PRICE TWENTY-FIVE CENTS

FM AND TELEVISION

JAN. 1946

FIRST TELEVISION STATION AT WASHINGTON, D. C.

SEE PAGE 3

Directory of Emergency Stations

★ ★ Edited by Milton B. Sleeper ★ ★

WHEN CAN TELEVISION TURN A PROFIT?

Facts, figures and "television know-how" are needed when considering this important question. Du Mont is qualified to help you find the answer. Du Mont has marched in the forefront of radio and electronic progress for the past 15 years. Du Mont has contributed importantly to television broadcasting and receiving equipment design. Du Mont has built more television stations than any other company. Du Mont has operated its own Station WABD and commercially programmed its telecasting time since 1942.

From this deep reservoir of television experience, Du Mont has drawn a pattern which you can use to plan your television future. This pattern is presented in detail in our new booklet, "The Economics of Television." This booklet sharpens but one axe—the tested superiority of Du Mont station equipment. It is another important Du Mont contribution to the development of a great new medium. Please request this booklet on your firm letterhead.

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Your old friend, the HRO, has seen active service all over the world with the armed forces of the United States and our allies. Much has been learned, and the HRO has emerged from its trial by fire an even better receiver than the superb receiver you knew before the War.

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Complete Matched FM and AM RADIO COMMUNICATION EQUIPMENT

Engineered and Built by Doolittle

FREQUENCY MONITORS (FM and AM)
Direct reading. No charts or complicated calculations necessary. Models available for 110 Volt A.C. or battery operated portable use. Meet FCC requirements.

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That's because DOOLITTLE pioneering work back in the days of emergency radio's infancy was basically sound.

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Turn all this experience to your advantage. Build the success of your emergency forces around FM or AM equipment *completely engineered, built and matched by* DOOLITTLE.

With such equipment in your service . . . many benefits are yours today . . . and will still be yours years from now!

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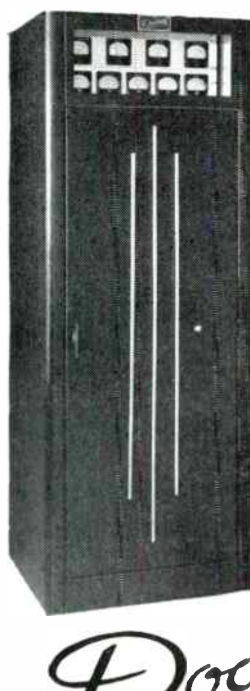
Models up to 60 watts output. Crystal controlled. Complete with Transmitter, Receiver, Power Supply and all Accessories.



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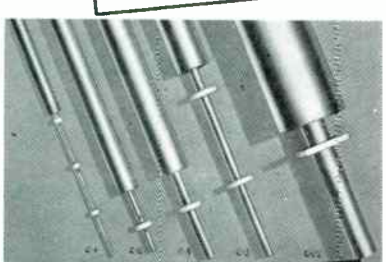

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FM AND TELEVISION

FORMERLY: FM RADIO-ELECTRONICS

VOL. 6 | JANUARY, 1946 | NO. 1

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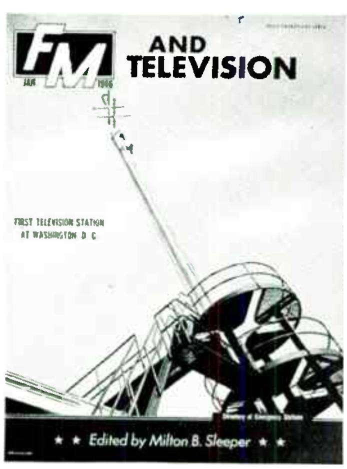


THIS MONTH'S COVER

DUMONT LABORATORIES will soon have a television transmitter operating with the antenna shown on this month's cover. The 90-ft. mast, weighing nearly 3 tons, has been erected on the roof of Washington's Hotel Harrington. The main mast is of seamless steel tubing 16 ins. in diameter, while the top mast tapers from 6 to 3½ ins. Designers Fellheimer and Wagner, of New York, provided means for lowering the top mast to facilitate tuning and inspection. A crane was set up on the Hotel to raise the mast 232 ft. to the roof. During experimental operation, station call letters will be W3XWT.

Entered as second-class matter, August 22, 1945, at the Post Office, Great Barrington, Mass., under the Act of March 3, 1879. Additional entry at the Post Office, Concord, N. H. Printed in the U. S. A.

WHAT'S NEW THIS MONTH

1. FCC Hearing on Lower FM Band

2. FM Allocation Plan

1. Just as we are closing this issue, word has been received that, in response to a petition filed by Zenith Radio Corporation, the FCC will hold a hearing January 18th to consider the possible retention of the 42- to 50-mc. band for FM broadcasting.

This was not unexpected. FCC advisers who insisted that FM must move to 80 mc. justified their stand on the basis of the necessity for providing rural FM coverage. Now, the Commissioners realize that they were misled, for the contentions of those who spoke with the authority of personal knowledge and experience are being confirmed. Upper band FM cannot deliver the rural coverage that Mr. Norton read from his curves. Perhaps that is the reason why Mr. Norton is no longer at the FCC.

The notice of the new hearing, dated January 3, 1946, reads:

Federal Communications Commission
Washington, D. C.

The Commission having under consideration a petition filed by Zenith Radio Corporation on January 2, 1946, requesting that the band 42 megacycles to 50 megacycles be assigned for FM broadcasting in addition to the assignment already made to FM in the 88 to 108 megacycle band.

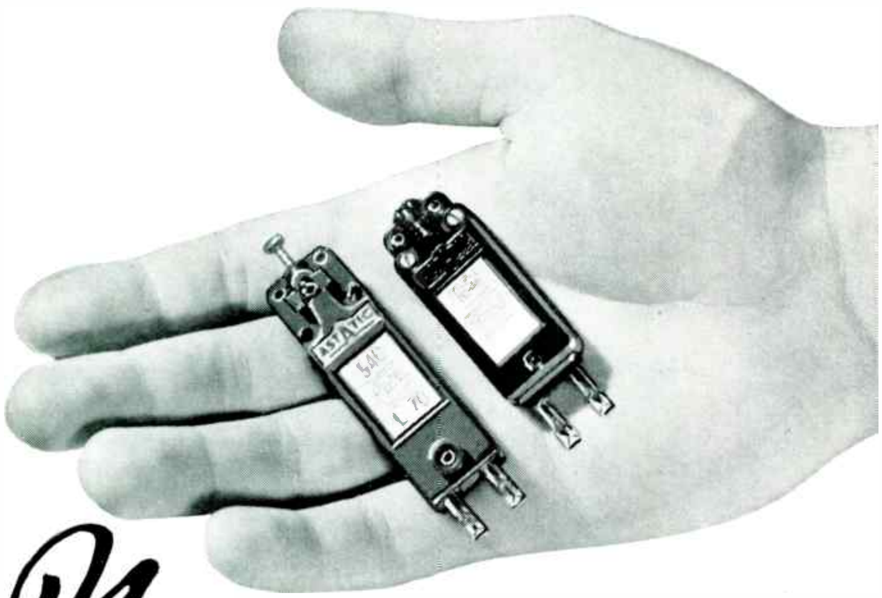
IT IS ORDERED, This 3rd day of January, 1946, that a hearing on said petition be held before the Commission *en banc* at 10:00 A.M., on January 18, 1946, on the following issues:

1. Whether the band 42 megacycles to 50 megacycles, or any part of it, should be made available for FM broadcasting in addition to the assignment already made to FM in the 88 to 108 megacycle band.

2. If any portion of such band is made available for FM broadcasting, whether such frequencies should be available for Non-Commercial Educational, Community, Metropolitan and Rural FM stations or only for Rural FM stations and whether such frequencies should be available for FM stations in the entire United States or only in Area II.

3. To obtain information concerning the additional cost of FM receivers if the band 42 megacycles to 50 megacycles or

(CONTINUED ON PAGE 70)



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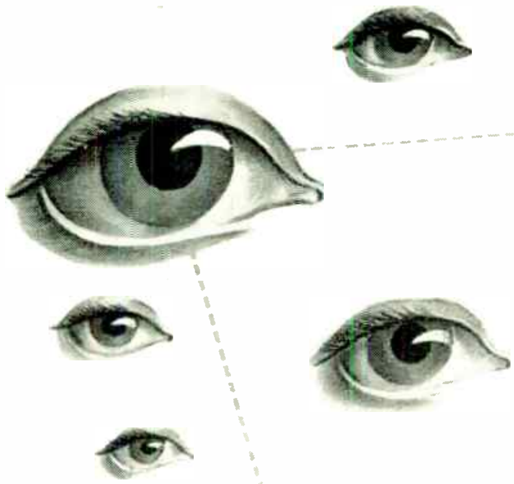

ENGINEERING SALES

Garrard: Distributors are being appointed for Garrard record changers, now available again in the U. S., by Garrard Sales Corp., 401 Broadway, New York 13, N. Y.

G.E.: New sales manager of industrial and transmitter tubes is J. E. Nelson. He will make his headquarters at Schenectady.

Hallicrafters: Has appointed Jack F. McKinney of Dallas as southwestern regional sales manager of its Echophone home radio division. Robert H. Campbell has joined the Company in the same capacity for the midwest territory.

Raytheon: General sales manager of the receiving tube division is L. R. O'Brien, formerly director of sales for Ken-Rad. He will make his headquarters at Raytheon's Chicago office, 445 Lake Shore Drive.

Measurements: Frank M. Murphy has opened a Chicago office at 21 E. Van Buren Street, where he will operate as sales representative for Measurements Corporation.

Farnsworth: Has moved its Chicago distributing branch from 540 N. Michigan Avenue to new offices and showrooms in the American Furniture Mart, 666 Lake Shore Drive. E. J. Hendrickson is manager of this branch.

Eitel-McCullough: Tim Coakley of Boston has been appointed Eimac sales and engineering representative for the New England states.

Radio Receptor: New Washington and government representative for Radio Receptor is F. G. Harlow, formerly sales engineer for Westinghouse.

Hollywood: Ernest V. Roberts is back at Fry & Roberts, manufacturers' representatives at 6406 Sunset Boulevard, after four years divided between the R.A.F. and serving as a 1st Lieutenant of the Marines.

Philco: The name of Philco Radio & Television Corporation, wholly-owned subsidiary handling distribution of Philco products in the U. S., has been changed to Philco Products Incorporated.

Harry B. Segar: Of Buffalo, N. Y., passed away on November 22nd. He was the very successful and popular representative of Amphenol, Jensen, and I.R.C.

HOW TO BRIDGE THIS GAP QUICKLY

HERE, on the "banks" of '45 are a handful of the thousands of products stranded by the flood waters of the war in '41. All of them were applications making use of our type of plastics—Synthane. You are probably taking up where you left off or going into new lines of manufacture.

If you are a little rusty on the pre-war part Synthane might have played in your product, or need assistance in designing for the use of Synthane in new or improved products, send for our complete catalog, or ask for our help now.

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Gentlemen:

Please send me without obligation the complete catalog of Synthane technical plastics.

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VHF-UHF

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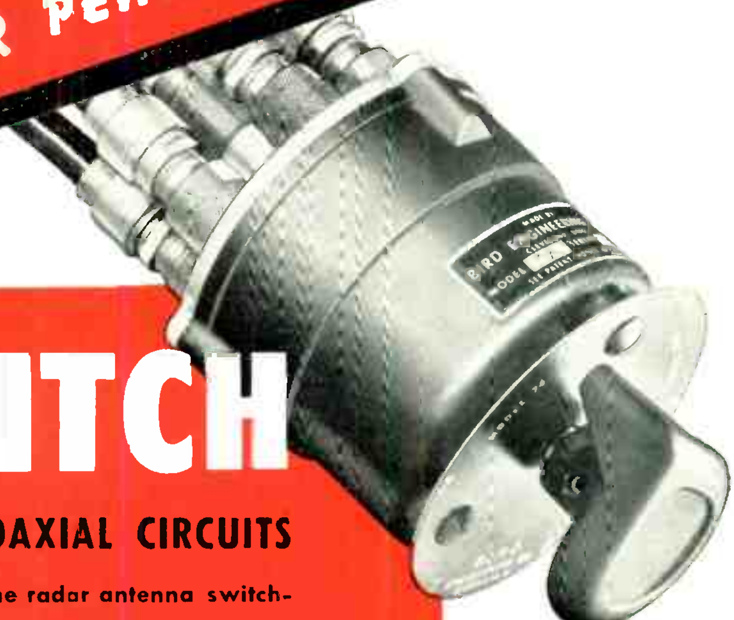
NOW READY FOR PEACETIME USES!



COAXWITCH

A SELECTOR SWITCH FOR COAXIAL CIRCUITS

This new switch was developed for airborne radar antenna switching. A 50-ohm device, it maintains a constant characteristic impedance. To retain *LOW* standing wave ratios and secure maximum transfer of r-f energy, specify "Coaxwitch". Available now, in two models; Model 74 for single coaxial circuits; Model 72-2 for handling two coaxial circuits simultaneously.

Write for Catalog Pages

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The new G-E two-studio Consolette is a compact, flexible and economical speech input equipment designed to meet the needs of every station, FM or AM.

A Partial List of the Features that make the G-E Consolette an Important Part of Every Station, FM or AM:

- Contains all amplifiers and controls for complete operation of 2 studios, announce booth, turntables, and remote lines.
- Input connections for 8 studio microphones, 2 announce microphones, talkback microphone, 8 remote lines (including network), 2 transcription turntables, and 4 special cue input circuits.
- Output connections for 2 outgoing lines, 4 loudspeakers, 4 sets of "on-air" and "rehearsal" lights, and headphones.
- 4 pre-amplifiers provide simultaneous operation of 4 microphones.
- 2 program amplifiers provide extreme flexibility in operation and reliability of service. Each amplifier has individual gain control and power supply.
- Monitor amplifier with individual power supply is also used for talk-back circuit with "over-ride" feature. All "interlocking" is built in.
- Simultaneous facilities for broadcasting and rehearsing.
- Electrical performance to meet FM requirements. At normal output level distortion is less than 1% rms, 50 to 7500 cycles. Response is within 2 db, 30 to 15,000 cycles. Noise level is 65 db below program level.
- Two-tone, blue-gray cabinet is only 10½ inches high, providing complete visibility over top of consolette.

Big-Station Studio Control Flexibility for Every FM and AM Station

THE General Electric Consolette provides complete studio control facilities—monitoring, cueing, simultaneous broadcasting and rehearsing, and over-ride talk-back that operates without need for order wires—all at a price *any* station can afford, FM or AM.

Here is an outstanding control unit that contains all the amplifiers and controls needed for complete operation of one studio, two studios, or two studios and an announcer's booth—including ten microphone inputs. Two program amplifiers permit instantaneous switching of the program from one amplifier to the other.

A new improved push-button system and simplified switching gives the G-E Consolette exceptional flexibility and new freedom from operating errors. Careful arrangement of controls and a correctly sloped panel combine full visibility with operating ease unmatched by ordinary consolettes. A hinged top and a hinged-type chassis mounting provide complete accessibility.

Ask your nearest G-E office for a copy of the new brochure that gives complete data on the new G-E Consolette, or write: *Electronics Department, General Electric Company, Schenectady 5, New York.*

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Use G-E Electronic Tubes in your station for maximum dependability and finer performance.

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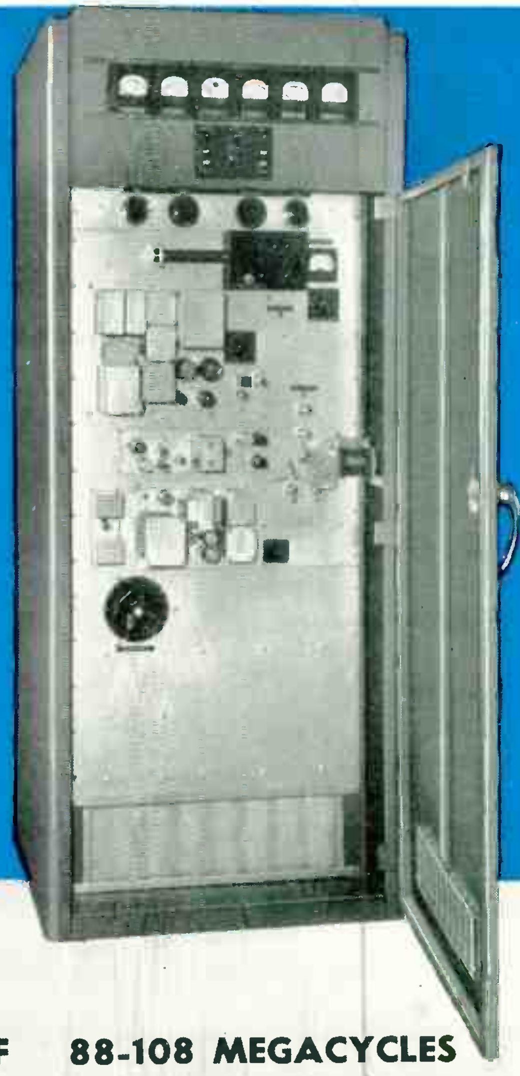
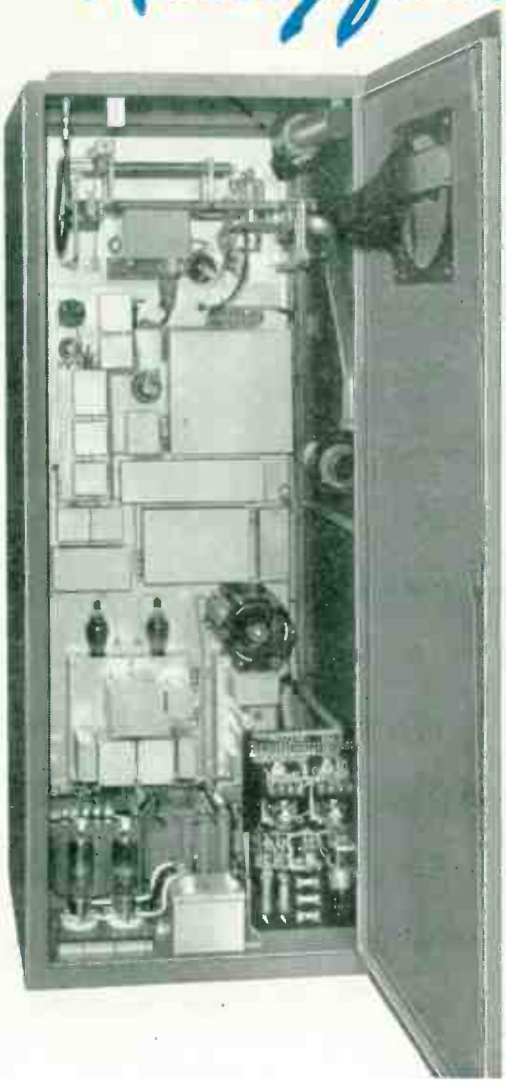
The New TEMCO High Fidelity FM BROADCAST TRANSMITTER



*Ready for delivery**



MODEL 250 BCF 88-108 MEGACYCLES

TEMCO proudly presents this outstanding achievement in FM engineering—the result of 10 years of pioneering in custom-built, superlative communication equipment.

HIGHLIGHTS OF THE TEMCO 250 BCF

- Normal rated output power 250 watts. Maximum rated output power 375 watts.
- Continuous monitoring of the carrier frequency by a center frequency deviation meter calibrated directly in cycles.
- An exciter unit — heart of the transmitter—characterized by tuning simplicity accomplished by employing only 4 stages to raise the primary oscillator frequency to the carrier frequency.
- A new circuit of technically advanced concept which maintains a high degree of center frequency stabilization without introduction of distortion.
- Peak efficiency and great dependability are obtained by the use of new miniature V-H-F tubes in the exciter.
- Improved design in the IPA and PA stages eliminating tank radiation, feedback, radio frequency and high voltage potentials from the tank circuits and transmitter frame.

*A limited quantity of the TEMCO Model 250 BCF will be available for January delivery. Orders will be filled in rotation as received. ACT NOW. Place your order at once.

NOW ON DISPLAY FOR YOUR INSPECTION.
Phone or wire for an appointment.

