that this condition may be most effective for separating sounds from either side of a dividing line such as the footlights of a stage. Evidently, this reveals possibilities which are worth employing in a practical microphone.

In incorporating these advantages into the 639B microphone, choice had to be made as to the number of patterns to provide. Means for continuously varying the percentage of combination would introduce serious contact and noise problems in the low level microphone circuit, whereas by proper design fixed switch positions will provide reliable operation and sufficient choice of pattern for all practical purposes. The main structural details of the 639B microphone are identical with those of the 639A. In this microphone, as described in earlier articles,[4,5] it was possible by carefully designing the elements and by the application of a phase equalizing circuit to obtain a cardioid directional characteristic which agreed very closely with the theoretical cardioid over the entire frequency range from 40 to 10,000 cycles.

In the 639B provision has been made for reducing the output of the pressure element so that all of the directional patterns shown in the full page illustration opposite page 5 may be obtained. This is accomplished by connecting different values of shunt resistance across the dynamic pressure element. This is done without ever breaking the main microphone cir-

4. Pick-Ups, December 1938.
5. Bell Laboratories Record, July, 1939.

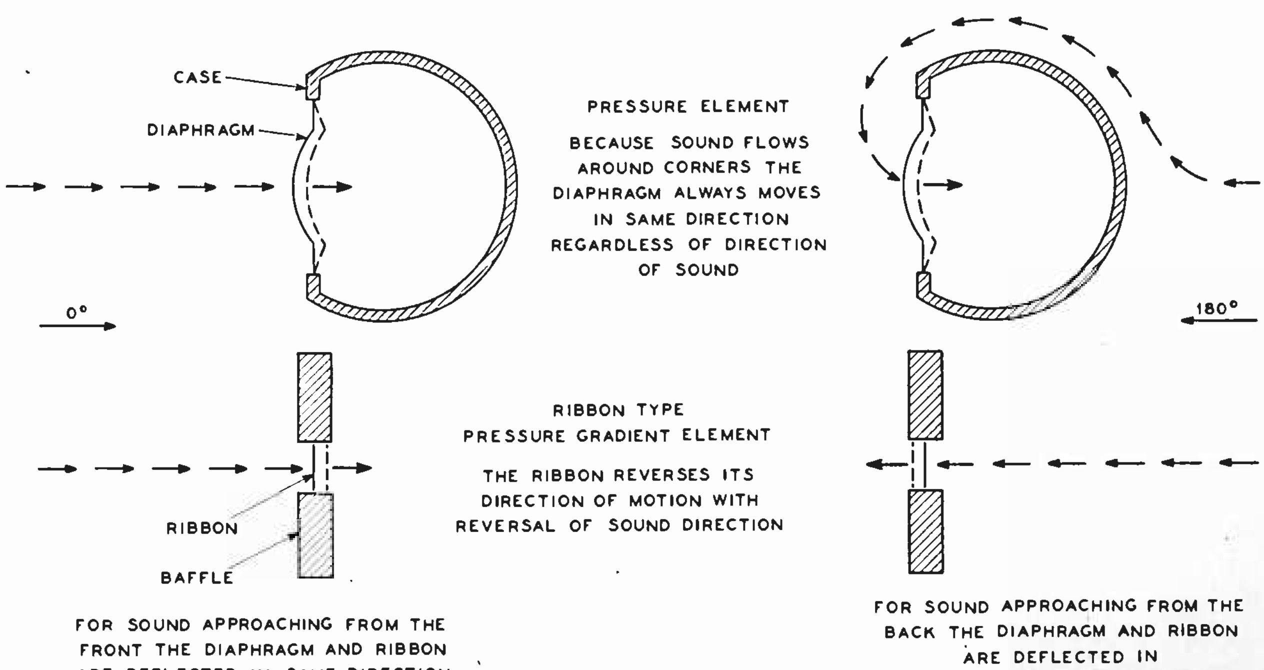
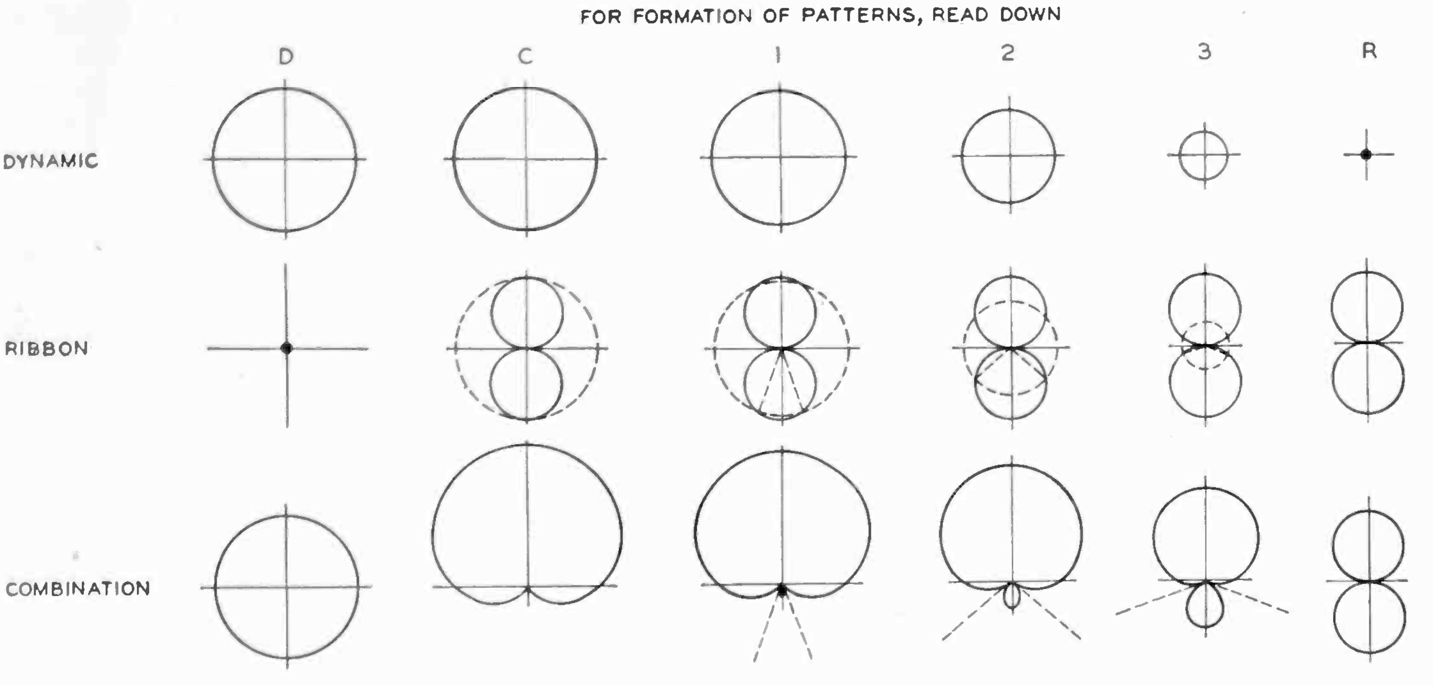