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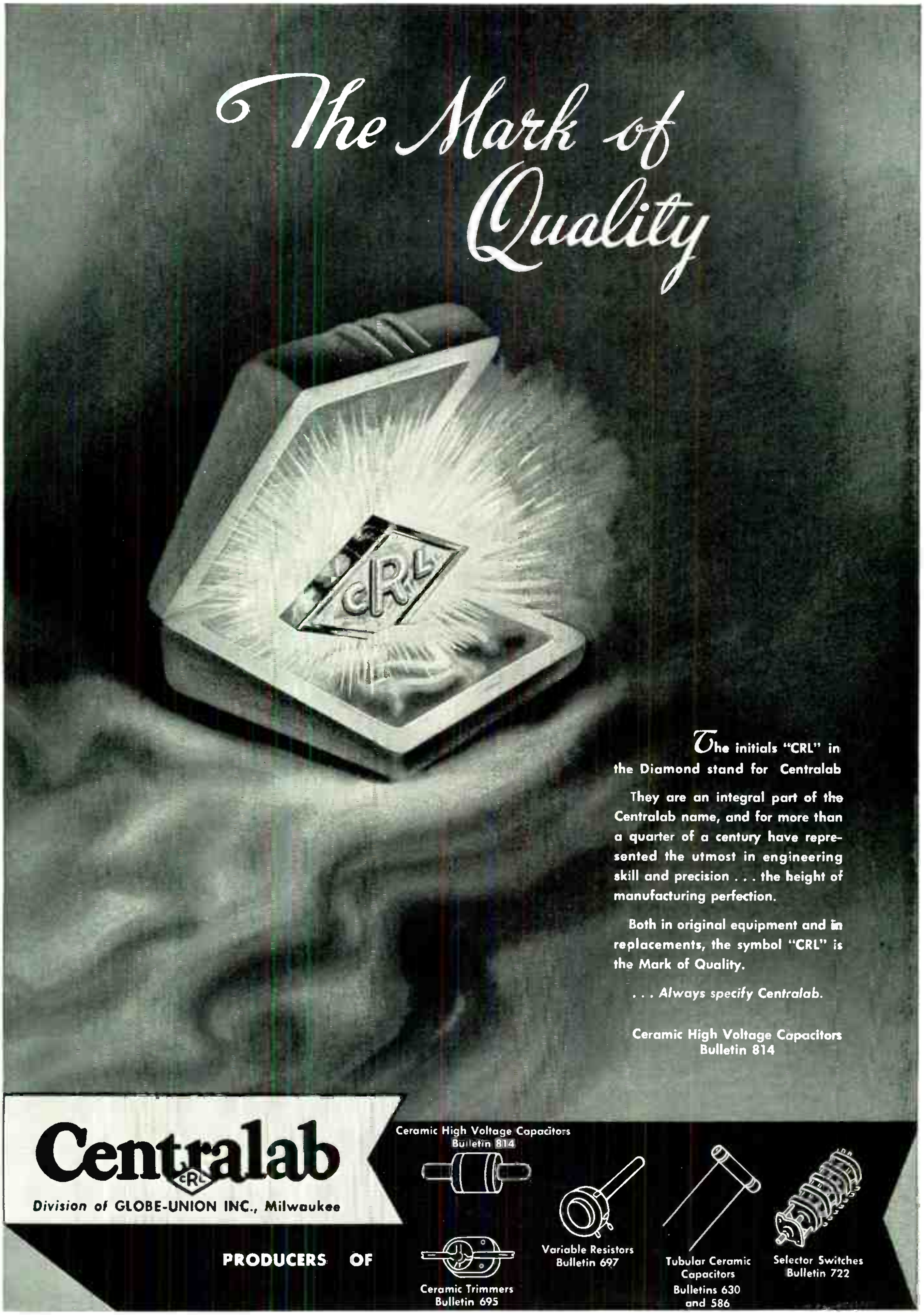
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The initials "CRL" in the Diamond stand for Centralab
They are an integral part of the Centralab name, and for more than a quarter of a century have represented the utmost in engineering skill and precision . . . the height of manufacturing perfection.
Both in original equipment and in replacements, the symbol "CRL" is the Mark of Quality.
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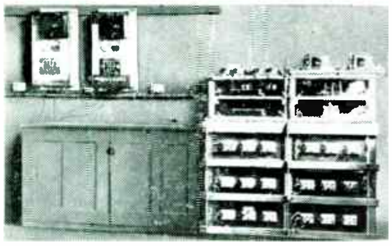
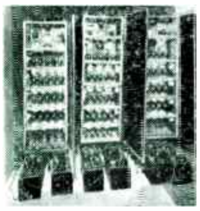
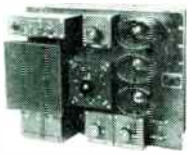


1915. World's first vacuum tube repeater, produced by Western Electric, made transcontinental telephone calls possible.



1919. Among the earliest P. A. amplifiers were these made by Western Electric and used at Victory Way Celebration in New York City after World World I.

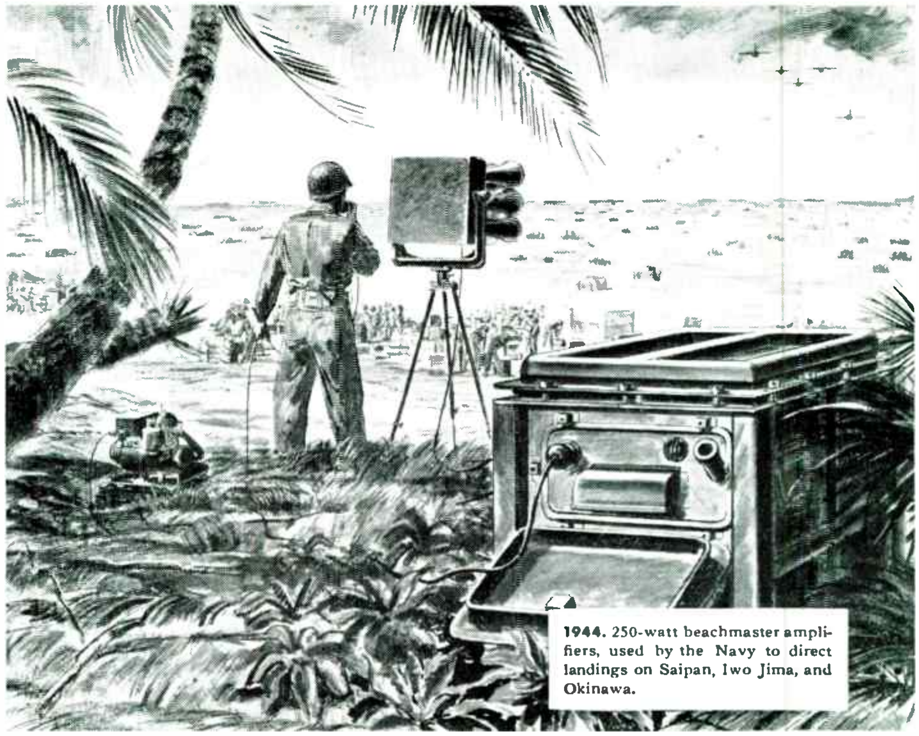


1922. First amplifier used generally in commercial broadcasting. Many of these 8-type amplifiers are still in use.

1931. Negative feedback principle introduced by Western Electric in telephone amplifiers, since applied to broadcasting and public address equipment.

1931. Western Electric developed this first all AC amplifier unit which eliminated batteries, made equipment more compact.

1936. One of the twenty 1000-watt amplifiers used in the world's largest commercial public address system at Roosevelt Raceway on Long Island.



1944. 250-watt beachmaster amplifiers, used by the Navy to direct landings on Saipan, Iwo Jima, and Okinawa.

AMPLIFIER HISTORY... Made by

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For more than 30 years, Western Electric has made amplifier history. The skill and ability that time alone can bring, plus experience gained producing highly specialized sound equipment for war, mean continued leadership for Western Electric in the years ahead.

Buy Victory Bonds and hold them!

1937. 120-121 type Western Electric amplifiers for use in the finest audio systems for AM and FM transmission.

1942. New and improved battle announcing system amplifiers of the type that helped save the crippled carrier *Franklin.*

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FOR PRICES, SEE PAGE 56

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CLAIM STAKING

Hallicrafters and Very High Frequency

Based on the facts in the case, Hallicrafters can stake out a very strong claim to leadership in the very high frequency field. The facts include such things as the Model S-37, FM-AM receiver for very high frequency work. The Model S-37 operates from 130 to 210 Mc.—the highest frequency range of any general coverage commercial type receiver.

Hallicrafters further supports its claim to domination in the high frequency field with the Model S-36A, FM-AM-CW receiver. The 36A operates from 27.8 to 143 Mc., covers both old and new FM bands and is the only commercially built receiver covering this range.

Further developments in this direction can soon be revealed—adding further support to Hallicrafters claim to continued supremacy in the high frequency field.

HALLICRAFTERS NEW $600,000 HOME NOW UNDER CONSTRUCTION.

hallicrafters RADIO

THE HALLICRAFTERS CO., MANUFACTURERS OF RADIO AND ELECTRONIC EQUIPMENT • CHICAGO 16, U. S. A.

A GI'S REPORT ON LOWER-BAND FM

A Veteran Radio Operator's Experience with FM under Battle Conditions

BY PAUL L. ZENS*

DEAR Mr. Editor,

Your article entitled "Observations of an AM Listener" in the November, 1945 issue of *FM* AND TELEVISION checks with my own experience since I returned to the United States. My only complaint about what you said is that you didn't put enough emphasis on the superior service that FM can give radio listeners.

In fact, for all the FM listening you have done, you really don't know how good FM is, and how much superior it is to AM. During the War, there were only some fifty FM broadcasting stations in the whole U.S.A. In Europe, we had thousands of FM transmitters, many times the number of broadcasting stations there will ever be here at home, and in a much smaller area.

As a T/4 radio operator in a combat Infantry division, I listened to FM many more hours a day, day in and day out, than you ever had time to do. Of course, I was trained on CW, but in battle, at least everywhere I was, there was no dot-dash operation. It was too slow, and too liable to errors and interference from static or other transmitters.

One of the main reasons the American Army moved so fast against the Germans was that it had overall information supplied by fast communications. In combat teams, that meant radio, and that radio meant FM!

For example: In one Infantry division we had a minimum of 81 SCR-300 radios operating on 18 frequencies, and more than 150 sets in the 600 series operating on about 40 frequencies. These figures are minimum approximations. It was a rare day when a much larger number of sets was not in use. And of course I am referring only to our own division.

Army radios are made sensitive rather than selective on the general idea that it is better to hear anything at all than to hear nothing at all. On the basis of tactical use, the most important radio was the SCR-300, the walkie-talkie, used between battalion HQ and the line companies. This equipment has a range from 40 to 48 megacycles, the highest frequencies used by the Army in tactical operations. There was, therefore, ample opportunity for trouble and vexation arising from operational interference. The SCR-300 was a sensitive and responsive set, but I cannot recall a single instance when our SCR-300's were made inoperative because of transmissions on other networks.

We radio operators at battalion HQ, working as combat radiomen, gave thanks that we did not have to use AM, although we did carry one AM set with us. One night, up in the Siegfried Line, when we needed more equipment than we had, we got out the AM set. The loudspeaker crackled and roared with static. Twenty different stations came in at once with a noise like a platoon of tanks. I think we heard everybody in Europe on that AM receiver. I mean, at the same time. We picked up messages in English — both American and British variety — French, Russian spoken by women operators, and some German. At least, we heard everybody except the station we were trying to reach, which was the nearest station.

It was like being on a party line with a lot of shrill-voiced gossips. We never did establish contact. There was too much static, and too many stations came in on the same or adjacent frequencies. The Executive Officer finally yelled: "Get that set to hell out of here!" It was never used again until after V-E Day. In fact, we were forbidden to use it.

I *know* the war in Europe would have lasted longer if we hadn't had FM on our side. We were able to shoot fast and effectively because we could get information quickly and accurately by voice, on FM.

Incidentally, it is my conviction that the Germans did not hear us, for they did not attempt to jam our transmissions, nor was there any evidence that our messages were intercepted and the information used against us. It was all so simple that the Army had to surround its radio operation with an air of hocus-pocus lest it be seen that the cunning of the matter lay in its very simplicity.

We had some relatively simple procedures. Our relay systems were good examples of what could be done easily to handle difficult problems. In Army parlance, our *relays* were nothing more than operators whose function it was to transmit messages between two other stations which could not reach each other, but could talk to a relay operator.

An incident on the Siegfried Line will explain our relay operations. At this time, the going was especially rough. The Germans were shelling our battalion with their usual vicious monotony, and one company in particular was in an extremely dangerous situation.

The Germans were so well dug in that their positions could not be reached effectively by our artillery. The weather, as usual, was too bad for us to get air support. There was only one weapon we could use to help the endangered company—the high-flying, straight-dropping mortars.

The commander of the besieged company was immediately in front of the Germans, but in a poor spot to observe the strike of the shells. If he stuck his head out of his foxhole, it would likely be blown off. The battalion commander, up front but off to one side, could see the shells burst but he could not see the company. The company itself was too far away from battalion HQ to be reached by the HQ radio. In this geographically complicated battalion setup, it was necessary to arrange a fancy radio and telephone network, and fast.

I was working at the HQ radio, and at my side was the chief gunnery officer of the mortar platoon, with his maps and a telephone. I gave him the messages from up front. He translated them into ordnance information and then telephoned instructions to the mortar HQ. In turn, his orders were sent from the mortar HQ to the gun crews by radio. Altogether, the network was made up of two telephones and seven radios operating on two frequencies. The battalion CO, the operator at the mortar HQ, and I were all relay operators. The elapsed time from the original request for mortar fire until the last round was on its way was 20 minutes, and in that time we threw 180 rounds into the Jerries.

This relay operation sounds very simple, and it was, but only because our FM voice communication was so clean and clear that, despite the tremendous noise around us, we worked as if we were each in sound-proofed rooms. Actually, the company CO was in a foxhole, the battalion CO was in a parked jeep, and I was out in the woods. Our own guns were making a terrible racket, German shells were bursting around us, and it was raining very hard.

A good deal of the talking we did that day was in code. We might call the mortars "rain barrels," while ranges and positions were given as letters or numbers. If we had been forced to spend a long time organizing the radio network, or if uncertain reception had made it necessary to ask for repeats to make sure we heard the encoded parts correctly, that barrage might have come too late. The Germans could have moved away or into attack, as we thought they might, or they could have got reinforcements. Anything can happen in a fast-moving battle. But with our FM communications we didn't waste a word, which is another way of saying that we didn't lose a second.

(CONTINUED ON PAGE 73)

*6 Kenilworth Road, Worcester, Mass.

N.Y.-WASHINGTON COAXIAL CABLE

How AT & T Is Preparing To Handle Network Television

BY ARNOLD C. NYGREN

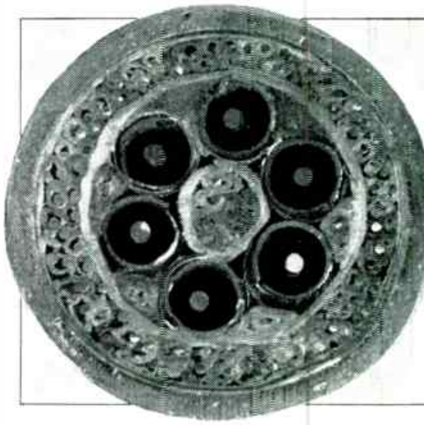


FIG. 1. CABLE WITH SIX COAXIAL LINES

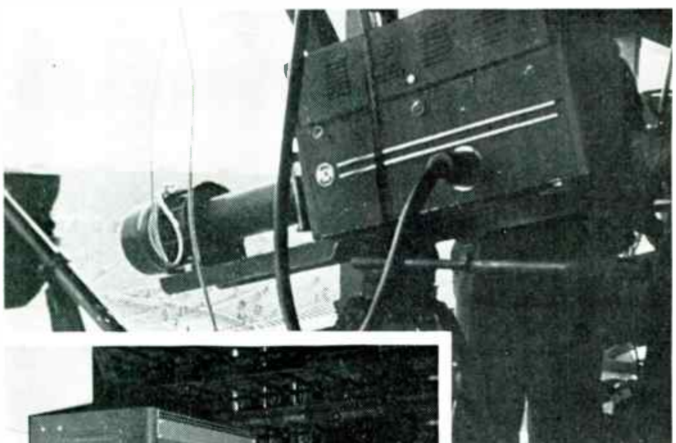
WITH the television industry planning to make transmitting and receiving equipment available in a few months, a coaxial line system stands by to make network television a reality. Television has had and will continue to have many problems in providing good video service direct from transmitter to receiver, but network facilities must be developed and put into operation before commercial television can become economically practicable.

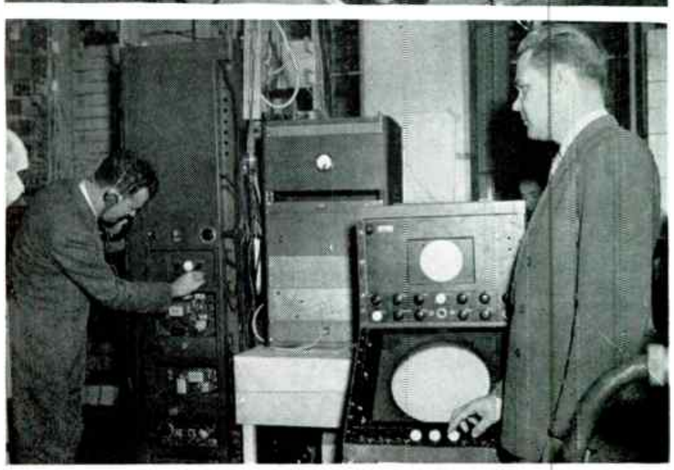
Networks have made possible the elaborate, high-cost radio programs of today, and it is only through similar networks that television can succeed on a nation-wide scale. Unfortunately, television, already confronted with high costs of equipment and programming, cannot utilize existing telephone wire circuits as a distribution system. Transmitting video signals presents many problems not encountered in handling aural signals which require, at the most, a 15,000-cycle bandwidth. To provide and maintain a path several megacycles wide for video signals is a highly technical undertaking.

The public and the press had a preview of network television on December 1st, 1945, at the time of the annual Army-Navy football game at the Municipal Stadium in Philadelphia. The event was transmitted by special wire from the Stadium to the Philadelphia terminal of the American Telephone and Telegraph Company, then by coaxial cable to New York, and on to the NBC transmitter atop the Empire State Building, a distance of approximately 100 miles. Because this link will be part of a future nation-wide system and is already an important leg of the 225-mile Washington-New York circuit scheduled to go into regular service this month, its basic details are of great interest.

Coaxial Cables ★ Anticipating the need and importance of suitable circuits for the distribution of television programs, the American Telephone and Telegraph Company began a study of the problems involved 10 or 12 years ago. As a result of these studies, the Philadelphia-New York coaxial cable was subsequently installed on an experimental basis. The circuit was later extended to Washington, D. C. Early installations utilized two and four coaxial cables, with later installations using the newer type cables carrying six or eight coaxials.

Fig. 1 is an end view of the latter type. The tube of each coaxial line is approximately ¼ in. in diameter, and is formed from flat copper strip. Hard rubber disc separators of extremely low dielectric loss support the inner conductor. In addition to the six coaxials, there are other wires required for various operating circuits. Each coaxial tube is capable of carrying one television program circuit or 480 separate and simultaneous telephone channels in one direction. In the outer layer are 42 pairs of telephone wires for handling additional telephone conversations.





ABOVE: FIG. 2, LEFT, CAMERA AT PHILADELPHIA STADIUM

FIG. 3, RIGHT, AMPLIFIER ROOM BELOW THE STADIUM

BELOW: FIG. 4, LEFT, ONE OF THE INTERMEDIATE AMPLIFIER POINTS BETWEEN THE STADIUM AND THE RACE STREET TERMINAL

FIG. 5, RIGHT, CARRIER TERMINAL EQUIPMENT AT RACE STREET EXCHANGE

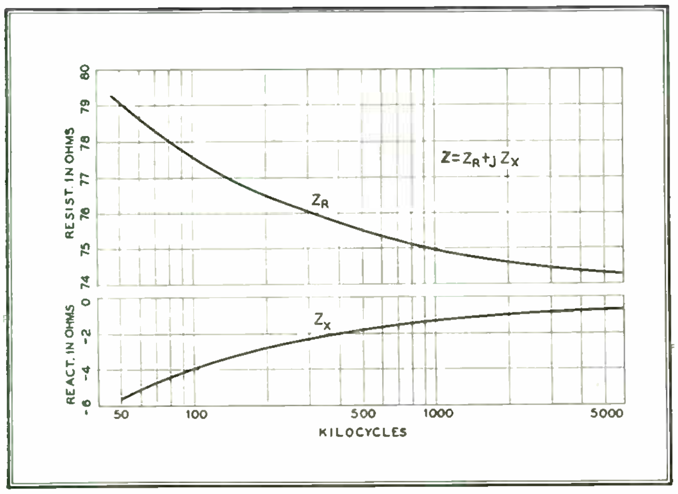


FIG. 6. IMPEDANCE CHARACTERISTICS AS A FUNCTION OF FREQUENCY FOR A 5-MILE LENGTH OF INSTALLED COAXIAL CABLE

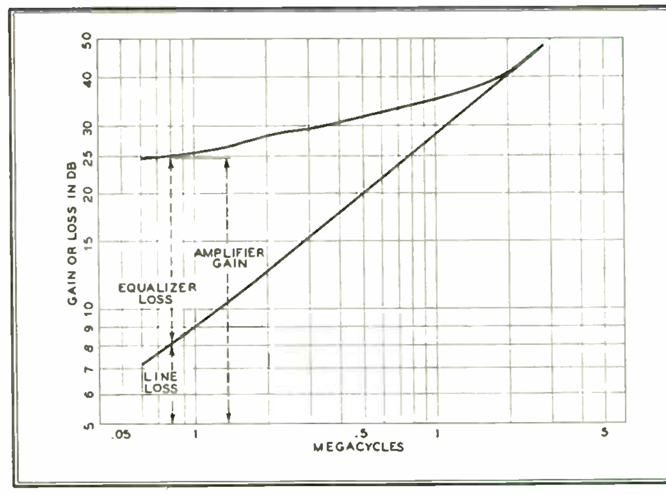


FIG. 7. OVERALL GAIN AND LOSS IN THE LINE. LOSS IS MADE UP BY THE LINE EQUALIZER, TO MAINTAIN ZERO NET LOSS

Local Philadelphia Line ★ The handling of a network program requires the co-operation of many engineers. A pick-up made at some distance from the terminal of the coaxial adds to the many problems involved. The Army-Navy pick-up was typical of such a situation, as the Stadium is located 6 miles south of the coaxial terminal, and required the use of a special wire circuit satisfactory for television. An ordinary telephone pair was selected for the extension from the terminal to the Stadium. For a wide band circuit, no branching can be tolerated. Therefore great care was taken in providing a pair that was clean throughout its entire length. Usually this requires a redistribution of circuits in the particular area involved. Repeaters are required about every mile in a circuit of this type, 5 being used in this case.

From the press box in the west stand, Fig. 2, where the television cameras were located, the program was fed to the Stadium transmitting amplifier room beneath the stand, Fig. 3. From this point, the signals were fed via the repeater points, such as the one shown in Fig. 4, to the receiving terminal at 900 Race Street, Fig. 5, for final monitoring of the extension before transmittal to New York.

Philadelphia-N.Y. Coaxial ★ The many advantages of coaxial cables for long-distance broad-band transmissions are well known. Fig. 6 shows the impedance characteristics as a function of frequency for a 5-mile length of installed cable.

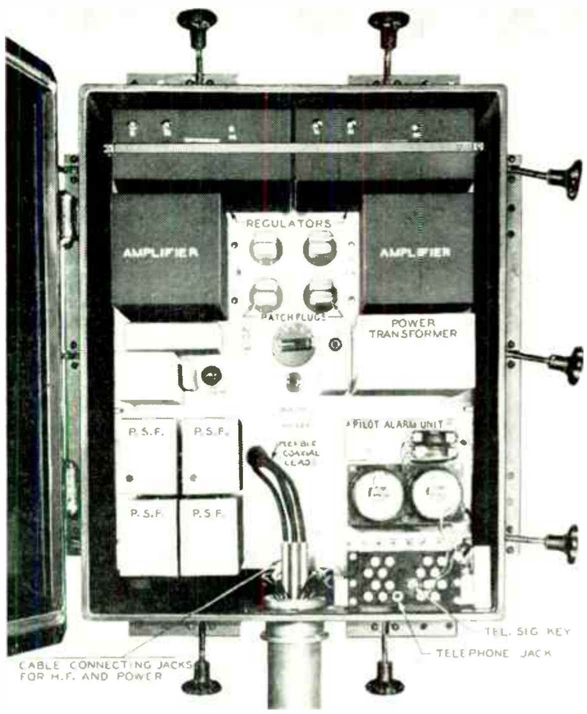
Amplifying equipment, and not the cable itself, determines the bandwidth of a coaxial system within the present required ranges on which studies have been conducted. The amplifiers currently in use provide for approximately a 2.7-mc. bandwidth. To date this has satisfied the demands of black and white transmission. Undoubtedly improvements in the overall system will make better net-work facilities desirable in the future.

The amplifier units installed at intervals along the cable employ a 3-stage feedback circuit with 2 small pentodes in parallel in each stage, providing an output power of .1 to .2 watts at a plate potential of 130 volts. The tubes are used in parallel as a safety factor. Power for the amplifier is transmitted over the coaxial itself from main stations located at about 50-mile intervals, and is separated from the signal at the repeater points by power supply filters.

The overall gain is equal to the line loss plus the loss in the equalizer, as is shown in Fig. 7. The difference between the gain and line loss is made up by a line equalizer, so that, to a first approximation, zero loss in transmission is obtained at all frequencies within the band over each repeater section. Feedback in the order of 30 db is effective around the entire amplifier at frequencies up to 2 mc. with about 10 db additional around the final stage.

To obtain a high degree of transmission stability and linearity, the feedback gradually falls off about 10 db from 2 mc. up to 3 mc. With this type amplifier and cable, repeater sections are required about every 5 miles.

Temperature, tube, and component variations require compensation to provide constant ampli-



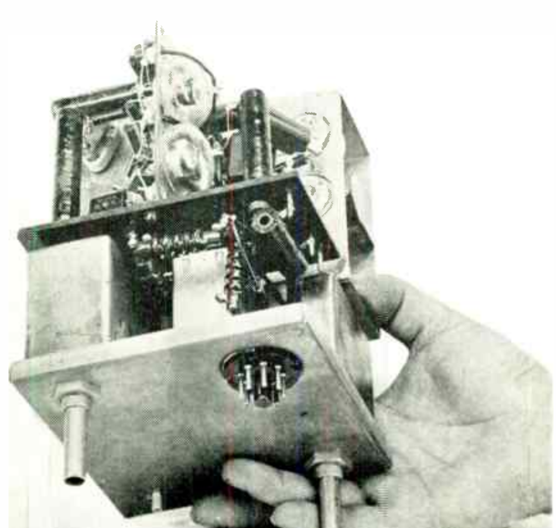


FIG. 8, BELOW: 3-MC. AMPLIFIER UNIT OF THE REPEATER ASSEMBLY

FIG. 9, ABOVE: THIS TYPE OF REPEATER IS REQUIRED EVERY 5 MILES

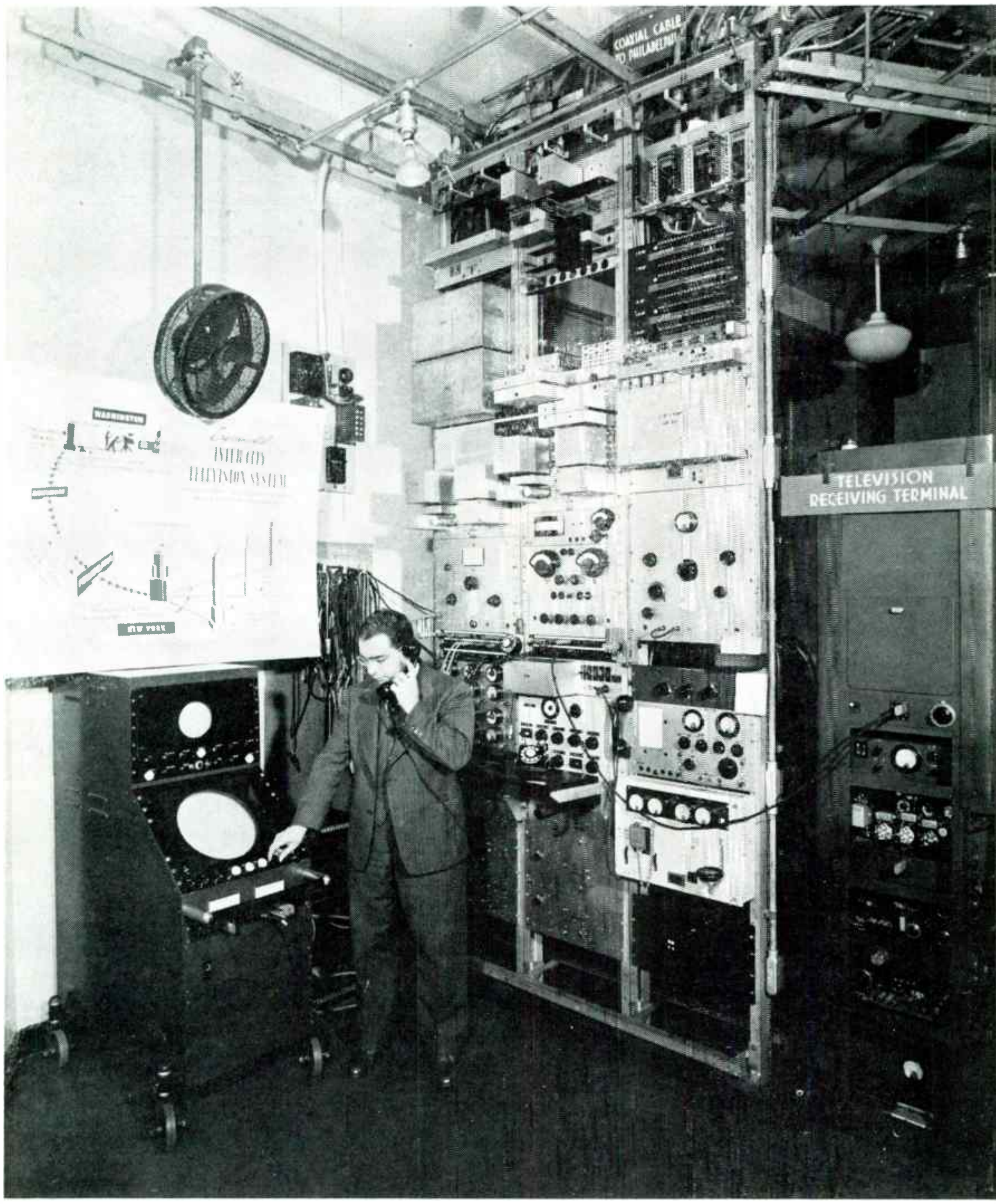


FIG. 10. NEW YORK CITY TERMINAL OF THE N. Y.-WASHINGTON COAXIAL CABLE. TELEVISION SIGNALS ARE MONITORED HERE, THEN CONDUCTED TO ANY OF THE TELEVISION BROADCASTING STATIONS IN THE CITY

fier gain. This is accomplished automatically at each amplifier by means of a small thermistor, made up of oxides which have a very large negative temperature coefficient of resistance.

In this system, three pilot frequencies of 64, 2064, and 3096 kc. are transmitted along the line with the signal. A high impedance crystal filter circuit is bridged across the coaxial at the repeater to isolate these frequencies, which are then amplified and rectified for use in controlling the output of an oscillator. This output is then used to control the resistance of the thermistor. Thus, the regulation maintains substantially constant output voltages at the pilot frequencies over a range of about 9 db in input voltage, which is more than ordinarily obtained in practice.

To compensate for changes in loss in the coaxial conductors over a wide variation in temperature, the feedback circuit has been designed so that changes in the resistance of the thermistor produce changes in gain over the entire frequency band. Overall and supplementary adjustments are required at 50-mile intervals, in addition to the 5-mile points, to give the desired overall accuracy and uniformity. Fig. 8 shows the 3-mc. amplifier unit, and Fig. 9, the complete repeater assembly capable of handling two coaxials, one for each direction. The complete assembly contains, in addition to the two amplifiers, the power supply, equalizers, automatic regulators and various automatic alarm circuits. The overall size is about 2 by 2 by 1 ft.

Twenty repeater points, including a main repeater at Princeton, were required for the Philadelphia to New York transmission of the Army-Navy game. The New York terminal, Fig 10, is located at 32 Sixth Avenue. Here, in addition to the 3-mc. terminating equipment, are located the amplifiers for voice transmission over the associated wires in the coaxial cable, or over the coaxial tubing itself if so desired. The complete system provides for 480 voice circuits, stacked one above the other, in the frequency band from 68 to 2044 kc. which can be transmitted over a pair of coaxials. In television trans-

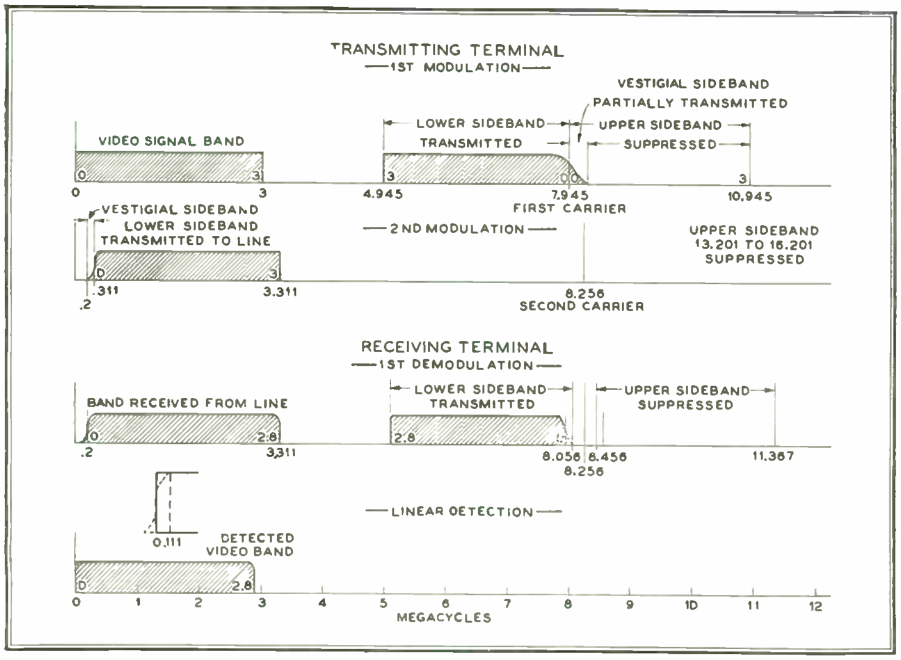


FIG. 11. MODULATION AND DEMODULATION OF SIGNALS FOR CABLE TRANSMISSION

mission, a program is treated as one voice circuit, occupying a bandwidth of approximately 2.7 mc.

The video frequency range is not suitable for long distance transmission, due to the relatively low frequencies involved. The carrier method used in this system provides for raising the entire video frequency band to a region more suitable for transmission. Also, to conserve frequency space, single side band transmission is employed. Although the amplifiers pass a bandwidth from about 64 kc. to 3100 kc., slightly less than 3 mc. are used due to the difficulty of equalizing delay distortion near the lower edge of the band. Allowing about 100 kc. for proper shaping of the vestigial side band, a net television band of about 2.7 mc. is obtained with the carrier placed at 311 kc.

Two modulation steps are used to bring the carrier up this amount, as shown in Fig. 11. A frequency of 311 kc. was selected, to take full advantage of the available feedback in the amplifier. In the first modulation step, the signal is modulated with a carrier of approximately 8 mc., using a band filter selecting the lower sideband, part of the carrier, and a portion of the upper sideband. This is illustrated at the top of Fig. 11. The resultant is again modulated with about an 8.3 mc.

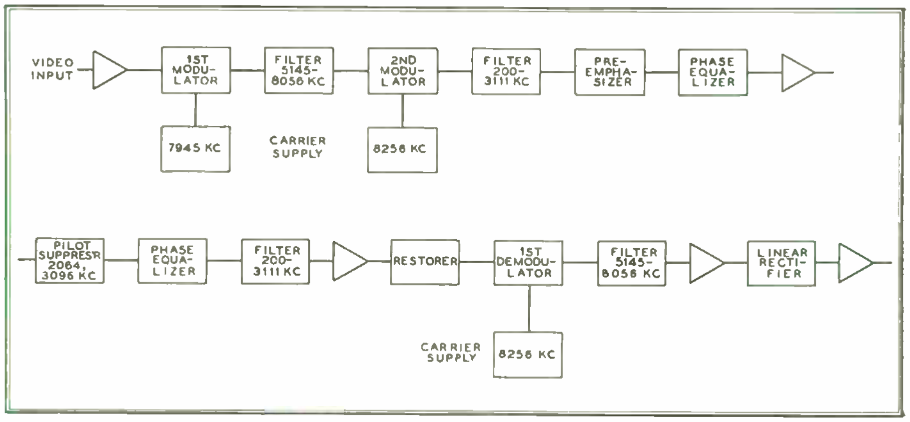


FIG. 12. BLOCK DIAGRAM OF THE TRANSMITTING AND RECEIVING TERMINALS

carrier and the lower sideband selected, as Fig. 11 shows at the second line. It is then in position for transmittal over the coaxial line.

Fig. 12 is a block diagram of the transmitting and receiving carrier terminals. Pre-emphasis and de-emphasis, plus a phase equalizer, are used to help override noise and spurious modulation products and to correct for phase distortion. Fig. 13 shows the frequency allocation of the pilot frequencies, program channel, and television channel.

Within New York City, a permanent shielded cable was used for extension of the coaxial system to the Empire State Building. For this distance no intermediate repeater amplifiers are required.

Network Service ★ With the coaxial cable system now extended and tested as far as Washington, D. C., a regular network television service on an experimental basis was started in January of this year. It is expected that the system will be officially inaugurated about the end of January. Shortly after that event, it is planned to make the cable facilities available to CBS, NBC and Dumont two nights a week each for regular service.

New Facilities ★ An improved eight-coaxial type of cable, in which the diameter of each tube is .375 ins. in diameter, is being planned for early installation in other sections of the country, principally along the 1,450-mile Dallas-Los Angeles route, and for the proposed Buffalo-Cleveland, and New York-Philadelphia projects. With this larger tubing it is expected that repeater stations every 8 miles will provide the same circuit capacity. Main stations, now situated at intervals of as much as 80 miles with the smaller coaxial, can be spaced as far as 150 miles with the newer type. Upon the availability of wider-band associated equipment, a bandwidth of approximately 4 mc. can be handled, providing an improved video channel is desired. A cross section of the new eight-coaxial cable is shown in Fig. 14. Two of these wires will be used for pilot alarm, four as the cableman's talker, and the remaining two for gas pressure alarm. In the center of the cable are two quads of wires, also for pilot alarm. Around these are eight pairs of wires for express and local order wires, plus spares. It is planned to have a 38-mile sample section ready for tests this year.

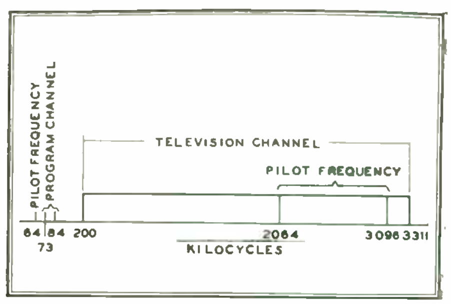


FIG. 13. ALLOCATION OF PILOT, PROGRAM, AND TELEVISION FREQUENCY CHANNELS

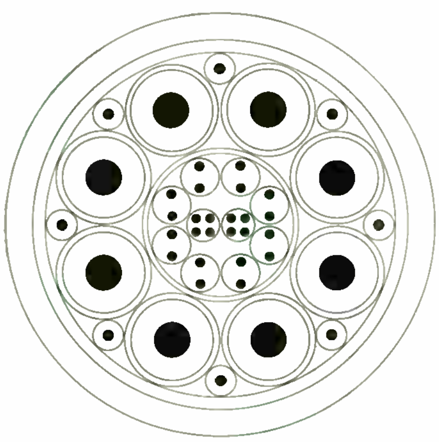


FIG. 14. NEWEST TYPE COAXIAL CABLE

SPOT NEWS NOTES

Items and comments, personal and otherwise, about manufacturing, broadcasting, communications, and television activities

E. Finley Carter: Former vice president in charge of industrial relations for Sylvania has been named vice president in charge of engineering, following the resignation of Roger M. Wise.

Television Licensees: On December 21st, the FCC announced that the following commercial television stations have been licensed:

Balaban & Katz, Chicago	WBKB	66–72 mc.
CBS, New York	WBCW	54–60 mc.
DuMont, New York	WABD	76–82 mc.
NBC, New York	WNBT	66–72 mc.
Philco, Philadelphia	WPTZ	60–66 mc.
G. E., Schenectady	WRGB	66–72 mc.

In addition, the following experimental stations have been licensed:

Balaban & Katz, Chicago	W9XBK	66–72 mc.
Crosley, Cincinnati	W8XCT	66–72 mc.
DuMont, New York	W2XVT	76–82 mc.
DuMont, Passaic	W2XWV	76–82 mc.
Don Lee, Los Angeles	W6XAO	54–60 mc.
Philco, Springfield, Pa.	W3VE	60–66 mc.
Tele. Prod'ns, Los Angeles	W6XYZ	76–82 mc.
Zenith Radio, Chicago	W9XZV	54–60 mc.
RCA, Camden	W3XEP	82–88 mc.
Univ. of Iowa, Ia. City	W9XUI	44–50 mc. also 210–216 mc.

Arthur Freed: Vice president and general manager of Freed Radio Corporation: "One very important fact the dealers will have to learn about FM is that all sets will not give identical performance just because they have FM circuits. Until official standards are established, dealers should check the performance of FM models with great care before putting them on sale, giving special attention to sensitivity, noise level, and audio range. Also, a complete antenna system should be sold with every receiver, for reception problems at 88 to 108 mc. are very different from those at AM broadcast frequencies."

FM for Irrigation Control: At Garwood, Texas, the Garwood Irrigation Company has been authorized to erect an FM headquarters station and to operate two 50-watt and four 35-watt mobile units for cars which patrol 200 miles of canals, in addition to ditches, extending over 100,000 acres of farms. Until now, communications between water patrons, patrols, and headquarters have been catch-as-catch-can, and much damage has been done from lack of close water regulation. Now, patrons will be able to phone headquarters and get instructions to the nearest patrol in a matter of minutes.

David B. Smith: Director of Philco's research division since 1941 and present chairman of the RMA television standards committee, has been appointed vice president in charge of engineering of Philco Corporation.

Radio Set Prices: Of 75 radio sets listed in OPA reports No. 2 and 3, the average retail price was $37. Of these, 63 were AC-DC models, and 12 were AC types.

Of the 63 AC-DC models, 55 were priced under $30, and averaged $23.95. Only 8 AC-DC models were above $30. They averaged $35.38. Lowest in these two groups was $10.55; highest was $41.25.

Eight AC table models, ranging from $37.85 to $82.70, averaged $52.78. One AC table combination and four console combinations, averaging $150.95, were responsible for bringing up the average of the entire 75 sets to the $37 average. All were for AM tuning only.

Prior to the war, the average retail unit sale of FM-AM radios was about $350. When OPA prices are issued for postwar FM-AM models, there will be more in the lower brackets than formerly, but the type of sets that were most popular in the past will be upped enough to keep the average of FM-AM unit sales close to the old level.

Significance of this data is that the dollar volume is going to be too low to support all the old and new companies unless FM broadcasting and FM set sales are promoted aggressively. This applies to components manufacturers, too.

The analysis above shows that AM sets will mean very little business for transformer and coil-winding manufacturers, or for those producing anything better than the cheapest grades of condensers, resistors, tuning controls, and other radio parts.

In short, the industry needs FM to raise the average unit of sale as much as listeners need FM to provide enjoyable radio reception.

C. R. Runyan, Jr.: Presented with the Armstrong Medal by the Radio Club of America at its annual dinner in December. This much-coveted honor was in recognition of his contributions to amateur radio over a period of nearly 40 years, and for his work in building the 100-mc. FM transmitter at his station W2AG, Yonkers, where he gave hundreds of demonstrations, including that for the IRE when Major Armstrong disclosed his FM system to the industry.

CBS Color Television: The demonstration of color television which CBS promised to give the press on January 8th was called off on the 7th. Last-minute announcement explained that the engineering department had been disorganized by influenza, and expressed the hope that their new, higher-powered transmitter will be in operation by the time a new date can be set for the demonstration.

Lawrence K. Marshall: President of Raytheon Manufacturing Company: "Perhaps one of the greatest detriments to the sale of such technically complex products as television receivers has been the difficulty of obtaining satisfactory installation work. . . . In fact, the sales departments at both Raytheon and Belmont feel that service facilities may decide the ultimate public acceptance or rejection of much new electronic equipment."