Fig. 1—Schematic illustration of the principle of operation of the 639 cardioid directional microphone.



	D	C	1	2	3	R
DYNAMIC (D) IN %	100	50	46	39	25	0
RIBBON (R) IN %	0	50	54	61	75	100
INDEX I	1	1/3	1/3.2	1/3.6	1/4	1/3
INDEX J	1	1/7	1/9	1/13.7	1/7	1

Fig. 2—Formation of directivity patterns by combinations of ribbon and dynamic microphone elements.

cuit so that the possibility of noisy operation of the switching circuit is reduced to a minimum.

The 639A cardioid microphone was provided with a three-position switch to permit the selection of either the dynamic or the ribbon elements in addition to the cardioid combination. The addition of three more positions to this switch in the 639B provides for the selection of the three new directional patterns. This shunting of the dynamic element does, of course, change the impedance of this portion of the microphone, but the impedance of the ribbon element is unchanged, and the alteration of the impedance of the combination is not sufficient to alter appreciably the response when the microphone is operating with conventional speech input equipment.

While shunting the output of the pressure element to reduce its output is all that would be necessary to obtain the new directional patterns in an ideal theoretical microphone, the problem is somewhat complicated in the practical case. It has been mentioned that phase equalization in the 639A was largely responsible for the resulting excellent agreement of the directional characteristic with the theoretical cardioid over a wide range of frequencies. While

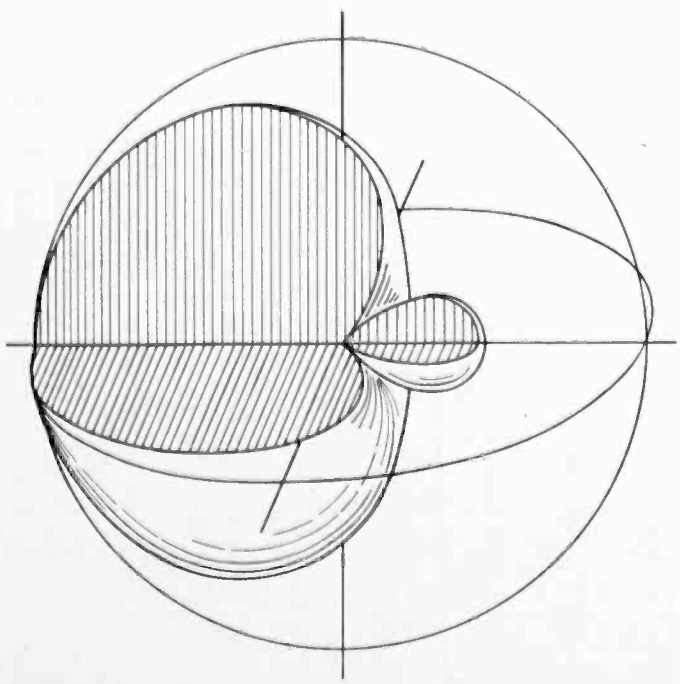


Fig. 3—Three-dimensional plot of No. 2 directivity pattern. A quarter section has been removed to show more clearly the form of the surface obtained. At any angle, the sensitivity is proportional to the length of the radius drawn to the surface of the solid.

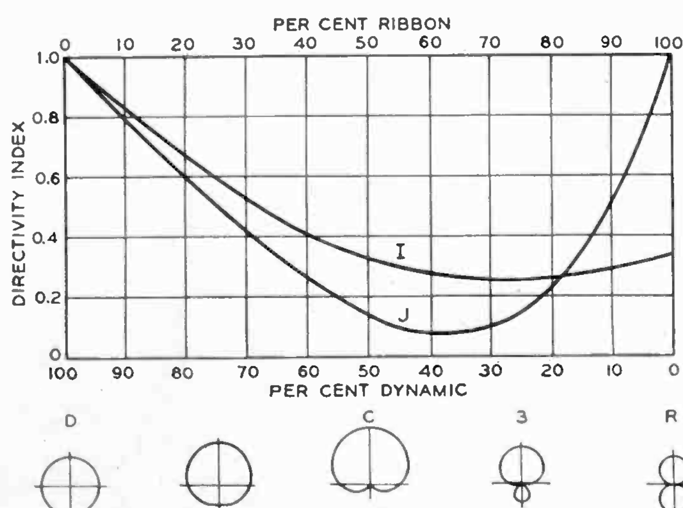


Fig. 4—Variation of directivity indices with the relative proportions of the output voltage supplied by the ribbon and dynamic elements.

this equalization was used partly to compensate for phase differences arising within the elements themselves, a part of the correction applied was to compensate for the phase difference caused by the different path length which sound had to travel in reaching the two elements. With the selection of new angles of minimum sensitivity the amount of this correction required is changed.