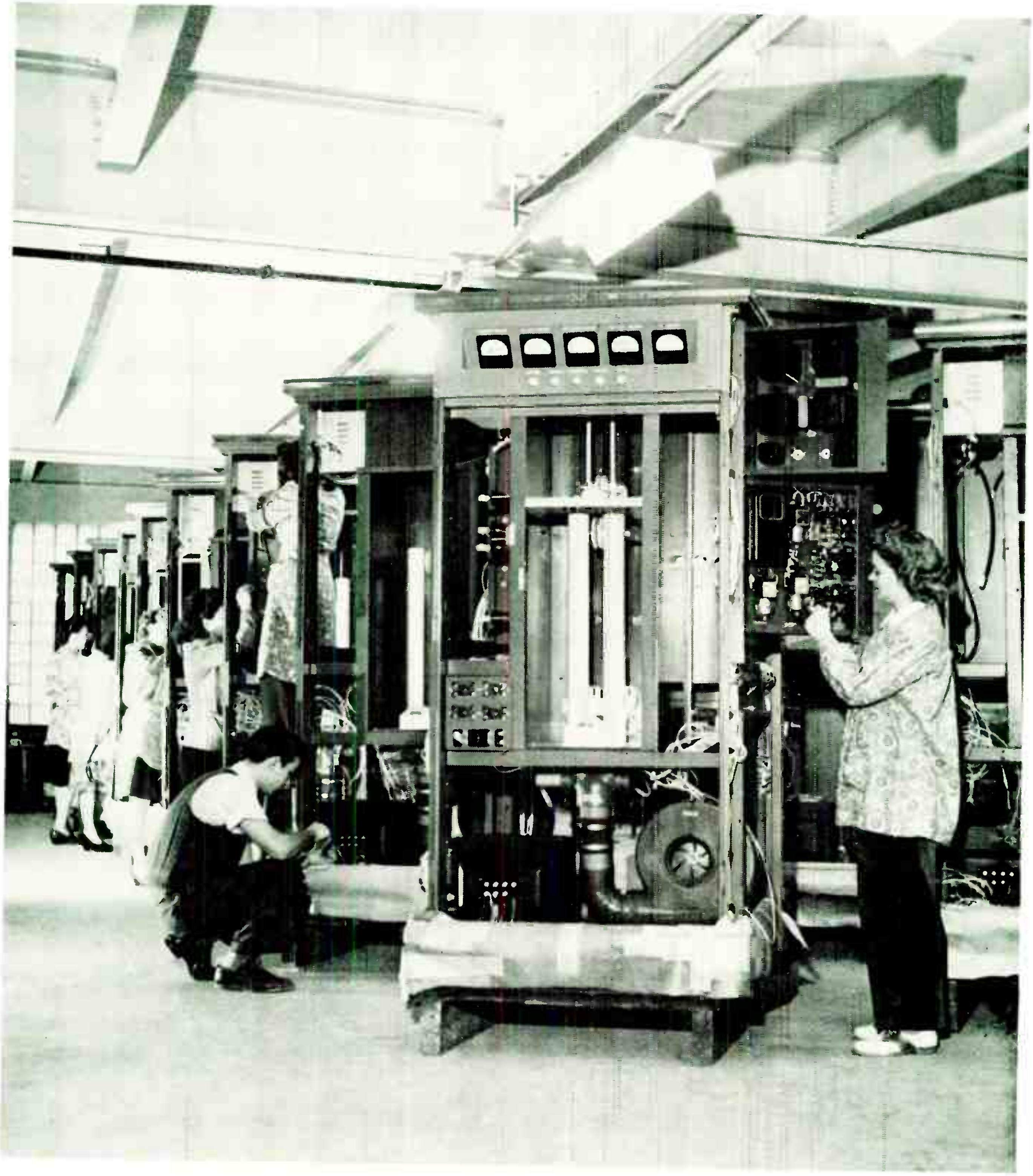
FM Antenna: After erecting a 105-ft. Wincharger antenna at Radio Hill, Great Barrington, we can discuss this kind of an undertaking from first-hand experience. What the job involved, how it was accomplished, and how much it cost will be told in detail, with progressive pictures, in a forthcoming issue of *FM* AND TELEVISION Magazine. Considering that the work was carried out during a prolonged period of sub-zero weather when the wind was tearing around the Berkshire Hills, you'll be surprised to know how easy it was.

Comdr. Robert M. Booth, Jr.: Who did an outstanding job at the radio laboratory of the Naval Aircraft Factory, Philadelphia, is now associated with the law office of Kremer & Bingham, 921 Tower Building, Washington, D. C.

Television Expansion: DuMont Laboratories have set up a new Television Broadcasting Division, in which will be centered the operation of WABD New York, the new studios at John Wanamaker's, W3XWT Washington, and stations at Pittsburgh, Cleveland, and Cincinnati, for which applications have been filed. The new division will be under the direction of Leonard F. Cramer, DuMont vice president.

Microwave Radio: Applications have been filed by the American Telephone and Telegraph Company for a chain of microwave relay stations between Milwaukee and Chicago. This system will be used in coöperation with WMJT, *The Milwaukee Journal's* projected television station, for carrying video programs. Service will be available to others who are able to make use of it.

This system, with intermediate installations at Barrington, Ill., and at Wilmot and Prospect, Wis., will cost about $500,000. If there is no delay in obtaining FCC approval, the relay should be ready for tests in the spring of 1947. Towers 120 ft. high will carry antennas designed for operation on frequencies in the 4,000-mc. range.



NEWS PICTURE

PERHAPS the first 1-kw. new-band FM transmitters to be installed will be these units nearing completion in REL's plant No. 2 at Long Island City, N. Y. Shipments are scheduled to start soon, but engineers attending the I.R.E. Winter Conference may have a chance to examine finished transmitters if impatient customers can be kept waiting for a few days.

Some of these units will go into stations authorized to use only 1 kw., while others, authorized to operate on higher power, will go on the air now with 1 kw., and add power amplifiers later, when available.

As manufacturers' plans are now developing, new band-transmitters will be installed at a rate that will build up the demand for receiving sets as fast as receiver production can be accelerated. This is a healthy condition, for the chicken will not be waiting to emerge from the egg, nor will the egg have to wait upon the chicken to lay it.

As higher power extends transmitting range to outer suburban and rural areas, set manufacturers will be ready to expand their distribution. Thus, FM should progress in a balanced, orderly manner which, it is hoped, will protect the industry from the sudden boom, quickly followed by widespread failures, experienced in the period from 1920 to 1922.

HIGH-QUALITY FM REPRODUCTION

A Duplex Loudspeaker and Associated Amplifier to Match FM Audio Quality

BY JOHN K. HILLIARD*

THE FCC's standards of good engineering practice for FM broadcast stations, requiring the transmission of frequencies of 50 to 15,000 cycles with very low distortion, will make available to radio listeners a degree of audio fidelity that has never been realized from AM transmission.

At FM broadcast studios, it will be necessary to use monitors with a frequency range up to 15,000 cycles in order to check transmitting line noises, telephone carrier cross-talk, and high-frequency disturbances that may overload the transmitter and produce intermodulation effects throughout the audible range.

There would be no reason to transmit frequencies up to 15,000 cycles unless reproducers of corresponding capability are available to radio listeners. Thus it is evident that loudspeakers and their associated amplifiers are the limiting factors, both at FM studios and in listeners' homes, in achieving the sense of presence that FM can provide.

These remarks may challenge the reader to reply: "If the speaker on my AM receiver could go up to 15,000 cycles, I still would turn down the tone control to cut off everything above 3,000 cycles. I don't like that shrill quality."

*Chief Engineer, Altec Lansing Corporation, 6900 McKinley Ave., Los Angeles, Calif.

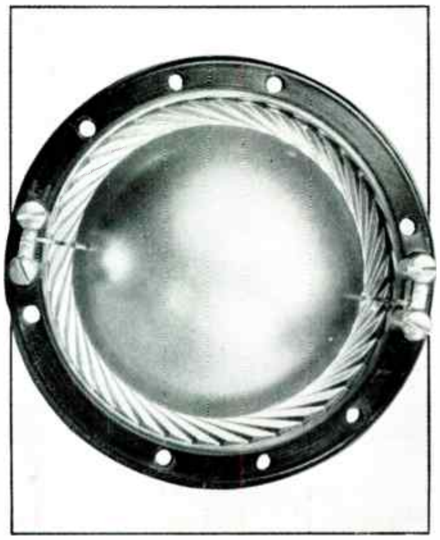


FIG. 2. HF DIAPHRAGM IS ALUMINUM

Audio reproduction is a personal matter, and a matter of personal experience. Therefore, it is impossible to convince a listener that he will enjoy something he has never heard. It can only be said that listeners accustomed to AM reception, or wartime reception of recordings and network programs on FM, should reserve judgment until they hear full-quality FM on speakers that deliver undistorted reproduction up to 15,000 cycles. It has been the writer's experience that such a demonstration of FM reception invariably results in the question: "How can I get an outfit like that for *my* home?"

Conventional Speakers ★ Conventional single-unit loudspeakers furnished in radio receivers, phonographs, and even station-monitors have several limitations. These are:

1. Intermodulation distortion produced when high frequencies are superimposed on low frequencies which cause large diaphragm excursions. (The lower the frequency, the larger the diaphragm movement for constant power output.)
2. The size of the diaphragm is limited by non-uniform radiation, due to the fact that the angle of distribution decreases as the frequency increases.
3. Requirements for best low-frequency reproduction are opposed to those for proper high-frequency radiation. Large diaphragms and heavy voice coils are needed for low frequencies, while very small diaphragms of extremely small mass are required for the highest frequencies.
4. The speed of propagation of sound in

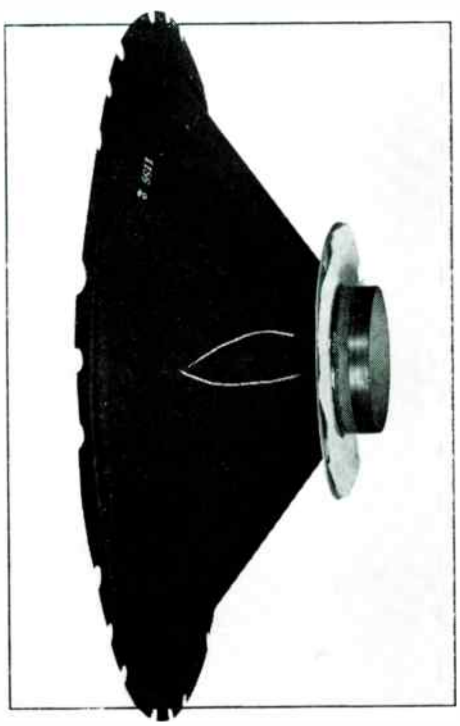


FIG. 3. LF DIAPHRAGM IS MOLDED PAPER

FIG. 1. THE ASSEMBLED DUPLEX SPEAKER, SHOWING POSITION OF THE DIFUSER

a paper cone does not permit efficient radiation of high frequencies.

In addition there are related factors of amplifier design which will be discussed in the latter part of this paper.

It was recognized many years ago that great improvement in audio reproduction could be achieved by the use of two loudspeakers, one for low frequencies and another for the higher frequencies. Such a two-way loudspeaker, when properly designed, reduces the limitations listed above to a very marked degree.

The Duplex Loudspeaker ★ The Altec Lansing duplex loudspeaker, Fig. 1, is a permanent magnet speaker which incorporates several advanced design features and utilizes some of the newer materials which meet certain very special requirements. One unique feature is the concentric arrangement of the high- and low-frequency speaker units on a common horizontal

FIG. 5. SPEAKER CABINET OF 7 CU. FT.

axis. Both speaker units are mounted on a single 15-in. die cast frame. This provides compactness unobtainable in two-way speaker systems employing two separate horn assemblies. The die cast frame assures permanent alignment of the cone and voice coil. The rated capacity of this speaker is 25 watts, and it can be used safely up to this power without fear of damage to any of its parts.

HF Speaker Unit ★ The high-frequency speaker unit of this assembly utilizes a metal diaphragm, Fig. 2, having an active vibrating diameter of 1¾ ins. It is designed to operate as a piston up to frequencies above the limits of audibility. It is made of aluminum alloy to obtain the required stiffness and a velocity of transmission three times as great as that of paper. The resulting light weight and high stiffness prevents it from breaking up and producing the intermodulation effects so common with paper diaphragms.

Tangential corrugations in the com-

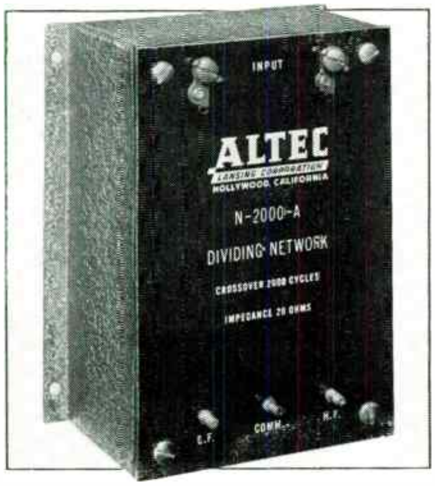


FIG. 4. THE DIVIDING NETWORK UNIT

pliant portion surrounding the dome are used instead of the usual annular type. The tangential compliance permits three times as much movement as the annular type for the same stress. This results in an increased freedom of motion which allows the diaphragm to handle large stresses to the center of the dome.

If the diaphragm were made small enough to radiate sound directly, without having a sharp beam, it would be too small

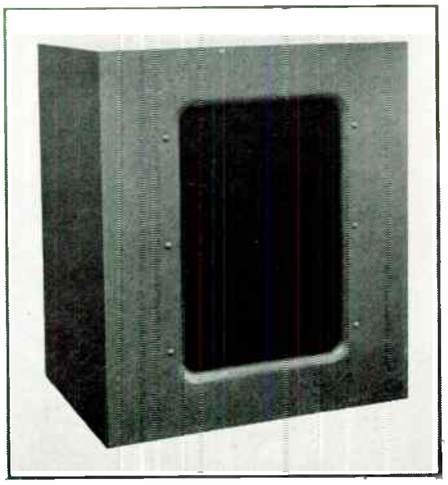


FIG. 6. THIS CABINET IS OF 6 CU. FT.

to handle the required power. This condition necessitated the selection of the multicellular high-frequency horn as a radiating medium.

As Fig. 1 shows, the horn has six cells, each cell having a 20° angle. Since the configuration is 2 by 3 cells, the maximum angles of radiation are 40° × 60°. The angles, size, and cut-off of the high-frequency horn were specifically selected to prevent interference from the low-frequency cone.

The high-frequency horn is mounted on the end of the low-frequency pole piece which is bored out to permit the passage of sound from the high-frequency diaphragm to the horn. The sound, as it leaves the diaphragm, passes through annular slits which effectively prevent destructive interference being set up within the chamber. This transducer is very necessary as, otherwise, unequal path lengths from the diaphragm to the chamber would cause standing waves.

The voice coil of the high-frequency unit is constructed of edgewise wound aluminum ribbon. The use of this ribbon provides 27% more conductor material in the air gap, with the result that the efficiency is increased to the extent that approximately 22% more acoustic power is obtained.

The diaphragm is clamped to a cast bakelite ring which is held in position by three screws which secure it to the top plate. This can be seen in Fig. 2. By means of these screws, the diaphragm and voice coil assembly can be removed easily without special tools. Accurately positioned dowel pins in the top plate and corresponding holes in the bakelite ring assure proper alignment of the voice coil within the gap.

LF Speaker Unit ★ The low-frequency speaker unit, Fig. 3, employs a seamless, molded cone having an effective area of 116 sq. ins. The cone is moisture resistant and is mounted within the die cast frame concentric with the high-frequency speaker unit.

The low-frequency voice coil is constructed of edgewise wound copper ribbon to provide the maximum amount of conductor in the air gap. This greatly improves the efficiency. The voice coil is considerably larger than usual, being 3 in. in diameter. This results in an increased ability to handle higher power without

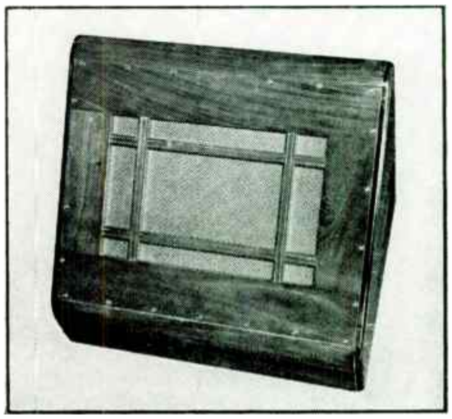


FIG. 7. WALL-MOUNTED CORNER CABINET

undue temperature rise. It also permits a decreased cone depth with an increase in the effective stiffness of the cone, causing it to act more nearly as a piston. The impedance of the voice coil is approximately 20 ohms and the resonance of the cone and voice coil assembly is 40 cycles in free air. A clamping ring secures the outer rim of the cone to the frame. The inner spider assembly is held in place by screws so that it is a simple operation to remove the entire coil and cone assembly.

Permanent Magnets ★ There are two permanent magnets made of Alnico No. 5, one for each diaphragm. These magnets are of the center-core type, and the soft magnetic materials forming the path between the pole pieces are amply proportioned so that the magnetic flux is conducted through the outside walls and up to the air gap with little loss. The flux density is considerably higher than that ordinarily used in commercial units in the past. This provides better damping of the diaphragms which, in turn, materially increases their ability to handle transients having steep wave fronts. The design is such that the loss due to external leakage is extremely low. The magnets do not attract metal objects in the immediate vicinity, nor will they materially deflect the beam of a cathode ray tube operated in close proximity.

Efficiency ★ The Altec Lansing speaker has an overall efficiency in the region of 500 to 1500 cycles such that it produces 92 db (ref. 10 16 dynes per sq. in.) at a distance of 5 ft. with an input of 0.1 watt.

This increased efficiency minimizes distortion at all performance levels, and gives a much greater dynamic volume range. This can be demonstrated readily by placing a conventional loudspeaker alongside the duplex speaker and balancing them to give the same acoustic output at some medium level. It will then be observed that when the input is decreased to the point where output is zero on the conventional speaker, the duplex speaker will still be audible. Similarly, at high volume, as the input to both speakers is increased, it will be observed that the duplex speaker will deliver more acoustical energy. This is due to the increased linearity of the flux in the air gap.

Dividing Network ★ The cross-over point of the dividing network unit, Fig. 4, is approximately 2000 cycles. It was necessary to select this high cross-over frequency so that the size of the multi-cellular horn could be kept small because, mounted on the face of the low-frequency horn, it would otherwise obstruct the low-frequency cone radiation.

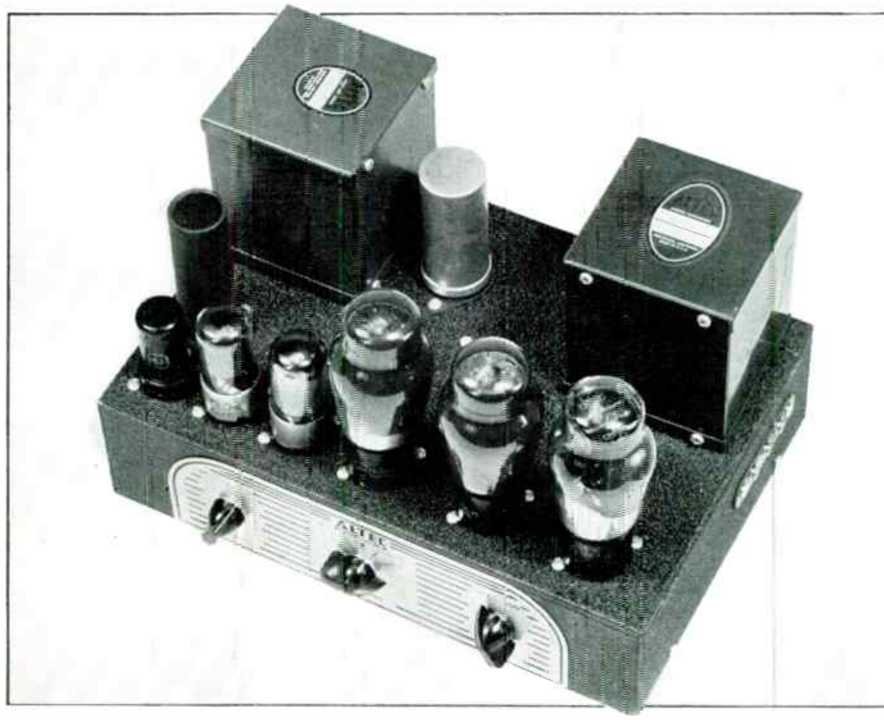


FIG. 8. THIS AMPLIFIER, DESIGNED FOR THE DUPLEX SPEAKER, USES 6L6'S

Distribution & Frequency Range ★ The angle of distribution of sound energy is determined by the number and size of the cells in the high frequency horn. Each cell in the duplex loudspeaker has a distribution angle of 20°. Since the horn has six cells with a configuration of 2 by 3 cells, the angles of coverage are 40° by 60°. Provision is made for rotating the horn to give either of these angles of horizontal distribution with the corresponding angle of vertical distribution, as may be required.

The frequency range of the speaker is such that it will radiate efficiently over the entire 40° by 60° area up to 15,000 cycles. The low-frequency range is limited only by the size of the cabinet used, down to its natural resonant frequency of 40 cycles. The deviation of impedance with frequency is considerably less than with less efficient loudspeakers, and for this reason it is possible to secure fundamental radiation at low frequencies provided proper loading is used.