Accordingly, provision has been made so that as the output of the dynamic element in the 639B is reduced the constants of the phase corrective network are changed by an amount necessary to supply the proper correction for the new directional pattern. The result is shown by Fig. 5 where the response with respect to frequency for several angles of each directional pattern is given. It is apparent from these curves that except where the sensitivity is so low as to pick up little if any sound, the curves are nearly parallel. How nearly these curves follow the ideal patterns may be judged by comparing the theoretical reduction of efficiency shown on page 4 with the measured reduction for the several angles which are plotted in Fig. 5.

A 639B microphone was used in connection with the public address installation for the occasion of the appearance of Anthony Eden, former British Foreign Secretary, at the annual dinner of the National Association of Manufacturers at the Waldorf-Astoria, New York, December 9, 1938. In this situation, it was found that pattern 2 on page 4 permitted a 2 db increase in the sound output of the system over that obtainable with the 639A cardioid before singing occurred. Although the 639A gave quite satisfactory service in this location the additional improvement obtained in this trial encouraged extensive probing into the action of these pick-up patterns in other field conditions. The general results have been so unusual, that several prominent situations will be described and analyzed in the light of our previous discussion.

A sound reinforcement system for the U. S. Congress went into the House of Representatives in January, 1939. Because of the highly reflecting marble walls and shape of the auditorium, feedback

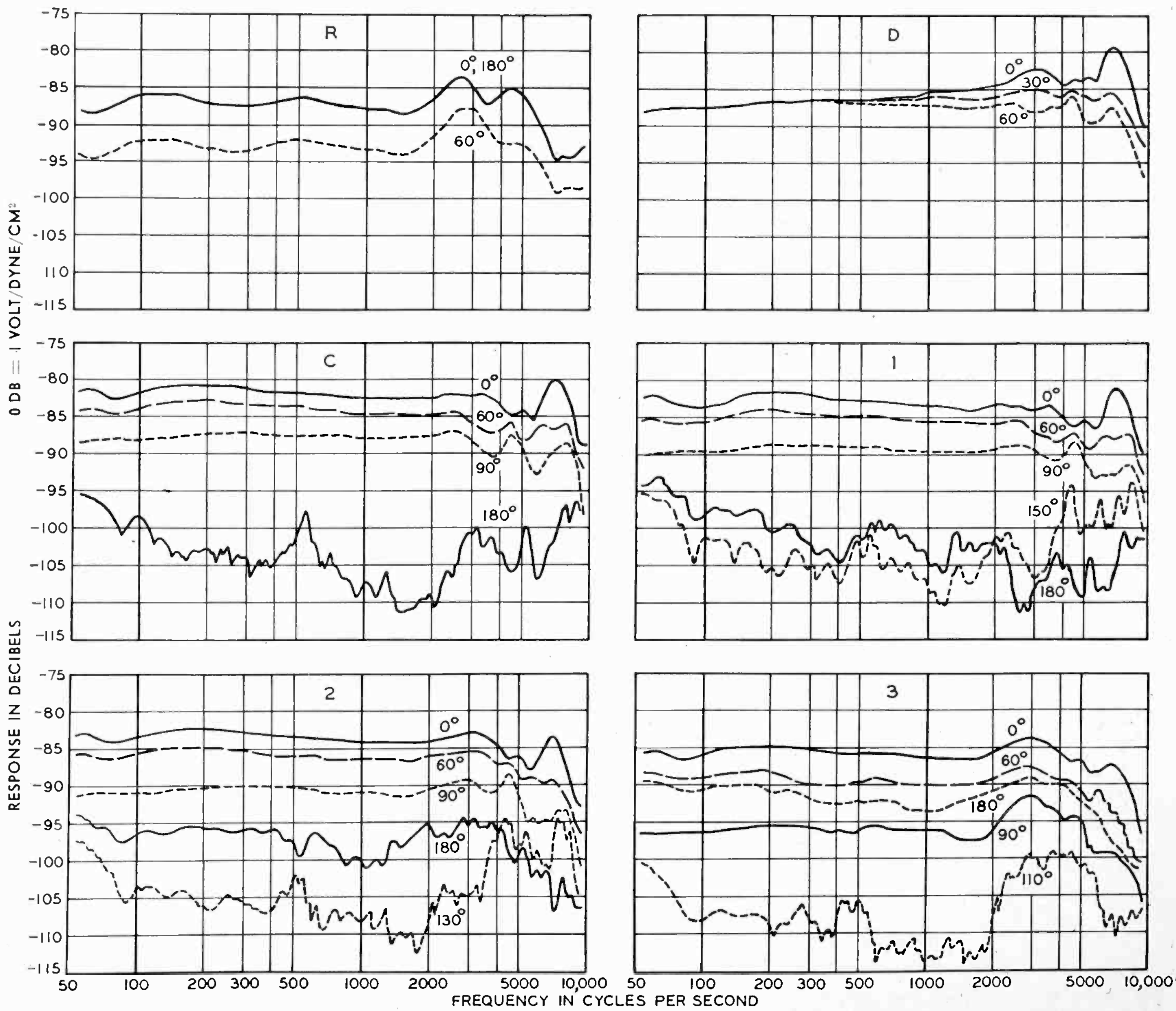


Fig. 5—Field responses of a typical production model 639B microphone for the six switch positions. Because of the unusually wide discrimination, the lower curves in each group contribute negligible amounts to the total pick-up. Minute variations in the sensitivity of the individual elements prevent absolute cancellation and account for the unevenness of these curves on a decibel scale.