Speaker Mountings ★ The duplex speaker is adaptable to many types of cabinets and enclosures. It is normally furnished in three standard cabinets, as follows:

1. The largest cabinet, Fig. 5, is 38 by 30 by 16 ins., and has a volume of approximately 7 cu. ft. A tuned port at the

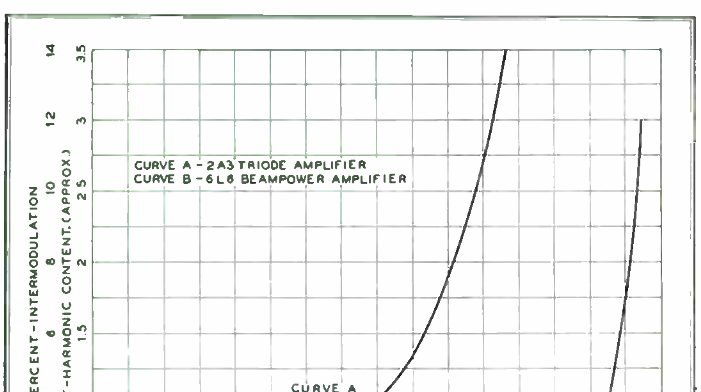


FIG. 9. COMPARISON OF INTERMODULATION WITH 2A3'S AND 6L6'S

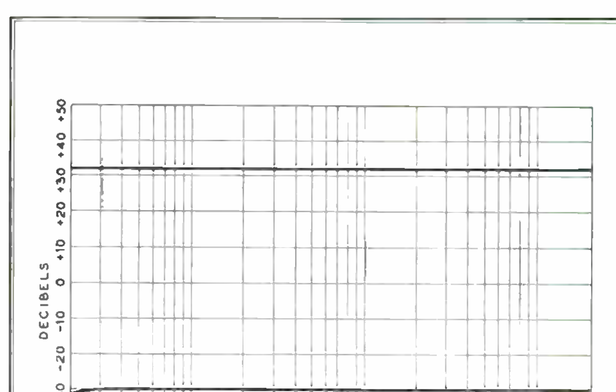


FIG. 11. FREQUENCY CHARACTERISTICS OF THE AMPLIFIER

lower front of the cabinet has an opening of 90 sq. ins. This port maintains radiation down to 55 cycles.

2. The medium-size cabinet, Fig. 6, is 30 by 25 by 18 ins., with a volume of 6 cu. ft. Its port area is 60 sq. in. and it radiates down to 60 cycles.

3. The corner, or wall mounted cabinet, is triangular in shape, as shown in Fig. 7. It is intended for small studios where it is desirable to hang the speaker in a corner or on the wall. Its volume is 5½ cu. ft. and the port is adjusted to radiate down to 65 cycles.

A smaller cabinet, having a volume of 4 cu. ft. with a port area of 50 sq. in., will be efficient down to 70 cycles. Since the duplex loudspeaker resonates in free air at 40 cycles, it follows that the speaker will not produce a peak in any of the cabinets described. It should not be assumed that response in any of these cabinets is uniform down to the cut-off frequency. Actually, the response will be down at least 10 db. However, appreciable radiation can be obtained at fundamental frequencies down to the speaker resonant frequency.

It should be realized that there is no substitute for adequate cabinet size when good low-frequency performance is required. Accordingly large cabinets or enclosures having a volume of 8 to 10 cu. ft. are desirable for good performance down to 50 cycles. A wall can be used as an infinite baffle with good results if a minimum volume of 8 to 10 cu. ft. is provided at the rear. The large cabinet shown in Fig. 5 has a duplex speaker mounted in the top portion, with the port below. This is done so that high frequencies can be radiated directly, without having low obstacles blocking their path.

The internal bracing of the cabinets provides the equivalent of ¾-in. plywood, so that no appreciable amount of cabinet vibration is permitted. Eliminating vibration of the cabinet walls or supports prevents dissipation of acoustic energy in friction, with its resultant decrease in the effective output. Rock wool pads, 1 in. thick, are placed on at least three of the sides to reduce slap or hang-over effects within the cabinet. Because the cabinet is subjected to vibration of large amplitude at low frequencies, it is not advisable to mount the amplifier in the cabinet with the speaker, since feedback may be generated.

Upon first hearing the duplex speaker, the listener may feel that more bass response is required. However, after more careful observation it will usually be agreed that true bass response is actually being heard. This is due to the lack of cabinet and speaker resonance which, by generating harmonics, gives a false bass response.

Input Requirements ★ Where the source of input to the loudspeaker has distortion, as in the case of phonograph records, poor transcriptions, or over-modulated transmitters, it is advisable to provide a low pass filter ahead of the loudspeaker. Several taps should be included for adjustment in the 6,000 to 10,000 cycle area. By proper adjustment, input distortion can be made less objectionable than with unlimited response.

The amplifier output impedance determines to a great extent the amount and quality of bass response obtained from a loudspeaker. Heretofore, because of the low internal damping in loudspeakers, it has been necessary and customary to adjust the amplifier impedance much lower than the normal impedance of the loudspeaker. This mismatch of impedances was used purposely to provide a high degree of external damping for the speaker. By this method, the counter EMF generated by the speaker was high and the diaphragm had less tendency to "free-wheel" than when driven from a matched impedance.[1]

An analogy can be made to a meter movement. If the meter is terminated in a load which has a low resistance compared to the meter resistance, the meter movement will not overshoot on pulses but will be over-damped in its action. However, if the meter is terminated in a resistance greater than its critical resistance, the meter will overshoot and oscillate before coming to a steady reading.

Since the duplex speaker has a very high efficiency, due to greater flux density and low resistance, a very high internal damping is provided. This results in a very constant impedance over a wide frequency range. For this reason the duplex loudspeaker can be operated from an amplifier having an output impedance equal to that of the loudspeaker without the free-wheeling effect mentioned above.

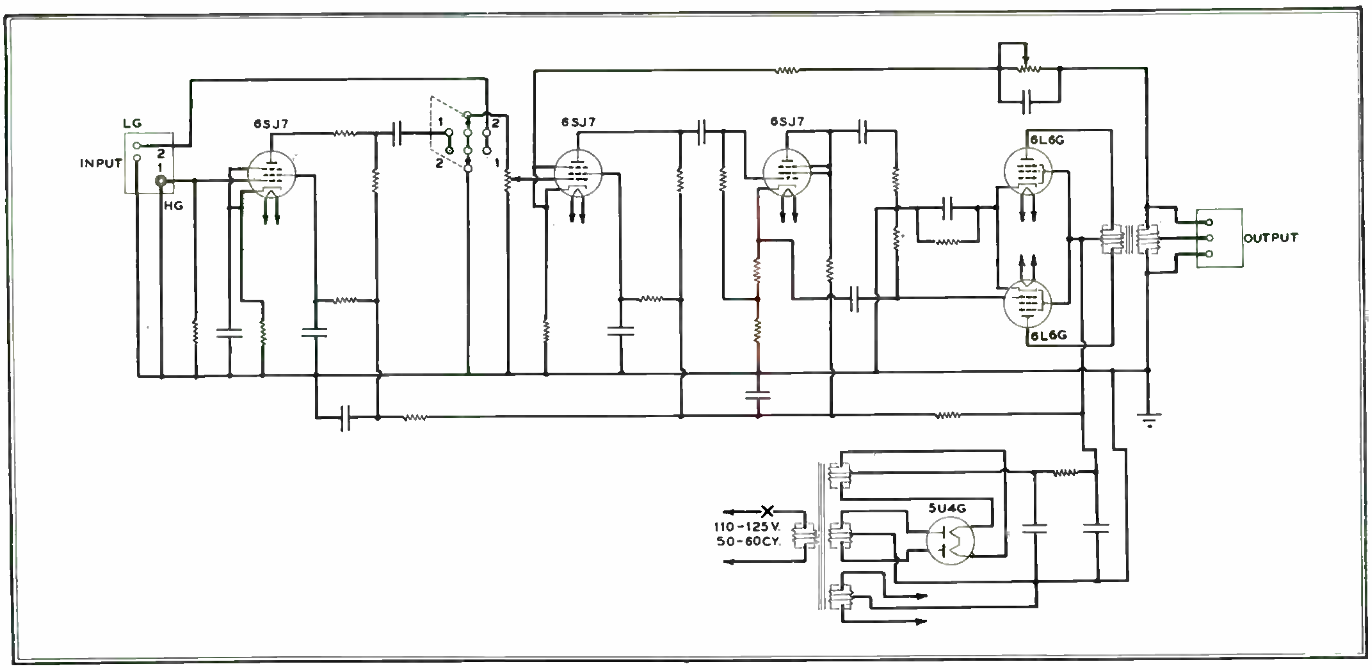


FIG. 10. SCHEMATIC DIAGRAM OF THE AMPLIFIER DESIGNED TO DRIVE THE DUPLEX TYPE LOUDSPEAKER

The A-323 Amplifier ★ The extremely wide frequency range of the duplex speaker makes necessary the use of an amplifier of very high quality, in order to give the best sound reproduction. In the past there has been a very decided preference for low-impedance output triodes, rather than beam power tubes, to operate loudspeakers. Apparently this preference was justified in a great many cases. However, the beam power tube has the advantages of high efficiency, greater power sensitivity, and its indirect heater gives less hum. Tests were made to determine how the beam power tube could be utilized

(CONTINUED ON PAGE 57)

[1] Elements of Acoustical Engineering, Olson, pages 140-141.

ANALYSIS OF METROPOLITAN FM ALLOCATIONS

Showing Both Channel Assignments for Each City, and the Cities Sharing Each Channel from 92.1 to 103.9 Mc. — Channel-Frequency Chart Appears on the Last Page

METROPOLITAN FM CHANNELS ASSIGNED TO U. S. CITIES

ALABAMA

Pop. 2,833,000
Sq. Mi. 51,279

Anniston
280
Inc. Gadsden
Bessemer
see Birmingham
Birmingham
226, 228, 230, 232, 234
Inc. Bessemer
Decatur
251
Dothan
267, 269
Gadsden
see Anniston
Huntsville
249
Mobile
231, 250, 271, 273
Montgomery
258, 260, 263
Muscle Shoals
244, 246
Opelika
277
see Columbus, Ga.
Selma
221, 223
Sylacauga
275
see Talladega
Talladega
273
see Sylacauga
Tuscaloosa
254, 256
TOTAL 26 stations

ARIZONA

Pop. 499,000
Sq. Mi. 113,810

Globe
221, 223
Lowell
229, 231
Phoenix
245, 247, 249, 251, 253
Prescott
225, 227
Safford
233, 235
Tucson
237, 239, 241, 243
Yuma
238, 240
TOTAL 19 stations

ARKANSAS

Pop. 1,949,000
Sq. Mi. 52,525

Blytheville
249, 251
see Jonesboro
El Dorado
277, 279
Fort Smith
267, 269
Helena
241, 243
Hot Springs and Hot Springs N.P.
271, 273, 275
Jonesboro
268, 270
see Blytheville
Little Rock
257, 259, 261, 263, 265
Pine Bluff
221
Siloam Springs
245, 247
TOTAL 21 stations

CALIFORNIA

Pop. 6,907,000
Sq. Mi. 155,652

Bakersfield
264, 266, 268
Chico
226, 228
El Centro
232, 234
Eureka
230, 232
Fresno
270, 272, 274, 276, 278
Los Angeles
Metropolitan Dist.
223, 225, 227, 229, 231, 233, 235, 237, 239, 241, 243, 245, 247, 249, 251, 253, 255, 257, 259, 261
Marysville
222, 224
Merced
230, 232
Modesto
257
Monterey
261
Palm Springs
269, 271
Redding
232, 234, 236
Riverside
273, 275
Sacramento
271, 273, 275, 277, 279
Salinas
280
San Bernardino
277, 279
San Diego
222, 224, 226, 228, 230
San Francisco — Oakland
Metropolitan Dist.
221, 223, 225, 227, 229, 231, 233, 235, 237, 239, 241, 243, 245, 247, 249, 251, 253, 255
San Jose
263, 265
San Luis Obispo
222, 224
Santa Barbara
274, 276, 278
Santa Maria
234, 236
Santa Rosa
258, 260
Stockton
267, 269
Visalia
238, 240
Tulare
242, 244
Watsonville
259
TOTAL 96 stations

COLORADO

Pop. 1,123,000
Sq. Mi. 103,658

Alamosa
222, 224
Colorado Springs
265, 267, 269, 271
Denver
245, 247, 249, 251, 253, 255, 257, 259, 261, 263
Durango
226, 228
Grand Junction
230, 232
Greeley
276, 278
La Junta
233, 235
Pueblo
273, 275, 277, 279
Sterling
272, 274
TOTAL 30 stations

CONNECTICUT

Pop. 1,709,000
Sq. Mi. 4,820

Bridgeport
265, 267, 269
Inc. Danbury
Danbury
see Bridgeport
Hartford
226, 228, 230, 232, 234, 236
Inc. Meriden
Meriden
see Hartford
New Haven
263, 271, 275, 277, 279
New London
250, 252
Stamford
Community channel
Waterbury
222, 224, 261, 273
TOTAL 20 stations

DELAWARE

Pop. 267,000
Sq. Mi. 1,965

Wilmington
264, 266, 268
Inc. Bridgeton, N. J.
TOTAL 3 stations

DIST. OF COLUMBIA

Pop. 663,000
Sq. Mi. 62

Washington
221, 223, 225, 227, 229, 231, 233, 263, 265, 267, 269, 271
TOTAL 12 stations

FLORIDA

Pop. 1,897,000
Sq. Mi. 54,861

Daytona Beach
233, 235
Fort Myers
233, 235
Fort Lauderdale
229, 231
Gainesville
267, 269
Jacksonville
240, 242, 244, 246, 248
Key West
225, 227
Lakeland
237, 239
Miami — Miami Beach
238, 240, 242, 244, 246, 248
Ocala
250, 252
Orlando
258, 260, 262
Palm Beach
250, 252
Panama City
275, 278
Pensacola
225, 227, 229
St. Augustine
226, 228
St. Petersburg
221, 223, 225
Sarasota
241, 243
Tallahassee
271, 273
Tampa
227, 229, 231
West Palm Beach
254, 256
TOTAL 49 stations

GEORGIA

Pop. 3,124,000
Sq. Mi. 58,725

Albany
226, 228, 230
Athens
261, 263
Atlanta
251, 253, 255, 257, 259
Augusta
233, 235, 237
Brunswick
221, 223
Cedartown
269, 271
Inc. Dalton
Columbus
242, 244, 246
see Opelika, Ala.
Cordele
254, 256
Dalton
see Cedartown and Rome
Dublin
266, 268
Gainesville
276
Griffin
222, 224
LaGrange
238, 240
Macon
270, 272, 274, 279
Moultrie
262, 264
Rome
265, 267
Savannah
253, 255, 257, 259
Thomasville
249, 251
Toccoa
249
Valdosta
236, 238
Waycross
232, 234
West Point
248
TOTAL 49 stations

IDAHO

Pop. 525,000
Sq. Mi. 83,354

Boise
271, 273, 275
Idaho Falls
268, 270
Lewiston
257, 259
Nampa
267, 269
Pocatello
277, 279
Twin Falls
239, 241, 243
Wallace
268, 270
TOTAL 16 stations

ILLINOIS

Pop. 7,897,000
Sq. Mi. 56,043

Aurora
275, 277
Inc. Joliet
Bloomington
230, 232
Cairo
243
Carbondale
263
Carthage
259, 261
Champaign
see Urbana
Chicago
221, 223, 225, 227, 229, 231, 233, 235, 241, 245, 247, 249, 253, 255, 257, 259, 261
Decatur
254, 256
East St. Louis
see St. Louis, Mo.
Elgin
see Chicago
Evanston
see Chicago
Freeport
271
Galesburg
234, 236
Harrisburg
255, 257
Herrin
259, 261
Jacksonville
278, 280
Joliet
see Aurora
Kankakee
243
Mt. Vernon
265
Peoria
222, 224, 226, 228
Quincy
249, 251
Rockford
273
Rock Island
264
see Davenport, Ia.
Springfield
267, 269, 276
Tuscola
250, 252
Urbana
258, 260, 262
Inc. Champaign
Waukegan
251
TOTAL 55 stations

INDIANA

Pop. 3,428,000
Sq. Mi. 36,045

Anderson
see Indianapolis
Columbus
237
Connersville
273
Elkhart
276, 278
Evansville
222, 224, 226, 228, 230, 232, 234
Inc. Henderson and Owensboro, Ky.
Fort Wayne
236, 238, 240
Hammond
263, 265
Indianapolis
223, 225, 227, 229, 231, 233, 235
Inc. Anderson
Kokomo
268, 270
Lafayette
272, 274
Marion
254
Muncie
277, 279
Richmond
275
Shelbyville
221
South Bend
267, 269
Terre Haute
242, 244
Vincennes
271, 273
West Lafayette
246
TOTAL 39 stations

IOWA

Pop. 2,538,000
Sq. Mi. 55,586

Ames
237
Boone
233, 235
Burlington
257
Cedar Rapids
241, 243
Clinton
279
Davenport
266, 268
see Rock Island, Ill.
Decorah
225, 227
Des Moines
263, 265, 267, 269, 272
Dubuque
256, 258, 260
Fort Dodge
253, 255
Iowa City
245, 247
Marshalltown
230, 239
Mason City
257, 259
Ottumwa
274, 277
Shenandoah
238, 240, 242
Sioux City
274, 276, 278
Spencer
241, 243
Waterloo
249, 251
TOTAL 39 stations

KANSAS

Pop. 1,801,000
Sq. Mi. 81,774

Atchison
264, 266
Coffeyville
276, 278
Dodge City
221, 223
Emporia
269, 271
Garden City
225, 227
Great Bend
258, 260
Hutchinson
237, 239
Kansas City
see Kansas City, Mo.
Lawrence
277, 279
Manhattan
222, 224
Pittsburg
238, 240
Salina
253, 255
Topeka
273, 275
Wichita
241, 243, 246, 249, 251
TOTAL 29 stations

KENTUCKY

Pop. 2,846,000
Sq. Mi. 40,181

Ashland
see Huntington, W. Va.
Bowling Green
242, 244
Harlan
240, 248
Henderson
see Evansville, Ind.
Hopkinsville
250, 252
Lexington
272, 274
Louisville
258, 260, 262, 264, 266, 268, 270
Owensboro
see Evansville, Ind.
Paducah
245, 247
Winchester
276, 278
TOTAL 19 stations

LOUISIANA

Pop. 2,364,000
Sq. Mi. 45,409

Alexandria
261, 263, 265
Baton Rouge
241, 243, 245
Lafayette
247, 249
Lake Charles
277, 279
Monroe
254, 256, 258
New Orleans
224, 226, 228, 233, 235, 237, 239
Shreveport
244, 246, 248, 250, 252
TOTAL 25 stations

MAINE

Pop. 847,000
Sq. Mi. 29,895

Augusta
226, 228, 230
Bangor
232, 234, 236, 238
Lewiston
222, 224
Portland
261, 263, 265
Presque Isle
240, 242
TOTAL 14 stations

MARYLAND

Pop. 1,821,000
Sq. Mi. 9,941

Baltimore
253, 255, 257, 259, 261, 273, 275, 277, 279
Cumberland
256, 262
Frederick
251
Hagerstown
Community channel
Olney
Community channel
Salisbury
Community channel
TOTAL 12 stations

MASSACHUSETTS

Pop. 4,317,000
Sq. Mi. 8,039

Boston
221, 223, 225, 227, 229, 231, 233, 235, 264, 266
Inc. Waltham
Fall River
243, 245, 247
Inc. New Bedford
Fitchburg
Community channel
Greenfield
Community channel
Haverhill
241
Holyoke
238, 240, 242, 244, 246, 248
Inc. Springfield
Lawrence
239
Lowell
237
New Bedford
see Fall River
North Adams
268
Pittsfield
280
Salem
Community channel
Springfield
see Holyoke
Waltham
see Boston
West Yarmouth
Community channel
Worcester
260, 262, 274, 276
TOTAL 28 stations

MICHIGAN

Pop. 5,256,000
Sq. Mi. 57,480

Ann Arbor
277, 279
Battle Creek
271, 273
Inc. Kalamazoo
Bay City
248, 250, 252
Inc. Saginaw
Benton Harbor
280
Cadillac
222
Calumet
242, 244
Dearborn
Community channel
Detroit
221, 223, 225, 227, 229, 231, 233, 235, 237, 239, 241, 243, 245, 247
Inc. Pontiac, Royal Oak and Wyandotte
East Lansing
258, 260, 262
Inc. Lansing
Escanaba
221, 223
Flint
264, 266, 268, 270
Inc. Lapeer
Grand Rapids
224, 226, 228, 230, 232, 234
Ironwood
276, 278
Jackson
Community channel
Kalamazoo
see Battle Creek
Lansing
see East Lansing
Lapeer
see Flint
Ludington
277, 279
Marquette
225, 227
Muskegon
254, 256
Pontiac
see Detroit
Port Huron
272, 274
Royal Oak
see Detroit
Saginaw
see Bay City
Sault Ste. Marie
233, 235
Traverse City
237, 239
Wyandotte
see Detroit
TOTAL 54 stations

MINNESOTA

Pop. 2,792,000
Sq. Mi. 80,858

Albert Lea
261
Duluth
222, 224, 226
Inc. Superior, Wis.
Fergus Falls
221, 223
Hibbing
232, 234
Mankato
222, 224
Minneapolis
244, 246, 248, 250, 265, 267, 269, 271, 273, 275, 277, 279
Inc. St. Paul
Moorhead
257, 259
see Fargo, N. D.
Northfield
238, 240
Rochester
234, 236
St. Cloud
252, 254
St. Paul
see Minneapolis
Virginia
228, 230
Willmar
227, 229
Winona
229, 231
TOTAL 36 stations

MISSISSIPPI

Pop. 2,184,000
Sq. Mi. 46,362

Clarksdale
245, 247
Columbus
237, 239
Corinth
264, 266
Greenville
236, 238
Greenwood
253, 255
Gulfport
253, 255
Hattiesburg
257, 259
Jackson
262, 264, 266, 268, 270
Laurel
242, 244
McComb
276, 278
Macon
272, 274
Meridian
246, 248
Natchez
272, 274
Tupelo
277, 279
Vicksburg
225, 227
TOTAL 33 stations

MISSOURI

Pop. 3,785,000
Sq. Mi. 68,727

Cape Girardeau
239, 241, 243
see Cairo, Ill.
Clayton
see St. Louis

Columbia
244, 246
Hannibal
240, 242
Jefferson City
264, 266
Joplin
272, 274
Kansas City
248, 250, 252, 254, 256, 258, 260, 262
inc. Kansas City, Kan.
Poplar Bluff
276, 278
St. Joseph
234, 236
St. Louis
221, 223, 225, 227, 229, 231, 233, 235, 237
inc. Clayton
Sedalia
268, 270
Springfield
224, 226, 228, 230, 232
TOTAL 39 stations

MONTANA

Pop. 559,000
Sq. Mi. 146,131

Billings
239, 241
Bozeman
243, 245
Butte
248, 250
Great Falls
256, 258
Helena
252, 254
Kalispell
260, 262
Miles City
235, 237
Missoula
264, 266
Sidney
230, 232
TOTAL 18 stations

NEBRASKA

Pop. 1,316,000
Sq. Mi. 76,808

Fremont
280
see Omaha
Grand Island
263, 265
Hastings
233, 235
Kearney
226, 228
Lincoln
245, 247, 249, 251
Norfolk
254, 256
North Platte
222, 224
Omaha
221, 223, 225, 227, 229, 231, 271
see Fremont
Scottsbluff
234, 236
TOTAL 24 stations

NEVADA

Pop. 110,000
Sq. Mi. 109,821

Boulder City
255, 257
Las Vegas
259, 261, 263
Reno
259, 261, 263
TOTAL 8 stations

NEW HAMPSHIRE

Pop. 491,000
Sq. Mi. 9,031

Claremont
271
Keene
Community channel
Laconia
259
Manchester
269, 279
Mount Washington
251, 253, 255, 257
Portsmouth
249
TOTAL 9 stations

NEW JERSEY

Pop. 4,160,000
Sq. Mi. 7,514

Alpine
see New York
Asbury Park
Community channel
Atlantic City
Community channel
Bridgeton
see Wilmington, Del.
Camden
see Philadelphia
Ewing Township
see Trenton
Jersey City
see New York
Newark
see New York
New Brunswick
Community channel
Paterson
see New York
Trenton
270, 272, 278
inc. Ewing Towush.
Zarephath
Community channel
TOTAL 3 stations

NEW MEXICO

Pop. 532,000
Sq. Mi. 122,503

Albuquerque
245, 247, 249, 251
Carlsbad
221, 223
Clovis
237, 239
Gallup
238, 240
Hobbs
246, 248
Las Vegas
254, 256
Roswell
233, 235
Santa Fe
258, 260
Tucumcari
276, 278
TOTAL 20 stations

NEW YORK

Pop. 13,479,000
Sq. Mi. 47,654

Albany
221, 223, 225, 227, 229, 231, 233, 235, 259, 264, 266, 272
inc. Schenectady and Troy
Auburn
see Syracuse
Batavia
241, 243
Binghamton
242, 244
Brooklyn
see New York
Buffalo
221, 223, 225, 227, 229, 231, 233, 235, 237, 239
inc. Niagara Falls
Coram
see New York or possibly Conn. channels
Corning
236
see Elmira
Dunkirk
277, 279
Elmira
238
see Corning
Freeport
Community channel
Gloversville
245
Hornell
260
Ithaca
258, 267
Jamaica
Community channel
Jamestown
268, 270
Kingston
Community channel
Massena
226, 228
Middletown
Community channel
Mt. Vernon
see New York
Newburgh
Community channel
New York
221, 223, 225, 227, 229, 231, 233, 235, 237, 239, 241, 243, 245, 247, 249, 251, 253, 255, 257, 259
inc. numerous adjacent cities
Niagara Falls
see Buffalo
Ogdensburg
260, 262
Olean
272, 274
Oswego
270
Plattsburg
222, 224
Poughkeepsie
Community channel
Rochester
245, 247, 249, 251, 253, 255
Saranac Lake
237, 239
Schenectady
see Albany
Syracuse
222, 224, 226, 228, 230, 232, 234
inc. Auburn
Troy
see Albany
Utica
250, 252, 254
Watertown
256, 265
West New Brighton
see New York
White Plains
see New York
Woodside
see New York
TOTAL 85 stations

NORTH CAROLINA

Pop. 3,572,000
Sq. Mi. 48,740

Asheville
232, 234, 236
Burlington
267
Charlotte
264, 266, 273, 275
see Gastonia
Concord
262
see Salisbury
Durham
257
Elizabeth City
236, 238
Fayetteville
263
Gastonia
270
see Charlotte
Goldsboro
259
Greensboro
251, 253, 255
see High Point and Winston-Salem
Greenville
241, 243
Henderson
265
Hickory
258
High Point
249, 278
see Greensboro and Winston-Salem
Kinston
225, 227
see New Bern
New Bern
229
see Kinston
Jacksonville
252, 254
Raleigh
235, 237 239
Roanoke Rapids
272, 274
see Rocky Mount
Rocky Mount
277, 279
see Roanoke Rapids
Salisbury
260
Washington
269
Wilmington
221, 223
Wilson
261
Winston-Salem
241, 243, 245, 247
see Greensboro and High Point
TOTAL 45 stations

NORTH DAKOTA

Pop. 642,000
Sq. Mi. 70,183

Bismarck
222, 224, 226, 228
inc. Mandan
Devil's Lake
231, 233
Fargo
261, 263
see Moorhead, Minn.
Grand Forks
236, 238, 240, 242
Jamestown
245, 247
Mandan
see Bismarck
Minot
249, 251
Valley City
268, 270
TOTAL 18 stations

OHIO

Pop. 6,908,000
Sq. Mi. 40,740

Akron
236, 238, 240
inc. Tallmadge
Alliance
242, 244, 246
inc. Canton
Ashland
264, 266
Ashtabula
see Erie, Pa.
Athens
275
Canton
see Alliance
Cincinnati
239, 241, 243, 245, 247, 249, 251, 253, 255
inc. Hamilton
Cleveland
222, 224, 226, 228, 230, 232, 234
inc. Lorain
Columbus
221, 223, 225, 227, 229, 231, 233, 235
Dayton
257, 259, 261, 263, 265
inc. Springfield
Dover
Community channel
East Liverpool
Community channel
Findlay
269
Fostoria
Community channel
Fremont
see Toledo
Hamilton
see Cincinnati
Lima
Community channel
Lorain
see Cleveland
Mansfield
276, 278
Marion
272, 274
Newark
268, 270
inc. Zanesville
Portsmouth
see Huntington, W. Va.
Springfield
see Dayton
Steubenville
see Wheeling, W. Va.
Tallmadge
see Akron
Toledo
249, 251, 253, 255
inc. Fremont
Warren
269, 271
also Sharon, Pa.
Wooster
248, 250
Youngstown
see Sharon, Pa.
Zanesville
see Newark
TOTAL 53 stations

OKLAHOMA

Pop. 2,336,000
Sq. Mi. 69,414

Ada
271, 273
Ardmore
246
Bartlesville
223
Elk City
238, 240
Enid
268, 270
Lawton
275, 277
Muskogee
221, 225
Norman
see Oklahoma City
Oklahoma City
253, 255, 257, 259, 261, 263, 265
inc. Ponca City and Norman
Okmulgee
250, 280
Ponca City
see Oklahoma City or Tulsa
Shawnee
242, 244
Tulsa
227, 229, 231, 233, 235
TOTAL 28 stations

OREGON

Pop. 1,090,000
Sq. Mi. 95,607

Albany
253, 255
Astoria
269, 280
Baker
254, 256
Bend
222, 224
Coos Bay
263, 265
Corvallis
257
see Albany
The Dalles
249, 251
Eugene
259, 261
Grants Pass
272, 274
Klamath Falls
238, 240, 242
LaGrande
226, 228
Medford
276, 278
Pendleton
230, 232
Portland
221, 223, 225, 227, 229, 231, 233, 235, 237, 239, 241, 243
see Vancouver, Wash.
Roseburg
267, 269
Salem
245, 247
TOTAL 42 stations

PENNSYLVANIA

Pop. 9,900,000
Sq. Mi. 44,832

Allentown
234, 236, 238, 240
inc. Bethlehem and Easton
Altoona
264, 266
Beaver Falls
see Pittsburgh
Bethlehem
see Allentown
Bradford
246
see Jamestown and Olean, N. Y.
Butler
see Pittsburgh
Clearfield
see DuBois
DuBois
248, 250
inc. Clearfield
Easton
see Allentown
Erie
259, 261, 263, 265
inc. Ashtabula, O.
Glenside
see Philadelphia
Greensburg
237, 239
Grove City
Community channel
Harrisburg
245, 247, 249, 270, 272, 278
Hazelton
Community channel
Indiana
Community channel
Johnstown
258, 260
Lancaster
222, 224
Lewistown
274, 276
Meadville
see Sharon
New Castle
see Sharon
New Kensington
see Pittsburgh
Philadelphia
242, 244, 246, 248, 250, 252, 254, 256, 258, 260, 262, 264, 266, 274, 276
inc. Glenside, Pa. and Camden, N. J.
Pittsburgh
221, 223, 225, 227, 229, 231, 233, 235
inc. New Kensington Beaver Falls and Butler, Pa.
Pottsville
Community channel
Reading
226, 228, 230, 232
Scranton
261, 263, 265, 269, 271, 273, 275, 277, 279
inc. Wilkes-Barre
Sharon
253, 255, 257, 273, 275
inc. Warren and Youngstown, O., and Meadville and New Castle
State College
252, 254
Sunbury
257, 259
Uniontown
241, 243
Washington
277, 279
Wilkes-Barre
see Scranton
Williamsport
221, 223
York
235, 237, 239, 241, 243
TOTAL 83 stations

RHODE ISLAND

Pop. 713,000
Sq. Mi. 1,067

Pawtucket
see Providence
Providence
254, 256, 258, 270, 272, 278
TOTAL 6 stations

SOUTH CAROLINA

Pop. 1,900,000
Sq. Mi. 30,495

Anderson
278, 280
Charleston
222, 224, 226
Columbia
250, 252, 254, 256
see Sumter
Conway
231
Florence
268
Greenville
225, 227, 229
see Spartanburg
Greenwood
240, 242
Rock Hill
238
Spartanburg
221, 223
see Greenville
Sumter
277, 279
see Columbia
TOTAL 21 stations

SOUTH DAKOTA

Pop. 643,000
Sq. Mi. 76,868

Aberdeen
253, 255
Pierre
277, 279
Rapid City
221, 223, 225, 227
Sioux Falls
262, 264, 266, 268
Vermillion
258, 260
Watertown
237, 239
Yankton
270, 272
TOTAL 18 stations

TENNESSEE

Pop. 2,916,000
Sq. Mi. 41,687

Bristol
269, 271, 277, 279
inc. Johnson City and Kingsport
Chattanooga
233, 235, 237, 239, 241, 243
inc. Cleveland
Clarksville
254, 256
Cleveland
see Chattanooga
Cookeville
263
Jackson
234, 236
Johnson City
see Bristol
Kingsport
see Bristol
Knoxville
222, 224, 226, 228, 230
Memphis
222, 224, 226, 228, 230, 232
Nashville
221, 223, 225, 227, 229, 261
TOTAL 32 stations

TEXAS

Pop. 6,415,000
Sq. Mi. 262,398

Abilene
245, 247
Amarillo
267, 269, 271
Austin
238, 246, 248
Beaumont
271, 273, 275
Big Spring
242, 244
Brady
227, 229
Brownsville
221, 223, 225, 233, 237, 239
inc. Harlingen and McAllen and Weslaco
Brownwood
258, 260
College Station
233, 236
Corpus Christi
241, 243, 245, 247, 249
Corsicana
254, 256
Dallas
226, 228, 230, 232, 235, 247
El Paso
225, 227
Fort Worth
239, 241, 243, 262, 279
Galveston
267, 269
Harlingen
see Brownsville
Houston
251, 253, 255, 257, 259, 262
Huntsville
229, 231
Kilgore
272, 274, 276, 278
inc. Longview and Tyler
Laredo
227, 229
Longview
see Kilgore
Lubbock
226, 228
Lufkin
221, 225
Midland
273, 275
McAllen
see Brownsville
Palestine
264, 266
Pampa
232, 234
Paris
258, 260
Pecos
277, 279
Plainview
262, 264
Port Arthur
223, 227
San Angelo
231, 233
San Antonio
261, 263, 265, 268, 270, 272, 274, 276
Sherman
268, 270
Sweetwater
253, 255
Temple
250, 252
Texarkana
223, 226, 242
Tyler
280
see Kilgore
Vernon
222, 224
Victoria
278, 280
Waco
222, 224
Waxahachie
see Dallas and Fort Worth
Weslaco
see Brownsville
Wichita Falls
249, 251
TOTAL 107 stations

UTAH

Pop. 550,000
Sq. Mi. 82,184

Cedar City
221, 223
Logan
273, 275
Ogden
265, 267
Price
277, 279
Provo
269, 271
Salt Lake City
245, 247, 249, 251, 253, 255, 257, 259, 261, 263
TOTAL 20 stations

VERMONT

Pop. 359,000
Sq. Mi. 9,124

Burlington
230, 232
Rutland
243
St. Albans
234, 241
Waterbury
246, 248
TOTAL 7 stations

VIRGINIA

Pop. 2,678,000
Sq. Mi. 40,262

Alexandria
see Washington, D. C.
Charlottesville
276, 278
inc. Staunton
Covington
236, 238
Danville
221, 223
Fredericksburg
see Washington, D. C.
Harrisonburg
232, 334
Lynchburg
268, 270
Martinsville
231, 233
Newport News
222, 224
see Norfolk, Suffolk and Portsmouth
Norfolk
226, 228
see Newport News, Portsmouth and Suffolk
Petersburg
258, 260
Portsmouth
230, 232
see Newport News, Norfolk and Suffolk
Richmond
242, 244, 246, 248, 250, 252, 254, 256
Roanoke
225, 227, 229
Staunton
see Charlottesville
Suffolk
see Newport News, Norfolk and Portsmouth
Winchester
Community channel
TOTAL 31 stations

WASHINGTON

Pop. 1,736,000
Sq. Mi. 66,836

Aberdeen
264, 266
Bellingham
276, 278
Centralia
260, 262
Everett
272, 274
Longview
273, 275
Olympia
256, 258
Port Angeles
268, 270
Pullman
238, 240
Pasco
242, 244
Seattle
222, 224, 226, 228, 230, 232, 234, 236, 238, 240, 242, 244
Spokane
221, 223, 225, 227, 229, 231
Tacoma
246, 248, 250, 252, 254
Vancouver
271
see Portland, Ore.
Walla Walla
234, 236
Wenatchee
267, 269
Yakima
265, 277, 279
TOTAL 49 stations

WEST VIRGINIA

Pop. 1,902,000
Sq. Mi. 24,022

Beckley
264, 266
Bluefield
250, 252, 254
inc. Welch
Charleston
222, 224, 226, 228, 230
Clarksburg
245, 247, 249, 251, 253
inc. Fairmont and Morgantown
Fairmont
see Clarksburg
Huntington
258, 260, 262
inc. Ashland, Ky.
Logan
232, 234
Morgantown
see Clarksburg
Parkersburg
273
Welch
see Bluefield

Wheeling
259, 261, 263, 265
Inc. Steubenville, O.
Williamson
242, 244
TOTAL 27 stations

WISCONSIN

Pop. 3,138,000
Sq. Mi. 55,256

Appleton
262, 264
Ashland
261, 263
Eau Claire
253, 255
Fond du Lac
278, 280
Green Bay
266, 268
Greenfield Township
see Madison
Janesville
238
La Crosse
221, 223
Madison
248, 250, 252
Inc. Greenfield Township
Manitowoc
258, 260
Marinette
249, 251
Medford
237, 239
Milwaukee
222, 224, 226, 228, 230, 232, 234, 236, 240, 242, 244, 246
Oshkosh
272, 274
Poynette
276
Racine
267, 269
Rice Lake
257, 259
Sheboygan
254, 256
Stevens Point
245, 247
Superior
see Duluth, Minn.
Wausau
233, 235
Wisconsin Rapids
241, 243
TOTAL 49 stations

WYOMING

Pop. 251,000
Sq. Mi. 97,548

Casper
247, 249
Cheyenne
239, 241, 243
Powell
251, 253
Rock Springs
221, 223
Sheridan
255, 257
TOTAL 11 stations

GRAND TOTAL 1577 stations

CITIES ASSIGNED TO FM CHANNELS

221

Ala. Selma
Ariz. Globe
Ark. Pine Bluff
Calif. San Francisco
D. C. Washington
Fla. St. Petersburg
Ga. Brunswick
Ill. Chicago
Ind. Shelbyville
Kan. Dodge City
Mass. Boston
Mich. Detroit
Escanaba
Minn. Fergus Falls
Mo. St. Louis
Neb. Omaha
N. M. Carlsbad
N. Y. Albany
Buffalo
New York
Ohio Columbus
Okla. Muskogee
Ore. Portland
Pa. Pittsburgh
Williamsport
S. C. Spartanburg
S. D. Rapid City
Tenn. Nashville
Tex. Brownsville
Lufkin
Utah Cedar City
Va. Danville
Wash. Spokane
Wis. La Crosse
Wyo. Rock Springs

222

Calif. Marysville
San Diego
San Luis Obispo
Colo. Alamosa
Conn. Waterbury
Ga. Griffin
Ill. Peoria
Ind. Evansville
Kan. Manhattan
Me. Lewiston
Mich. Cadillac
Minn. Duluth
Mankato
Neb. North Platte
N. Y. Plattsburg
Syracuse
N. D. Bismark
Ohio Cleveland
Ore. Bend
Pa. Lancaster
S. C. Charleston
Tenn. Knoxville
Memphis
Tex. Vernon
Waco
Va. Newport News
Wash. Seattle
W. Va. Charleston
Wis. Milwaukee

223

Ala. Selma
Ariz. Globe
Calif. Los Angeles
San Francisco
D. C. Washington
Fla. St. Petersburg
Ga. Brunswick
Ill. Chicago
Ind. Indianapolis
Kan. Dodge City
Mass. Boston
Mich. Detroit
Escanaba
Minn. Fergus Falls
Mo. St. Louis
Neb. Omaha
N. M. Carlsbad
N. Y. Albany
Buffalo
New York
Ohio Columbus
Okla. Bartlesville
Ore. Portland
Pa. Pittsburgh
Williamsport
S. C. Spartanburg
S. D. Rapid City
Tenn. Nashville
Tex. Brownsville
Port Arthur
Texarkana
Utah Cedar City
Va. Danville
Wash. Spokane
Wis. La Crosse
Wyo. Rock Springs

224

Calif. Marysville
San Diego
San Luis Obispo
Colo. Alamosa
Conn. Waterbury
Ga. Griffin
Ill. Peoria
Ind. Evansville
Kan. Manhattan
La. New Orleans
Me. Lewiston
Mich. Grand Rapids
Minn. Duluth
Mankato
Mo. Springfield
Neb. North Platte
N. Y. Plattsburg
Syracuse
N. D. Bismark
Ohio Cleveland
Ore. Bend
Pa. Lancaster
S. C. Charleston
Tenn. Knoxville
Memphis
Tex. Vernon
Waco
Va. Newport News
Wash. Seattle
W. Va. Charleston
Wis. Milwaukee

225

Ariz. Prescott
Calif. Los Angeles
San Francisco
D. C. Washington
Fla. Key West
Pensacola
St. Petersburg
Ill. Chicago
Ind. Indianapolis
Ia. Decorah
Kan. Garden City
Mass. Boston
Mich. Detroit
Marquette
Miss. Vicksburg
Mo. St. Louis
Neb. Omaha
N. Y. Albany
Buffalo
New York
N. C. Kinston
Ohio Columbus
Okla. Muskogee
Ore. Portland
Pa. Pittsburgh
S. C. Greenville
S. D. Rapid City
Tenn. Nashville
Tex. Brownsville
El Paso
Lufkin
Va. Roanoke
Wash. Spokane

226

Ala. Birmingham
Calif. Chico
San Diego
Colo. Durango
Conn. Hartford
Fla. St. Augustine
Ga. Albany
Ill. Peoria
Ind. Evansville
La. New Orleans
Me. Augusta
Mich. Grand Rapids
Minn. Duluth
Mo. Springfield
Neb. Kearney
N. Y. Massena
Syracuse
N. D. Bismarck
Ohio Cleveland
Ore. La Grande
Pa. Reading
S. C. Charleston
Tenn. Knoxville
Memphis
Tex. Dallas
Lubbock
Texarkana
Va. Norfolk
Wash. Seattle
W. Va. Charleston
Wis. Milwaukee

227

Ariz. Prescott
Calif. Los Angeles
San Francisco
D. C. Washington
Fla. Key West
Pensacola
Tampa
Ill. Chicago
Ind. Indianapolis
Ia. Decorah
Kan. Garden City
Mass. Boston
Mich. Detroit
Marquette
Minn. Willmar
Miss. Vicksburg
Mo. St. Louis
Neb. Omaha
N. Y. Albany
Buffalo
New York
N. C. Kinston
Ohio Columbus
Okla. Tulsa
Ore. Portland
Pa. Pittsburgh
S. C. Greenville
S. D. Rapid City
Tenn. Nashville
Tex. Brady
El Paso
Laredo
Port Arthur
Va. Roanoke
Wash. Spokane

228

Ala. Birmingham
Calif. Chico
San Diego
Colo. Durango
Conn. Hartford
Fla. St. Augustine
Ga. Albany
Ill. Peoria
Ind. Evansville
La. New Orleans
Me. Augusta
Mich. Grand Rapids
Minn. Virginia
Mo. Springfield
Neb. Kearney
N. Y. Massena
Syracuse
N. D. Bismarck
Ohio Cleveland
Ore. La Grande
Pa. Reading
Tenn. Knoxville
Memphis
Tex. Dallas
Lubbock
Va. Norfolk
Wash. Seattle
W. Va. Charleston
Wis. Milwaukee

229

Ariz. Lowell
Calif. Los Angeles
San Francisco
D. C. Washington
Fla. Ft. Lauderdale
Pensacola
Tampa
Ill. Chicago
Ind. Indianapolis
Mass. Boston
Mich. Detroit
Minn. Willmar
Winona
Mo. St. Louis
Neb. Omaha
N. Y. Albany
Buffalo
New York
N. C. New Bern
Ohio Columbus
Okla. Tulsa
Ore. Portland
Pa. Pittsburgh
S. C. Greenville
Tenn. Nashville
Tex. Brady
Huntsville
Laredo
Va. Roanoke
Wash. Spokane