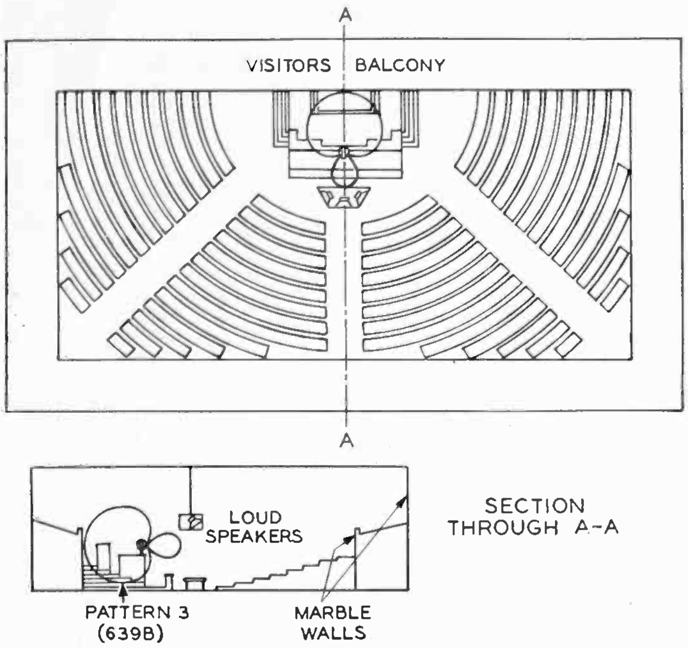


Fig. 6—Sound reinforcement system installed in the House of Representatives, Washington, D. C. Pattern 3 of the 639B cardioid microphone allows 8 db more reinforcement than is possible with nondirectional or bidirectional types. This is 3 db more than can be obtained with a normal cardioid characteristic.

conditions were so severe that sufficient gain could not be used with a nondirectional or bidirectional microphone to give serviceable reinforcement without "sing." To relieve this situation, a 639B was employed. Fig. 6 shows the approximate position of the microphone and loud speakers in the House. Here it was found that the ribbon bidirectional pattern could be employed to eliminate direct "spill-over" from the loud speakers but the other sensitive side established a feedback loop by picking up reflections from the marble back wall, and this pattern was not much better for this purpose than the nondirectional. The No. 3 pattern, however, proved to be the optimum and permitted an 8 db increase in sound output, 3 db more or twice the power that could be obtained with the cardioid which in itself was quite an improvement. Since this location was quite reverberant with a great many feedback paths of nearly equal prominence, it is reasonable to apply the standard index as a criterion. As we have seen this index predicts that in a random feedback condition, pattern 3 will pick up the minimum energy. However, the 639B with its six-way switch allowed this prediction to be checked, and permitted easy analysis of the problem with one microphone by quick change between the various patterns.

At the Madison Square Garden, huge indoor sports arena in New York, the sound reinforcement problem is complicated by changes necessitated in transition from a fight to an ice rink, or to a political rally. The loud speakers, which may be moved up and down, and from end to end in the arena, are arranged in a circle to radiate sound in all directions. Fig. 7 shows a typical setup with the microphone position at one side of the arena. This resulted in a feedback condition best served by pattern 2, the improvement being 6 db over the cardioid which in turn was 6 db over the dynamic, a total increase in power of 16 times what had been provided before. Moreover, associated with the increase in power was an improvement in naturalness since the microphone gave more prominence to direct over reverberant sound. Again the availability of the various pick-up patterns makes the 639B microphone unusually well adapted to the changing requirements of the Garden program.

These public address demonstrations of the intrinsic worth of these directivity patterns of the cardioid family, guarantee that reverberation effects in studio pick-up may be controlled to a greater degree than heretofore. To show this in practice a trial was arranged, through the cooperation of WOR, with a small symphonic orchestra, with Alfred Wallenstein conducting (see Fig. 8). In a previous trial with the normal 639A cardioid, the reproduced sound was characterized by increased definition of the individual instruments, while the bass was rich and clear without being boomy. In the new trial using pattern 3, Mr. Wallenstein expressed the opinion that the improvement was as much over the normal cardioid as the latter had been over the bidirectional ribbon type microphone. A curious subjective effect in these trials was that the bass, cleared of excess low frequency reverberation, permitted more attention to be given by ear to other sounds, thus aiding the impression of definition between instruments. This illustrates that progress has been made in developing our mechanical ear to do what we normally accomplish with two ears and a brain.

Our analysis so far has assumed that it is desirable to have the reproduced sound correspond