230

Ala. Birmingham
Calif. Eureka
Merced
San Diego
Colo. Grand Junction
Conn. Hartford
Ga. Albany
Ill. Bloomington
Ind. Evansville
Ia. Marshalltown
Me. Augusta
Mich. Grand Rapids
Minn. Virginia
Mo. Springfield
Mont. Sidney
N. Y. Syracuse
Ohio Cleveland
Ore. Pendleton
Pa. Pottsville
Tenn. Knoxville
Memphis
Tex. Dallas
Va. Portsmouth
Wash. Seattle
W. Va. Charleston
Wis. Milwaukee

231

Ala. Mobile
Ariz. Lowell
Calif. Los Angeles
San Francisco
D. C. Washington
Fla. Ft. Lauderdale
Tampa
Ill. Chicago
Ind. Indianapolis
Mass. Boston
Mich. Detroit
Minn. Winona
Mo. St. Louis
Neb. Omaha
N. Y. Albany
Buffalo
New York
N. D. Devil's Lake
Ohio Columbus
Okla. Tulsa
Ore. Portland
Pa. Pittsburgh
S. C. Conway
Tex. Huntsville
San Angelo
Va. Martinsville
Wash. Spokane

232

Ala. Birmingham
Calif. El Centro
Eureka
Merced
Redding
Colo. Grand Junction
Conn. Hartford
Ga. Waycross
Ill. Bloomington
Ind. Evansville
Me. Bangor
Mich. Grand Rapids
Minn. Hibbing
Mo. Springfield
Mont. Sidney
N. Y. Syracuse
N. C. Asheville
Ohio Cleveland
Ore. Pendleton
Pa. Reading
Tenn. Memphis
Tex. Dallas
Pampa
Vt. Burlington
Va. Harrisonburg
Portsmouth
Wash. Seattle
W. Va. Logan
Wis. Milwaukee

233

Ariz. Safford
Calif. Los Angeles
San Francisco
Colo. La Junta
D. C. Washington
Fla. Daytona Beach
Fort Myers
Ga. Augusta
Ill. Chicago
Ind. Indianapolis
Ia. Boone
La. New Orleans
Mass. Boston
Mich. Detroit
Sault Ste. Marie
Mo. St. Louis
Neb. Hastings
N. M. Roswell
N. Y. Albany
Buffalo
New York
N. D. Devil's Lake
Ohio Columbus
Okla. Tulsa
Ore. Portland
Pa. Pittsburgh
Tenn. Chattanooga
Tex. Brownsville
College Station
San Angelo
Va. Martinsville
Wis. Wausau

234

Ala. Birmingham
Calif. El Centro
Redding
Santa Maria
Conn. Hartford
Ga. Waycross
Ill. Galesburg
Ind. Evansville
Me. Bangor
Mich. Grand Rapids
Minn. Hibbing
Rochester
Mo. St. Joseph
Neb. Scottsbluff
N. Y. Syracuse
N. C. Asheville
Ohio Cleveland
Pa. Allentown
Tenn. Jackson
Tex. Pampa
Vt. St. Albans
Va. Harrisonburg
Wash. Seattle
Walla Walla
W. Va. Logan
Wis. Milwaukee

235

Ariz. Safford
Calif. Los Angeles
San Francisco
Colo. La Junta
Fla. Daytona Beach
Fort Myers
Ga. Augusta
Ill. Chicago
Ind. Indianapolis
Ia. Boone
La. New Orleans
Mass. Boston
Mich. Detroit
Sault Ste. Marie
Mo. St. Louis
Mont. Miles City
Neb. Hastings
N. M. Roswell
N. Y. Albany
Buffalo
New York
N. C. Raleigh
Ohio Columbus
Okla. Tulsa
Ore. Portland
Pa. Pittsburgh
York
Tenn. Chattanooga
Tex. Dallas
Wis. Wausau

236

Calif. Redding
Santa Maria
Conn. Hartford
Ga. Valdosta
Ill. Galesburg
Ind. Fort Wayne
Me. Bangor
Minn. Rochester
Miss. Greenville
Mo. St. Joseph
Neb. Scottsbluff
N. Y. Corning
N. C. Asheville
Elizabeth City
N. D. Grand Forks
Ohio Akron
Pa. Allentown
Tenn. Jackson
Tex. College Station
Va. Covington
Wash. Seattle
Walla Walla
Wis. Milwaukee

237

Ariz. Tucson
Calif. Los Angeles
San Francisco
Fla. Lakeland
Ga. Augusta
Ind. Columbus
Ia. Ames
Kan. Hutchinson
La. New Orleans
Mass. Lowell
Mich. Detroit
Traverse City
Miss. Columbus
Mo. St. Louis
Mont. Miles City
N. M. Clovis
N. Y. Buffalo
New York
Saranac Lake
N. C. Raleigh
Ore. Portland
Pa. Greensburg
York
S. D. Watertown
Tenn. Chattanooga
Tex. Brownsville
Dallas
Wis. Medford

238

Ariz. Yuma
Calif. Visalia
Fla. Miami
Ga. La Grange
Valdosta
Ind. Fort Wayne
Ia. Shenandoah
Kan. Pittsburg
Me. Bangor
Mass. Holyoke
Minn. Northfield
Miss. Greenville
N. M. Gallup
N. Y. Elmira
N. C. Elizabeth City
N. D. Grand Forks
Ohio Akron
Okla. Elk City
Ore. Klamath Falls
Pa. Allentown
S. C. Rock Hill
Tex. Austin
Va. Covington
Wash. Pullman
Seattle
Wis. Janesville

239

Ariz. Tucson
Calif. Los Angeles
San Francisco
Fla. Lakeland
Ida. Twin Falls
Ia. Marshalltown
Kan. Hutchinson
La. New Orleans
Mass. Lawrence
Mich. Detroit
Traverse City
Miss. Columbus
Mo. Cape Girardeau
Mont. Billings
N. M. Clovis
N. Y. Buffalo
New York
Saranac Lake
N. C. Raleigh
Ohio Cincinnati
Ore. Portland
Pa. Greensburg
York
S. D. Watertown
Tenn. Chattanooga
Tex. Brownsville
Fort Worth
Wis. Medford
Wyo. Cheyenne

240

Ariz. Yuma
Calif. Visalia
Fla. Jacksonville
Miami
Ga. La Grange
Ind. Fort Wayne
Ia. Shenandoah
Kan. Pittsburg
Ky. Harlan
Me. Presque Isle
Mass. Holyoke
Minn. Northfield
Mo. Hannibal
N. M. Gallup
N. D. Grand Forks
Ohio Akron
Okla. Elk City
Ore. Klamath Falls
Pa. Allentown
S. C. Greenwood
Wash. Pullman
Seattle
Wis. Milwaukee

241

Ariz. Tucson
Ark. Helena
Calif. Los Angeles
San Francisco
Fla. Sarasota
Ida. Twin Falls
Ill. Chicago
Ia. Cedar Rapids
Spencer
Kan. Wichita
La. Baton Rouge
Mass. Haverhill
Mich. Detroit
Mo. Cape Girardeau
Mont. Billings
N. Y. Batavia
New York
N. C. Greenville
Winston-Salem
Ohio Cincinnati
Ore. Portland
Pa. Uniontown
York
Tenn. Chattanooga
Tex. Corpus Christi
Fort Worth
Vt. St. Albans
Wis. Wisconsin Rapids
Wyo. Cheyenne

242

Calif. Tulare
Fla. Jacksonville
Miami
Ga. Columbus
Ind. Terre Haute
Ia. Shenandoah
Ky. Bowling Green
Me. Presque Isle
Mass. Holyoke
Mich. Calumet
Miss. Laurel
Mo. Hannibal
N. Y. Binghamton
N. D. Grand Forks
Ohio Alliance
Okla. Shawnee
Ore. Klamath Falls
Pa. Philadelphia
S. C. Greenwood
Tex. Big Spring
Texarkana
Va. Richmond
Wash. Pasco
Seattle
W. Va. Williamson
Wis. Milwaukee

243

Ariz. Tucson
Ark. Helena
Calif. Los Angeles
San Francisco
Fla. Sarasota
Ida. Twin Falls
Ill. Cairo
Kankakee
Ia. Cedar Rapids
Spencer
Kan. Wichita
La. Baton Rouge
Mass. Fall River
Mich. Detroit
Mo. Cape Girardeau
Mont. Bozeman
N. Y. Batavia
New York
N. C. Greenville
Winston-Salem
Ohio Cincinnati
Ore. Portland
Pa. Uniontown
York
Tenn. Chattanooga
Tex. Corpus Christi
Fort Worth
Vt. Rutland
Wis. Wisconsin Rapids
Wyo. Cheyenne

244

Ala. Muscle Shoals
Calif. Tulare
Fla. Jacksonville
Miami
Ga. Columbus
Ind. Terre Haute
Ky. Bowling Green
La. Shreveport
Mass. Holyoke
Mich. Calumet
Minn. Minneapolis
Miss. Laurel
Mo. Columbia
N. Y. Binghamton
Ohio Alliance
Okla. Shawnee
Pa. Philadelphia
Tex. Big Spring
Texarkana
Va. Richmond
Wash. Pasco
Seattle
W. Va. Williamson
Wis. Milwaukee

245

Ariz. Phoenix
Ark. Siloam Springs
Calif. Los Angeles
San Francisco
Colo. Denver
Ill. Chicago
Ia. Iowa City
Ky. Paducah
La. Baton Rouge
Mass. Fall River
Mich. Detroit
Miss. Clarksdale
Mont. Bozeman
Neb. Lincoln
N. M. Albuquerque
N. Y. Gloversville
New York
Rochester
N. C. Winston-Salem
N. D. Jamestown
Ohio Cincinnati
Ore. Salem
Pa. Harrisburg
Tex. Abilene
Corpus Christi
Utah Salt Lake City
W. Va. Clarksburg
Wis. Stevens Point

246

Ala. Muscle Shoals
Fla. Jacksonville
Miami
Ga. Columbus
Ind. West Lafayette
Kan. Wichita
La. Shreveport
Mass. Holyoke
Minn. Minneapolis
Miss. Meridian
Mo. Columbia
N. M. Hobbs
Ohio Alliance
Okla. Ardmore
Pa. Bradford
Philadelphia
Tex. Austin
Vt. Waterbury
Va. Richmond
Wash. Tacoma
Wis. Milwaukee

247

Ariz. Phoenix
Ark. Siloam Springs
Calif. Los Angeles
San Francisco
Colo. Denver
Ill. Chicago
Ia. Iowa City
Ky. Paducah
La. Lafayette
Mass. Fall River
Mich. Detroit
Miss. Clarksdale
Neb. Lincoln
N. M. Albuquerque
N. Y. New York
Rochester
N. C. Winston-Salem
N. D. Jamestown
Ohio Cincinnati
Ore. Salem
Pa. Harrisburg
Tex. Abilene
Corpus Christi
Utah Salt Lake City
W. Va. Clarksburg
Wis. Stevens Point
Wyo. Casper

248

Fla. Jacksonville
Miami
Ga. West Point
Ky. Harlan
La. Shreveport
Mass. Holyoke
Mich. Bay City
Minn. Minneapolis
Miss. Meridian
Mo. Kansas City
Mont. Butte
N. M. Hobbs
Ohio Wooster
Pa. Du Bois
Philadelphia
Tex. Austin
Vt. Waterbury
Va. Richmond
Wash. Tacoma
Wis. Madison

249

Ala. Huntsville
Ariz. Phoenix
Ark. Blythesville
Calif. Los Angeles
San Francisco
Colo. Denver
Ga. Thomasville
Toccoa
Ill. Chicago
Quincy
Ia. Waterloo
Kan. Wichita
La. Lafayette
Neb. Lincoln
N. H. Portsmouth
N. M. Albuquerque
N. Y. New York
Rochester
N. C. High Point
N. D. Minot
Ohio Cincinnati
Toledo
Ore. The Dalles
Pa. Harrisburg
Tex. Corpus Christi
Wichita Falls

Utah Salt Lake City
W. Va. Clarksburg
Wis. Marinette
Wyo. Casper

250

Ala. Mobile
Conn. New London
Fla. Ocala
Palm Beach
Ill. Tuscola
Ky. Hopkinsville
La. Shreveport
Mich. Bay City
Minn. Minneapolis
Mo. Kansas City
Mont. Butte
N. Y. Utica
Ohio Wooster
Okla. Okmulgee
Pa. Du Bois
Philadelphia
S. C. Columbia
Tex. Temple
Va. Richmond
Wash. Tacoma
W. Va. Bluefield
Wis. Madison

251

Ala. Decatur
Ariz. Phoenix
Ark. Blytheville
Calif. Los Angeles
San Francisco
Colo. Denver
Ga. Atlanta
Thomasville
Ill. Quincy
Waukegan
Ia. Waterloo
Kan. Wichita
Md. Frederick
Neb. Lincoln
N. H. Mt. Washington
N. M. Albuquerque
N. Y. New York
N. C. Greensboro
N. D. Minot
Ohio Cincinnati
Toledo
Ore. The Dalles
Tex. Houston
Wichita Falls
Utah Salt Lake City
W. Va. Clarksburg
Wis. Marinette
Wyo. Powell

252

Conn. New London
Fla. Ocala
Palm Beach
Ill. Tuscola
Ky. Hopkinsville
La. Shreveport
Mich. Bay City
Minn. St. Cloud
Mo. Kansas City
Mont. Helena
N. Y. Utica
N. C. Jacksonville
Pa. Philadelphia
State College
S. C. Columbia
Tex. Temple
Va. Richmond
Wash. Tacoma
W. Va. Bluefield
Wis. Madison

253

Ariz. Phoenix
Calif. Los Angeles
San Francisco
Colo. Denver
Ga. Atlanta
Savannah
Ill. Chicago
Ia. Fort Dodge
Kan. Salina
Md. Baltimore
Miss. Greenwood
Gulfport
N. H. Mt. Washington
N. Y. New York
Rochester
N. C. Greensboro
Ohio Cincinnati
Toledo
Okla. Oklahoma City
Ore. Albany
Pa. Sharon
S. D. Aberdeen
Tex. Houston
Sweetwater
Utah Salt Lake City
W. Va. Clarksburg
Wis. Eau Claire
Wyo. Powell

254

Ala. Tuscaloosa
Fla. West Palm Beach
Ga. Cordele
Ill. Decatur
Ind. Marion
La. Monroe
Mich. Muskegon
Minn. St. Cloud
Mo. Kansas City
Mont. Helena
Neb. Norfolk
N. M. Las Vegas
N. Y. Utica
N. C. Jacksonville
Ore. Baker
Pa. Philadelphia
State College
R. I. Providence
S. C. Columbia
Tenn. Clarksville
Tex. Corsicana
Va. Richmond
Wash. Tacoma
W. Va. Bluefield
Wis. Sheboygan

255

Calif. Los Angeles
San Francisco
Colo. Denver
Ga. Atlanta
Savannah
Ill. Chicago
Harrisburg
Ia. Fort Dodge
Kan. Salina
Md. Baltimore
Miss. Greenwood
Gulfport
Nev. Boulder City
N. H. Mt. Washington
N. Y. New York
Rochester
N. C. Greensboro
Ohio Cincinnati
Toledo
Okla. Oklahoma City
Ore. Albany
Pa. Sharon
S. D. Aberdeen
Tex. Houston
Sweetwater
Utah Salt Lake City
Wis. Eau Claire
Wyo. Sheridan

256

Ala. Tuscaloosa
Fla. West Palm Beach
Ga. Cordele
Ill. Decatur
Ia. Dubuque
La. Monroe
Md. Cumberland
Mich. Muskegon
Mo. Kansas City
Mont. Great Falls
Neb. Norfolk
N. M. Las Vegas
N. Y. Watertown
Ore. Baker
Pa. Philadelphia
R. I. Providence
S. C. Columbia
Tenn. Clarksville
Tex. Corsicana
Va. Richmond
Wash. Olympia
Wis. Sheboygan

257

Ark. Little Rock
Calif. Los Angeles
Modesto
Colo. Denver
Ga. Atlanta
Savannah
Idaho Lewiston
Ill. Chicago
Harrisburg
Ia. Burlington
Mason City
Md. Baltimore
Minn. Moorhead
Miss. Hattiesburg
Nev. Boulder City
N. H. Mt. Washington
N. Y. New York
N. C. Durham
Ohio Dayton
Okla. Oklahoma City
Ore. Corvallis
Pa. Sharon
Sunbury
Tex. Houston
Utah Salt Lake City
Wis. Rice Lake
Wyo. Sheridan

258

Ala. Montgomery
Calif. Santa Rosa
Fla. Orlando
Ill. Urbana
Ia. Dubuque
Kan. Great Bend
Ky. Louisville
La. Monroe
Mich. East Lansing
Mo. Kansas City
Mont. Great Falls
N. M. Santa Fe
N. Y. Ithaca
N. C. Hickory
Pa. Johnstown
Philadelphia
R. I. Providence
S. D. Vermillion
Tex. Brownwood
Paris
Va. Petersburg
Wash. Olympia
W. Va. Huntington
Wis. Manitowoc

259

Ark. Little Rock
Calif. Los Angeles
Watsonville
Colo. Denver
Ga. Atlanta
Savannah
Idaho Lewiston
Ill. Carthage
Chicago
Herrin
Ia. Mason City
Md. Baltimore
Minn. Moorhead
Miss. Hattiesburg
Nev. Las Vegas
Reno
N. H. Laconia
N. Y. Albany
New York
N. C. Goldsboro
Ohio Dayton
Okla. Oklahoma City
Ore. Eugene
Pa. Erie
Sunbury
Tex. Houston
Utah Salt Lake City
W. Va. Wheeling
Wis. Rice Lake

260

Ala. Montgomery
Calif. Santa Rosa
Fla. Orlando
Ill. Urbana
Ia. Dubuque
Kan. Great Bend
Ky. Louisville
Mass. Worcester
Mich. East Lansing
Mo. Kansas City
Mont. Kalispell
N. M. Santa Fe
N. Y. Hornell
Ogdensburg
N. C. Salisbury
Pa. Johnstown
Philadelphia
S. D. Vermillion
Tex. Brownwood
Paris
Va. Petersburg
Wash. Centralia
W. Va. Huntington
Wis. Manitowoc

261

Ark. Little Rock
Calif. Los Angeles
Monterey
Colo. Denver
Conn. Waterbury
Ga. Athens
Ill. Carthage
Chicago
Herrin
La. Alexandria
Me. Portland
Md. Baltimore
Minn. Albert Lea
Nev. Las Vegas
Reno
N. C. Wilson
N. D. Fargo
Ohio Dayton
Okla. Oklahoma City
Ore. Eugene
Pa. Erie
Scranton
Tenn. Nashville
Tex. San Antonio
Utah Salt Lake City
W. Va. Wheeling
Wis. Ashland

262

Fla. Orlando
Ga. Moultrie
Ill. Urbana
Ky. Louisville
Md. Cumberland
Mass. Worcester
Mich. East Lansing
Miss. Jackson
Mo. Kansas City
Mont. Kalispell
N. Y. Ogdensburg
N. C. Concord
Pa. Philadelphia
S. D. Sioux Falls
Tex. Fort Worth
Houston
Plainview
Wash. Centralia
W. Va. Huntington
Wis. Appleton

263

Ala. Montgomery
Ark. Little Rock
Calif. San Jose
Colo. Denver
Conn. New Haven
D. C. Washington
Ga. Athens
Ill. Carbondale
Ind. Hammond
Ia. Des Moines
La. Alexandria
Me. Portland
Neb. Grand Island
Nev. Las Vegas
Reno
N. C. Fayetteville
N. D. Fargo
Ohio Dayton
Okla. Oklahoma City
Ore. Coos Bay
Pa. Erie
Scranton
Tenn. Cookeville
Tex. San Antonio
Utah Salt Lake City
W. Va. Wheeling
Wis. Ashland

264

Calif. Bakersfield
Del. Wilmington
Ga. Moultrie
Ill. Rock Island
Kan. Atchison
Ky. Louisville
Mass. Boston
Mich. Flint
Miss. Corinth
Jackson
Mo. Jefferson City
Mont. Missoula
N. Y. Albany
N. C. Charlotte
Ohio Ashland
Pa. Altoona
Philadelphia
S. D. Sioux Falls
Tex. Palestine
Wash. Aberdeen
W. Va. Beckley
Wis. Appleton

265

Ark. Little Rock
Calif. San Jose
Colo. Colorado Springs
Conn. Bridgeport
D. C. Washington
Ga. Rome
Ill. Mt. Vernon
Ind. Hammond
Ia. Des Moines
La. Alexandria
Me. Portland
Minn. Minneapolis
Neb. Grand Island
N. Y. Watertown
N. C. Henderson
Ohio Dayton
Okla. Oklahoma City
Ore. Coos Bay
Pa. Erie
Scranton
Tex. San Antonio
Utah Ogden
Wash. Yakima
W. Va. Wheeling

266

Calif. Bakersfield
Del. Wilmington
Ga. Dublin
Ia. Davenport
Kan. Atchison
Ky. Louisville
Mass. Boston
Mich. Flint
Miss. Corinth
Jackson
Mo. Jefferson City
Mont. Missoula
N. Y. Albany
N. C. Charlotte
Ohio Ashland
Pa. Altoona
Philadelphia
S. D. Sioux Falls
Tex. Palestine
Wash. Aberdeen
W. Va. Beckley
Wis. Green Bay

267

Ala. Dothan
Ark. Fort Smith
Calif. Stockton
Colo. Colorado Springs
Conn. Bridgeport
D. C. Washington
Fla. Gainesville
Ga. Rome
Idaho Nampa
Ill. Springfield
Ind. South Bend
Ia. Des Moines
Minn. Minneapolis
N. Y. Ithaca
N. C. Burlington
Ore. Roseburg
Tex. Amarillo
Galveston
Utah Ogden
Wash. Wenatchee
Wis. Racine