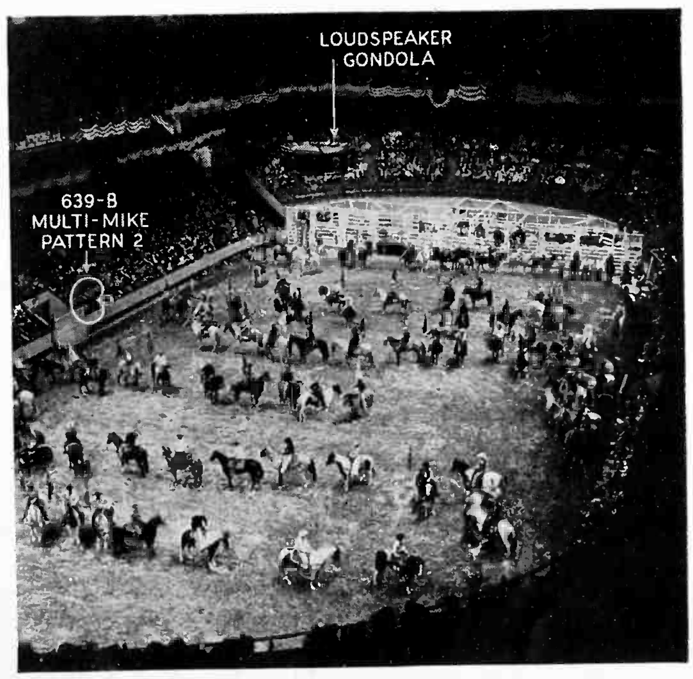


Fig. 7—Typical arrangement of 639B microphone and loudspeaker gondola for sound reinforcement in the Madison Square Garden, huge indoor sports arena in New York City. Normal cardioid directivity gave 6 db more reinforcement than the nondirectional, pattern 2 another 6 db; a total of 12 db.

to that which the listener would hear at the microphone position. At times, however, it may be desired to provide an illusion different from that observed at the microphone location, and for this purpose elaborate synthetic reverberation machines have been constructed. Additional reverberation may be used to give an impression of space and distance. In this connection, where studio characteristics permit, the 639B microphone may be employed to useful advantage. Direct sounds may be eliminated entirely from the pick-up by proper angling of the microphone and selecting the desired zone of minimum sensitivity. This extreme may be modified by actually using the microphone backwards; that is, by pointing the smaller lobe, as in pattern 3, toward the source of sound. Thus, the various pick-up patterns in the 639B microphone allow reverberation effects to be enhanced as well as suppressed, and provide a new control in a simple fashion. This control, for example, may be useful in studios which are operated under overcrowded conditions.

Field experience with the new microphone is rapidly confirming the advantages indicated by the theoretically-derived indices of directivity. Although there is no simple way of expressing completely and quantitatively the value of a given directivity pattern, our analysis has shown that the optimum choice for many pick-up conditions lies between patterns 2 and 3 of the cardioid family. On the other hand, the practical application of the 639B microphone is made very easy, since the sound engineer may try at the turn of the switch all the directivity patterns and choose the one that actual test proves the best suited to the particular acoustical condition. Moreover, the performance of the 639B follows the ideal directivity patterns to an unusual degree for the entire frequency range from low bass to high treble. Consequently, a program may be picked up in proper balance while annoying problems of reverberation, "slap-back," and feedback are effectively handled at the same time.

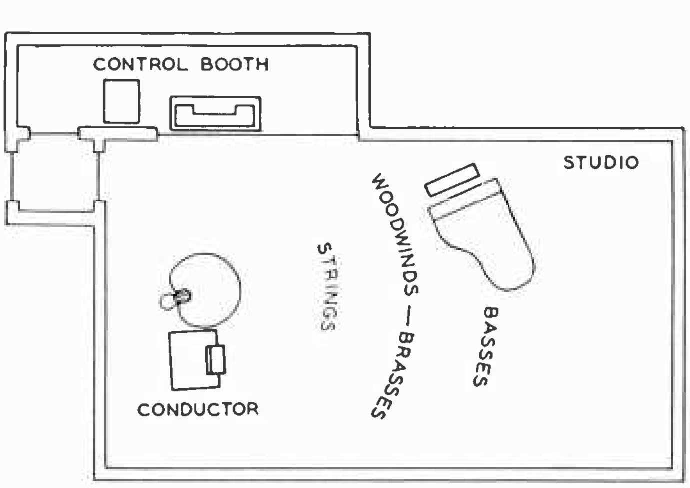


Fig. 8—Studio arrangement for the pick-up of a small symphony orchestra. One 639B microphone placed at one end leaves the studio free for action; yet reduces the pick-up of room reverberation. In case of excessive low-frequency reverberation, improvement is particularly noticeable in the quality of bass reproduction.

Architectural Competition Creates Wide Interest

The Beaux-Arts-Western Electric competition for the design of a 1000 watt broadcast transmitter station is arousing widespread interest among architectural students throughout the country. Latest reports from the Institute's headquarters show that over 30 universities, colleges and technical schools as well as numerous architectural clubs and ateliers have written in asking for full information.

New York University has requested 32 copies of the problem; Yale University—25; Alabama Poly Tech—9; University of Nebraska—7; Penn State—6. The Agricultural and Mechanical College of Texas states that they will use the comparative problem in one of the classes with more than 20 students already registered to compete. Students at the University of Southern California have formed an association composed of groups of three vying against each other for top honors.

Twenty states are represented in letters from individual students who have contacted the Beaux-Arts requesting detailed information concerning the contest. Some are digging in on their own while others plan to collaborate with one, two or three fellow architects in working out the design.

News of the competition has even penetrated the gray walls of the United States Penitentiary at Atlanta resulting in a letter from the supervisor of education there, stating that several men are planning to tackle the problem.

Word, also, has spread to Canada and from station CJOC, Alberta, comes the following inquiry. "I noticed in the January 15 issue of Broadcasting you are having a competition on designs of transmitter houses. I am wondering if you will make these designs available to the broadcasting stations in Canada at the completion of the competition and, if so, we would be pleased to hear further from you."

As announced in the December 1939 issue of PICK-UPS, the competition is sponsored by the Beaux-Arts Institute of Design and is open to architectural students in every school and atelier in the country. There will be three prizes offered by Western Electric—first prize $250, second $100, and third prize $50. Four of the country's outstanding architects and one leading broadcast engineer will judge the competition. They are: Alfred Fellheimer, of the firm of Fellheimer and Wagner; J. Andre Fouilhoux, of the firm of Harrison and Fouilhoux; Ely Jacques Kahn; Ralph Walker of the firm of Voorhees, Walker, Foley and Smith, and J. R. Poppele, chief engineer of Station WOR.

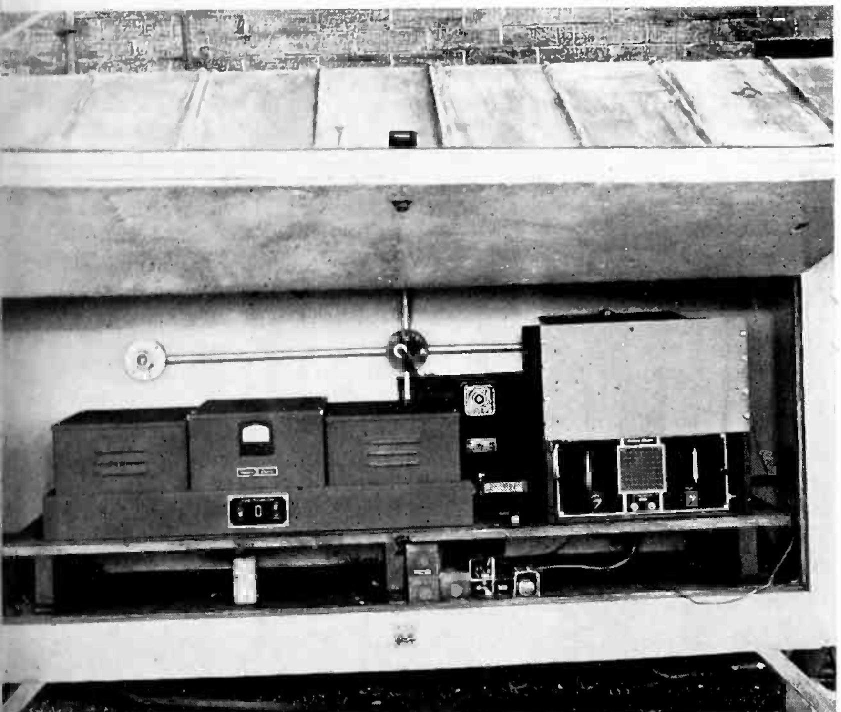
The contest closes June 1, 1940. For full particulars write to Beaux-Arts Institute of Design, 304 East 44th Street, New York City.

New Two-way Radio System Polices Fayette County, Ky.

By SANFORD HELT
Chief Engineer, WLAP, Lexington, Ky.

The Fayette County two-way police radio station WQOB was completed and placed in operation on February 15, 1939. Prior to this date the county had cooperated with the City of Lexington, Kentucky, in the operation of WPET on 1706 kilocycles. Outdoor telephone sets were in operation all over the county for patrol car communication with headquarters. Due to the great amount of police work necessary in the county, and the high operating cost of this previously employed system, the arrangement was found to be very unsatisfactory.

Fayette County covers an area of approximately 65 square miles, and has a population of over 80,000. The largest thorobred horse farms of the nation are found in this territory. Tobacco is the chief agricultural product, and warehouses in the county store hundreds of thousands of dollars in tobacco most of the time. The necessity for an efficient two-way county police radio system is apparent.



The project was proposed by County Judge William E. Nichols in the fall of 1938, with the wholehearted endorsement of Chief of Police John W. McCord. After a careful study of police radio equipment in other cities, the authorities placed an order for Western Electric apparatus.

The installation consists of a Western Electric 22A 25 watt ultra-high frequency fixed station transmitter and three cruisers equipped with 18A transmitters and 18E receivers. Two motorcycles are equipped with receivers only. A 19A receiver is employed for headquarters reception.

The headquarters equipment is mounted in a weatherproofed, air conditioned housing atop the First National Bank Building in Lexington, Kentucky, at a height of 200 feet above ground level or 1,000 feet above sea level. The coaxial antenna, also designed by Bell Telephone Laboratories, is supported atop a 62 foot self-supporting pipe construction mast mounted above the elevator pent house of the building. This places the radiator at a height of 262 feet.

Three wire line circuits connected the equipment with the remote control apparatus located on the first floor of the Fayette County Courthouse. Here, a 94D amplifier, high fidelity speaker, and associated control equipment are installed.

The system was installed by the author

Topping the page is the coaxial antenna 262 feet above ground. Center: Western Electric's 22A 25 watt transmitter and 19A receiver mounted in a weatherproof, air conditioned housing on the roof of the First National Bank building. Left: Dispatcher C. W. Westfall carries on two-way conversation with patrol cars.

and inspected and checked by T. E. Lenigan of Bell Telephone Laboratories.

Numerous field surveys have been made over the area served by WQOB, operating on a frequency of 37,100 kilocycles. The 22A transmitter lays down a signal which is reliable to distances of 30 or 40 miles. The 18A car transmitters work into headquarters from distances as great as 14 miles. The reliable service area for dependable two-way communication extends over a radius of approximately nine miles. It was not found necessary to employ remote receivers at any point in the county despite many stretches of rolling terrain. Since installation the equipment has rendered fine service, and all officials are highly pleased with the results obtained.

Illinois State Police Radio

(*Continued from page 11*)

up any one of the police posts of any of the 13 districts or the ports of entry on the states bordering Illinois, or the bridges in any district — in fact he can flash on the map practically any maneuver he wants his men to make.

Thus, if word is received that a crime has been committed in Indiana, for example, the chief can have squads at all ports of entry in a few minutes should the criminals attempt to cross the Illinois line. The manner in which this blockade system works out is best illustrated by an actual case.

Two men, later found to be hardened criminals, were attempting to start a stalled car on an Indiana highway. A state trooper, returning from an accident case accompanied by a newspaper man and a deputy sheriff, decided he might be of assistance, so he walked over to the car to ask if any help was required. When one of the men thought the trooper was reaching for a gun, he fired, killing the officer outright and kidnapping the sheriff and newspaper man.

Shortly after this occurred Superintendent Williams was listening to the family radio, enjoying his favorite after-dinner news commentator. The broadcast wound up with a flash on the Indiana killing. Calling his office the chief discovered that no Indiana police broadcast had been relayed to Illinois so he telephoned the Indiana superintendent of police who gave him a description of the fugitives and the license number of the car they had commandeered. Over the Illinois network went the signal to block Indiana ports of entry.

As the squads raced to their posts the radio was bringing them descriptions of the fleeing men. With this move under way, Williams next ordered a secondary line into action at posts behind the ports of entry. With these defenses set, he notified Indiana state police that they could release their squads guarding the state line as Illinois was ready to take over the assignment. This released a score of squads for patrol work to flush out the killers.

Shortly there came a flash that the fugitives were in Illinois. Both were expert marksmen and they had forced their way past one of the squad cars by shooting out its headlights.

Relentlessly Williams began to tighten his net. Now that contact had been made, police outside the zone were moved in. State troopers gave every farmer in the vicinity a telephone warning and description. Local police were assigned parts to play in the approaching drama.

Then came news of the next contact. The bandits had kidnapped a farmer and his four year old boy and had abandoned their own car.

Before long a state squad sighted the fugitives. Knowing from radio messages that innocent persons were in the car, the officers punctured the gas tank with a rifle bullet. In a few minutes they found the abandoned car, and with reinforcements from local sheriffs they closed in on a cornfield across which the killers had fled. As the officers approached a farm house a man darted toward a corn-crib. He was dropped by a volley of lead. The second killer was in the farmhouse, blazing at the officers.

Holding their fire, the posse surrounded the house. Fearing that members of the householder's family were being forced to act as shields, the officers held their fire until neighbors assured them that there was no one at home. A moment later, in answer to police gunfire, a man staggered from the house, signaling surrender. Wounded in the shoulder, he had decided to face trial rather than police bullets. Later he was electrocuted. The other criminal had been killed outright in the farm yard.

Chief Williams, ending the story, said: "Theirs was the fate of hundreds of others who underestimate the power of the forces of law and order."

This story illustrates well how the police force of one state cooperates with those of adjoining states in the fight against crime. Several midwestern states have already adopted uniform interstation signals and a nation-wide network is fast coming into being which will permit exchange of information between police on a scale formerly undreamed of.

It is practically impossible to estimate fully the effectiveness of police radio. Through its use in Illinois, the state police not only have greatly broadened their activities but also they have made the taxpayers' investment in the radio network yield millions in dividends in the form of stolen property recovered. The outlay of buildings, equipment, salaries, maintenance in three and one-half years totals less than the cost of building only ten miles of highway.

Superintendent Williams claims that with radio on the job a force of 350 men have been able to increase their efficiency somewhere between 300 and 400 per cent.

Robert N. Marshall

If anyone can knock the old "rolling stone" proverb into a cocked hat it is Robert N. Marshall of Bell Telephone Laboratories. Marshall has rubbed shoulders with practically every nationality on the globe, having lived in Canton, Shanghai, Manila as well as numerous cities in the United States. His travels have taken him across the Pacific four times, the Atlantic once and from coast to coast in the United States. He has seen Singapore, Suez, the Mediterranean and a long list of other interesting places.

Robert N. Marshall

The son of American missionaries, Marshall was born in Yeoung Kong, China. The first six years of his life were spent in Southern China with occasional visits to this country when furlough time came around. Fortunately for him and for the Laboratories as well, he and his parents were enjoying one of these vacations when the great Boxer rebellion occurred in 1900. All the other missionaries and their families in his locality in China were killed.

Marshall's boyhood in the Orient reads like an old-time movie thriller. When he was five years old he and his family were shipwrecked on the Pearl River while moving their household belongings from one town to another. All their worldly goods lost, they finally landed in Canton on Christmas morning clothed in pajamas—shivering but safe and ready to start life anew. Periodically they were washed or blown out of their various homes by Southern China's seasonal floods and hurricanes. Twice during Chinese insurrections they found themselves in the midst of bombing raids.

As the family never stayed more than three years in any one place Marshall hopped about all over the map getting his schooling. After attending the American high school in Shanghai he returned to the United States in 1924. The following year he entered Princeton University where he worked his way through to a B.S. degree by waiting on table, conducting a students' post office and handling gate receipts for athletic meets. He also replenished the Marshall exchequer during vacations by selling aluminum kitchen ware.

Marshall admits with a grin that he nearly flunked his first science course in China. Then and there he decided never to go in for anything scientific. Before entering Princeton he had about made up his mind to major in the arts. But when he found this would mean continuing Latin he vetoed the arts and toyed with the idea of history. Somehow history didn't quite click and despite his earlier resolution he ended by majoring in physics.

He graduated from Princeton in 1930 and immediately signed up with Bell Telephone Laboratories where he was assigned to the Transmission Instruments Department. Marshall has played an important part in the design of the 8-Ball, Salt Shaker, Machine Gun, 639A and 639B Cardioid microphones. Many of his spare moments at home are spent modelling mike stands and gadgets.

Marshall and W. R. Harry are co-authors of the article on the Six-Way Directional Microphone on page 3 in this issue of Pick-Ups.

Clyde M. Hunt – WJSV

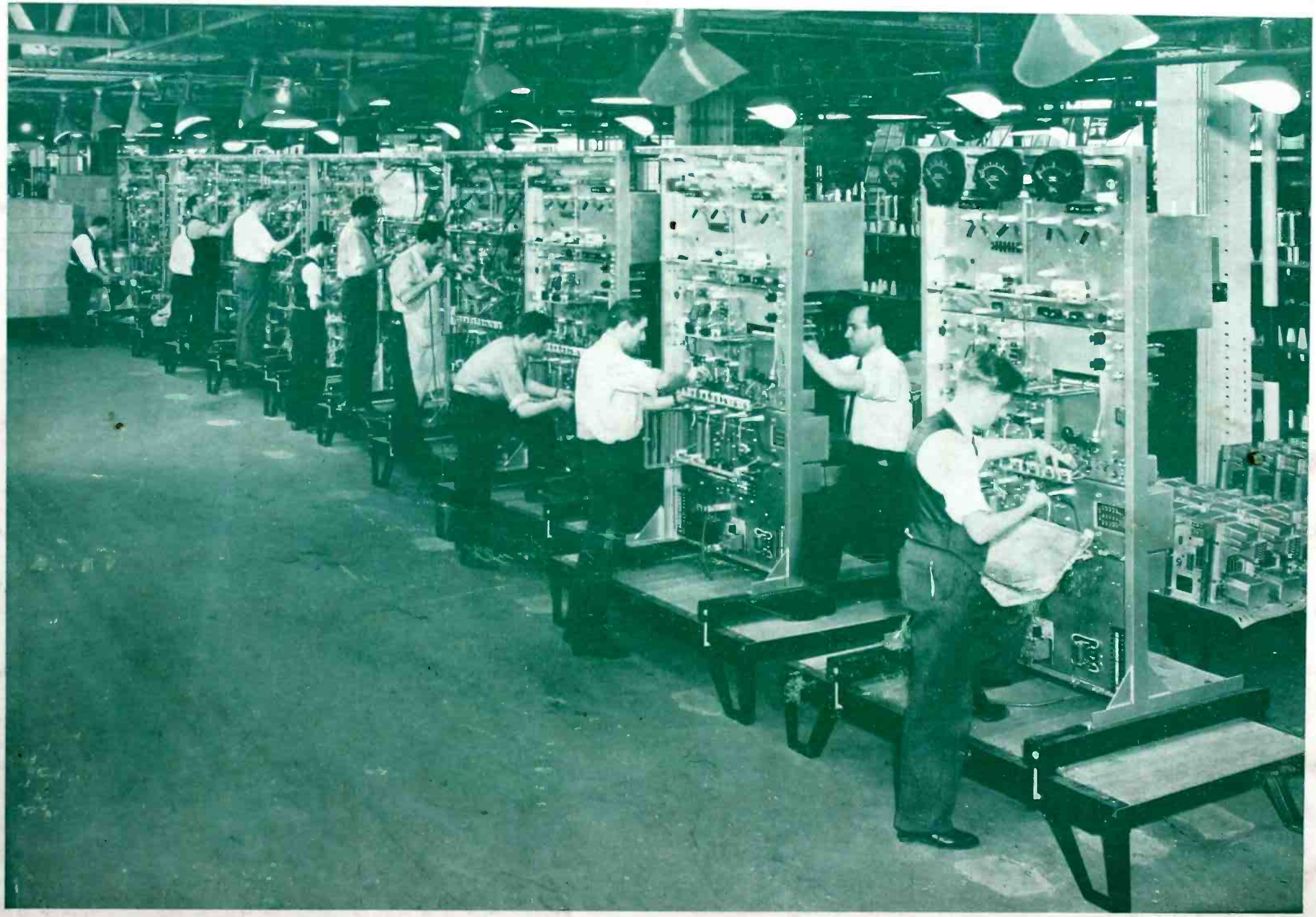
When Clyde M. Hunt was 22 his burning ambition was to become an electric locomotive salesman. A boy of 22 is rather young to be that kind of salesman so Clyde went to all the trouble of growing a mustache and making a special trip to St. Louis to get the job. He sold the company on his technical and selling ability, but, in spite of the mustache, he was considered too young to hold the job of selling these monsters to railroad executives.

He had been building receivers and playing with radio since the tender age of 14, and so, to ease an aching heart, he turned to radio as a profession. He has been in it ever since and today he is chief engineer of WJSV, Columbia's outlet for the Nation's Capital. Hunt has never had occasion to regret his choice of vocation, but he does feel rather badly about that wasted mustache.

Hunt is proud of his intimate associations with the last three presidents of the United States. It has been his job to pick up the presidential voices of Coolidge, Hoover and Roosevelt. He has traveled more than 100,000 miles in 47 states, Canada and Mexico on presidential special trains and has made at least five Western trips including two Pacific cruises in his rambles with microphones.

Clyde was born in Jackson, Tennessee, and reared in Memphis, with schooling in electrical engineering at the Memphis Technical High School, and a year at Union University, Jackson. He moved on to Washington, D. C., and a job with an electrical contractor in 1926. He helped to install the transmitter at WOL, and later became an operator at WMAL. During this time he took a turn at the microphone twice weekly over a period of about two years with his own feature called "How to Improve Your Radio Reception."

He joined WJSV in 1932, the year it was bought by Columbia, and soon was made supervisor. He became chief engineer in 1936. Under him he has a technical staff of 22 men. Reporting directly to him are John Palmquist, master control supervisor, and William Kriz, transmitter supervisor.



Ten more Western Electric 443 A-1 1,000 Watt Transmitters reach final assembly stage at the Specialty Products Shop, Kearny, New Jersey.