268

Ark. Jonesboro
Calif. Bakersfield
Del. Wilmington
Ga. Dublin
Idaho Idaho Falls
Wallace
Ind. Kokomo
Ia. Davenport
Ky. Louisville
Mass. North Adams
Mich. Flint
Miss. Jackson
Mo. Sedalia
N. Y. Jamestown
N. D. Valley City
Ohio Newark
Okla. Enid
S. C. Florence
S. D. Sioux Falls
Tex. San Antonio
Sherman
Va. Lynchburg
Wash. Port Angeles
Wis. Green Bay

269

Ala. Dothan
Ark. Fort Smith
Calif. Palm Springs
Stockton
Colo. Colorado Springs
Conn. Bridgeport
D. C. Washington
Fla. Gainesville
Ga. Cedartown
Idaho Nampa
Ill. Springfield
Ind. South Bend
Ia. Des Moines
Kan. Emporia
Minn. Minneapolis
N. H. Manchester
N. C. Washington
Ohio Findlay
Warren
Ore. Astoria
Roseburg
Pa. Scranton
Tenn. Bristol
Tex. Amarillo
Galveston
Utah Provo
Wash. Wenatchee
Wis. Racine

270

Ark. Jonesboro
Calif. Fresno
Ga. Macon
Idaho Idaho Falls
Wallace
Ind. Kokomo
Ky. Louisville
Mich. Flint
Miss. Jackson
Mo. Sedalia
N. J. Trenton
N. Y. Jamestown
Oswego
N. C. Gastonia
N. D. Valley City
Ohio Newark
Okla. Enid
Pa. Harrisburg
R. I. Providence
S. D. Yanktown
Tex. San Antonio
Sherman
Va. Lynchburg
Wash. Port Angeles

271

Ala. Mobile
Ark. Hot Springs
Calif. Palm Springs
Sacramento
Colo. Colorado Springs
Conn. New Haven
D. C. Washington
Fla. Tallahassee
Ga. Cedartown
Idaho Boise
Ill. Freeport
Ind. Vincennes
Kan. Emporia
Mich. Battle Creek
Minn. Minneapolis
Neb. Omaha
N. H. Claremont
Ohio Toledo
Okla. Ada
Pa. Scranton
Tenn. Bristol
Tex. Amarillo
Beaumont
Utah Provo
Wash. Vancouver

272

Calif. Fresno
Colo. Sterling
Ga. Macon
Ind. Lafayette
Ia. Des Moines
Ky. Lexington
Mich. Port Huron
Miss. Macon
Natchez
Mo. Joplin
N. J. Trenton
N. Y. Albany
Olean
N. C. Roanoke Rapids
Ohio Marion
Ore. Grants Pass
Pa. Harrisburg
R. I. Providence
S. D. Yankton
Tex. Kilgore
San Antonio
Wash. Everett
Wis. Oshkosh

273

Ala. Mobile
Talledega
Ark. Hot Springs
Calif. Riverside
Sacramento
Colo. Pueblo
Conn. Waterbury
Fla. Tallahassee
Idaho Boise
Ill. Rockford
Ind. Connersville
Vincennes
Kan. Topeka
Md. Baltimore
Mich. Battle Creek
Minn. Minneapolis
N. C. Charlotte
Okla. Ada
Pa. Scranton
Sharon
Tex. Beaumont
Midland
Utah Logan
Wash. Longview
W. Va. Parkersburg

274

Calif. Fresno
Santa Barbara
Colo. Sterling
Ga. Macon
Ind. Lafayette
Ia. Ottumwa
Sioux City
Ky. Lexington
Mass. Worcester
Mich. Port Huron
Miss. Macon
Natchez
Mo. Joplin
N. Y. Olean
N. C. Roanoke Rapids
Ohio Marion
Ore. Grants Pass
Pa. Lewistown
Philadelphia
Tex. Kilgore
San Antonio
Wash. Everett
Wis. Oshkosh

275

Ala. Sylacauga
Ark. Hot Springs
Calif. Riverside
Sacramento
Colo. Pueblo
Conn. New Haven
Fla. Panama City
Idaho Boise
Ill. Aurora
Ind. Richmond
Kan. Topeka
Md. Baltimore
Minn. Minneapolis
N. C. Charlotte
Ohio Athens
Okla. Lawton
Pa. Scranton
Sharon
Tex. Beaumont
Midland
Utah Logan
Wash. Longview

276

Calif. Fresno
Santa Barbara
Colo. Greeley
Ga. Gainesville
Ill. Springfield
Ind. Elkhart
Ia. Sioux City
Kan. Coffeyville
Ky. Winchester
Mass. Worcester
Mich. Ironwood
Miss. McComb
Mo. Poplar Bluff
N. M. Tucumcari
Ohio Mansfield
Ore. Medford
Pa. Lewistown
Philadelphia
Tex. Kilgore
San Antonio
Va. Charlottesville
Wash. Bellingham
Wis. Poynette

277

Ala. Opelika
Ark. El Dorado
Calif. Sacramento
San Bernardino
Colo. Pueblo
Conn. New Haven
Idaho Pocatello
Ill. Aurora
Ind. Muncie
Ia. Ottumwa
Kan. Lawrence
La. Lake Charles
Md. Baltimore
Mich. Ann Arbor
Ludington
Minn. Minneapolis
Miss. Tupelo
N. Y. Dunkirk
N. C. Rocky Mount
Okla. Lawton
Pa. Scranton
Washington
S. C. Sumter
S. D. Pierre
Tenn. Bristol
Tex. Pecos
Utah Price
Wash. Yakima

278

Calif. Fresno
Santa Barbara
Colo. Greeley
Fla. Panama City
Ill. Jacksonville
Ind. Elkhart
Ia. Sioux City
Kan. Coffeyville
Ky. Winchester
Mich. Ironwood
Miss. McComb
Mo. Poplar Bluff
N. J. Trenton
N. M. Tucumcari
N. C. High Point
Ohio Mansfield
Ore. Medford
Pa. Harrisburg
R. I. Providence
S. C. Anderson
Tex. Kilgore
Victoria
Va. Charlottesville
Wash. Bellingham
Wis. Fond du Lac

279

Ark. El Dorado
Calif. Sacramento
San Bernardino
Colo. Pueblo
Conn. New Haven
Ga. Macon
Idaho Pocatello
Ind. Muncie
Ia. Clinton
Kan. Lawrence
La. Lake Charles
Md. Baltimore
Mich. Ann Arbor
Ludington
Minn. Minneapolis
Miss. Tupelo
N. H. Manchester
N. Y. Dunkirk
N. C. Rocky Mount
Pa. Scranton
Washington
S. C. Sumter
S. D. Pierre
Tenn. Bristol
Tex. Pecos
Utah Price
Wash. Yakima

280

Ala. Anniston
Calif. Salinas
Ill. Jacksonville
Mass. Pittsfield
Mich. Benton Harbor
Neb. Fremont
Okla. Okmulgee
Ore. Astoria
S. C. Anderson
Tex. Tyler
Victoria
Wis. Fond du Lac

CHANNEL NUMBERS

Channel No.	Frequency Mc.	Channel No.	Frequency Mc.	Channel No.	Frequency Mc.	Channel No.	Frequency Mc.	Channel No.	Frequency Mc.	Channel No.	Frequency Mc.	Channel No.	Frequency Mc.
		211	90.1	226	93.1	241	96.1	256	99.1	271	102.1	286	105.1
		212	90.3	227	93.3	242	96.3	257	99.3	272	102.3	287	105.3
		213	90.5	228	93.5	243	96.5	258	99.5	273	102.5	288	105.5
		214	90.7	229	93.7	244	96.7	259	99.7	274	102.7	289	105.7
		215	90.9	230	93.9	245	96.9	260	99.9	275	102.9	290	105.9
201	88.1	216	91.1	231	94.1	246	97.1	261	100.1	276	103.1	291	106.1
202	88.3	217	91.3	232	94.3	247	97.3	262	100.3	277	103.3	292	106.3
203	88.5	218	91.5	233	94.5	248	97.5	263	100.5	278	103.5	293	106.5
204	88.7	219	91.7	234	94.7	249	97.7	264	100.7	279	103.7	294	106.7
205	88.9	220	91.9	235	94.9	250	97.9	265	100.9	280	103.9	295	106.9
206	89.1	221	92.1	236	95.1	251	98.1	266	101.1	281	104.1	296	107.1
207	89.3	222	92.3	237	95.3	252	98.3	267	101.3	282	104.3	297	107.3
208	89.5	223	92.5	238	95.5	253	98.5	268	101.5	283	104.5	298	107.5
209	89.7	224	92.7	239	95.7	254	98.7	269	101.7	284	104.7	299	107.7
210	89.9	225	92.9	240	95.9	255	98.9	270	101.9	285	104.9	300	107.9

FM BROADCASTING & COMMUNICATIONS HANDBOOK

Chapter 9—Designs for Antennas to Operate at 30 to 44, 72 to 76 and 152 to 162 Mc.

BY JAMES A. CRAIG *

THE antennas described herein are not presented as being radically new or theoretically superior. Rather, an attempt is made to catalogue and explain the action of certain types of antennas which have proved successful in actual service, and are known to operate at high efficiency. Further, the presentation is planned in such a form as to be understandable to those with a limited knowledge of mathematics.

All too frequently, those who control the appropriation of funds for communications systems are inclined to discount the important function performed by the radio transmitting or receiving antenna. However, the efficiency of an antenna can mean the difference between the ability or failure of a radio system to span a point-to-point distance, or to provide the required coverage over a given area.

Many antenna designs are much easier to construct on paper than to put into actual practice. This may be due to difficulty in matching impedances, to the necessity for much-too-critical adjustments, or because the construction is mechanically unwieldy and will not withstand the elements.

This text is written with the following specifications in mind: The emergency services require antennas or arrays that will provide high electrical efficiency and the required radiation pattern. At the same time, they must be simple, easy to match and adjust, and of mechanical construction that will withstand corrosion, icing conditions, and high winds. An antenna that will not meet these specifications is unsuited for day-in and day-out use, regardless of how well it performs on paper.

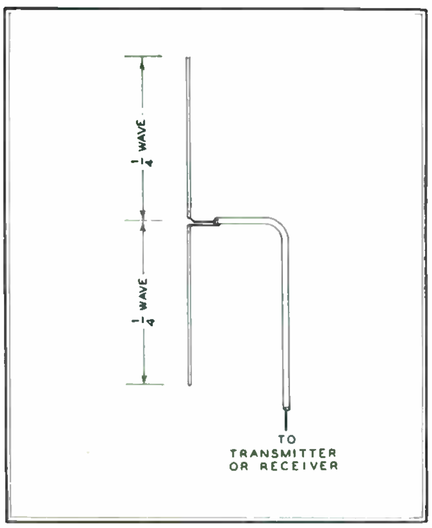


FIG. 1. SIMPLE VERTICAL HALF-WAVE DIPOLE

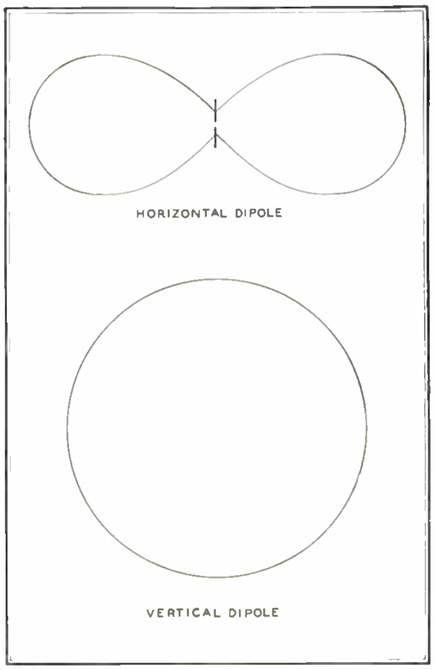


FIG. 2. RADIATION PATTERNS OF VERTICAL AND HORIZONTAL DIPOLE ANTENNAS

Antennas for Circular Coverage ★ Where a fixed station is required to transmit to mobile units or to many scattered fixed points, the vertical half-wave dipole, Fig. 1, might be considered the most desirable antenna because of its simplicity. It is, however, difficult to mount. Since it is fed at its center point, the transmission line must be led away horizontally for at least a wave-length before descending to the transmitter, because the proximity of the line to the lower quarter-wave element would interfere with its characteristics as a dipole. Otherwise, it would not be a dipole, for it could not be considered to be operating in free space.

Horizontal half-wave dipoles can be used only in special cases, since they are bi-directional in the horizontal plane. Typical radiation patterns in the horizontal plane for vertical and horizontal dipoles are shown in Fig. 2.

Another point to be considered is the choice between vertical and horizontal polarization of the radiated waves. Tests have shown that horizontal polarization provides better propagation characteristics than vertical polarization over most types of terrain. However, the requirement that mobile antennas be vertical, plus the fact that simple vertically polarized antennas are non-directional, dictates the choice of vertical polarization when communication with mobile units is involved.

If the lower half of a vertical half-wave dipole could simply be eliminated, there would remain nothing more than a quarter-wave whip antenna such as is used on mobile units. The difficulty here is that whereas the whip on a mobile unit has the body of the vehicle to work against as an RF ground or counterpoise, that condition does not prevail at the top of a fixed transmitting tower. The whip would then act as if it were floating, as far as an RF ground is concerned, and would not provide proper termination for the transmission line.

This can be overcome to a limited degree if some kind of counterpoise system of horizontal whips is used, as shown in Fig. 3. This antenna is popularly referred to as the "Whirling Joe" or ground-plane antenna.

A still better approach to the problem of mounting a half-wave vertical dipole would be to lead the transmission line, or coaxial cable, up inside the center of the lower half of the dipole. This is accomplished in the form of the half-wave coaxial or concentric antenna. Here the upper half of the dipole is called the whip, and the lower half is called the skirt. Reference to Fig. 4 shows that all elements have a common vertical axis, hence, the name "coaxial antenna." The support

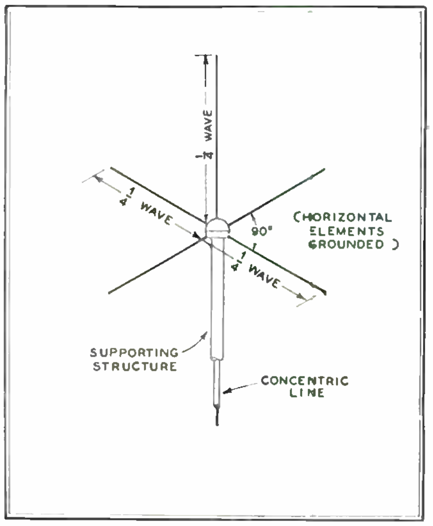


FIG. 3. THE GROUND-PLANE ANTENNA

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tube contains the transmission line, and is electrically common with the outer conductor of the line, both being at ground potential. The inner conductor of the coaxial line feeds the whip, which is insulated from the upper end of the support tube. The skirt, while directly connected to the top of the support, is insulated from it below this point by insulating rings which also keep it concentric with the support.

A coaxial antenna can be shunt-fed also. Then the whip is common electrically with

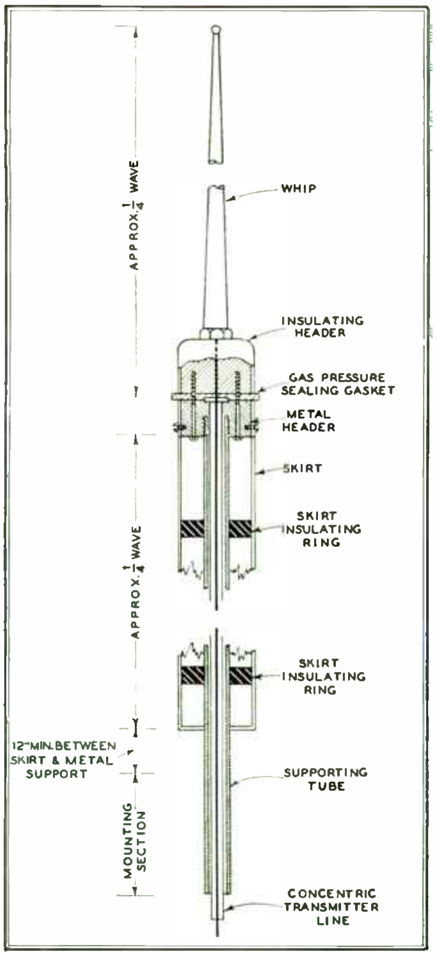


FIG. 4. SERIES-FED COAXIAL ANTENNA. THIS IS THE TYPE NOW MOST WIDELY USED

the support tube. Here the skirt is also grounded at its upper end as in the case of the series-fed coaxial antenna. To feed the antenna, it is necessary to take the center conductor of the transmission line through the support tube and connect it to the skirt at an impedance-matching point some distance down from its upper end, as in Fig. 5. Numerous reports from radiomen in the field attest to the fact that the correct location of this impedance point is rather difficult to determine, and that further adjustments may be required after installation to obtain maximum output.

About the only advantage that can be claimed for this arrangement is that the highest element, the whip, as well as the skirt, are at ground potential with respect to DC. It must be admitted that this fact provides a certain protection in case of a lightning strike.

Experience with several thousand series-fed coaxial antennas shows that lightning usually caused no structural damage to the antenna, but in the case of a heavy stroke, the coaxial transmission line suffers an arc-over or puncture within 6 or 8 ft. of the antenna header. Reports from the field show that the same thing occurs with shunt-fed coaxials, as would be expected. Our records show only three or four series-fed coaxial antennas that have sustained structural damage to the whip or the insulating header assembly. In these cases, the available evidence has lead to the assumption that the antennas were subjected to particularly heavy and direct lightning discharges. With either series-fed or shunt-fed antennas, the usual damage is to the line alone, necessitating its replacement.

Thus it would seem that any advantage of the shunt-fed coaxial over the series-fed, as far as lightning is concerned, is more theoretical than practical.

It is felt, therefore, that the series-fed coaxial antenna, as shown in Fig. 4, provides the ideal antenna for a fixed location for this type of service and coverage. It is a relatively simple structure, and can be built strongly of lightweight aluminum alloys. Such an antenna, cut for an operating frequency of 30 mc., weighs less than 10 lbs., including the support tube.

The vertical radiation pattern of a coaxial half-wave dipole antenna is shown in Fig. 11. It should be noted that this pattern is produced in all horizontal directions and can be compared to a doughnut flattened on the bottom and resting on a table, with a toothpick, representing the antenna, in the center of the hole.

The most critical portion of a coaxial antenna is the length of the skirt. If it is not cut correctly for the operating frequency, the performance of the antenna may be impaired seriously. However, this exact length can be computed readily. Then the skirt length can be cut with the knowledge that the antenna will perform at peak efficiency, and will require no further adjustments after installation.

On a typical coaxial antenna fabricated of aluminum, it has been found that with 50- or 52-ohm transmission line, the proper active or effective skirt length is slightly under 98% of an electrical quarter-wave at the operating frequency. The effective skirt length is that distance measured from the bottom of the metallic skirt-supporting header to the bottom of the skirt tube. Stated another way, it is the length of the air column enclosed between the skirt and the support tube. This is made clear in Fig. 4.

The reason for accurate skirt length adjustment stems from the fact that the skirt, in conjunction with the whip, provides the proper termination for the transmission line. In order for an antenna to radiate most efficiently, it must be capable of utilizing, as radiation, the maximum amount of the power delivered to it by the transmission line. This occurs when the impedance of the antenna, at its feed point, is equal to the characteristic or surge impedance of the transmission line. If the skirt length is not the proper value, the impedance presented by the antenna is not the characteristic impedance of the line. Consequently, some energy is not utilized by the antenna as radiation, but is reflected back down the line.

The skirt performs two important func-

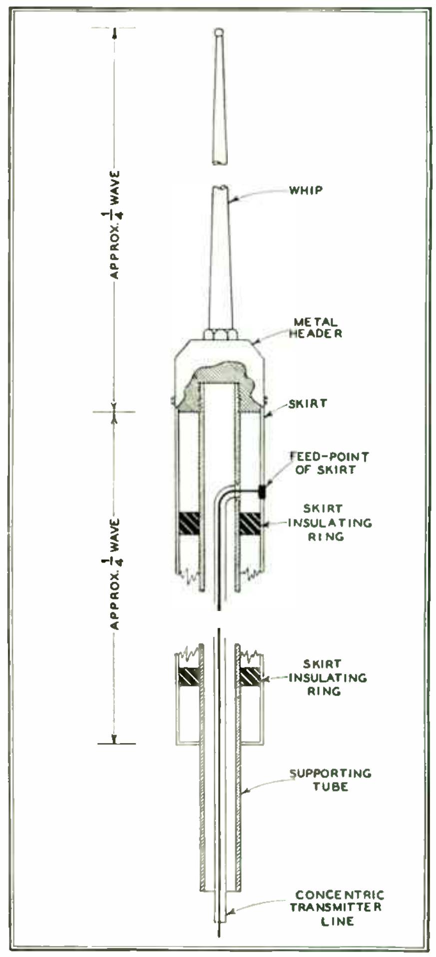


FIG. 5. SHUNT-FED TYPE OF COAXIAL, VERTICALLY POLARIZED ANTENNA

tions. The first is as a resonating stub to keep standing waves off the outside of the transmission line or the antenna support. This would destroy the desirable low-angle radiation pattern of the coaxial antenna as a half-wave dipole. In this manner, the skirt acts with the support tube as a metallic "insulator" to choke out the electrical continuity of the support pipe and antenna. Second, it is part of the half-wave dipole and, as such, must be a correct percentage of a quarter-wave. From the standpoint of its second function, the length of the skirt is less critical but, as a resonating stub, it is necessary to hold its length to a close tolerance.

Fig. 6 shows what is meant by standing waves on a line, and also how voltage and current are distributed along the antenna elements. This illustration also shows the

EVERYTHING NEW FOR FM —

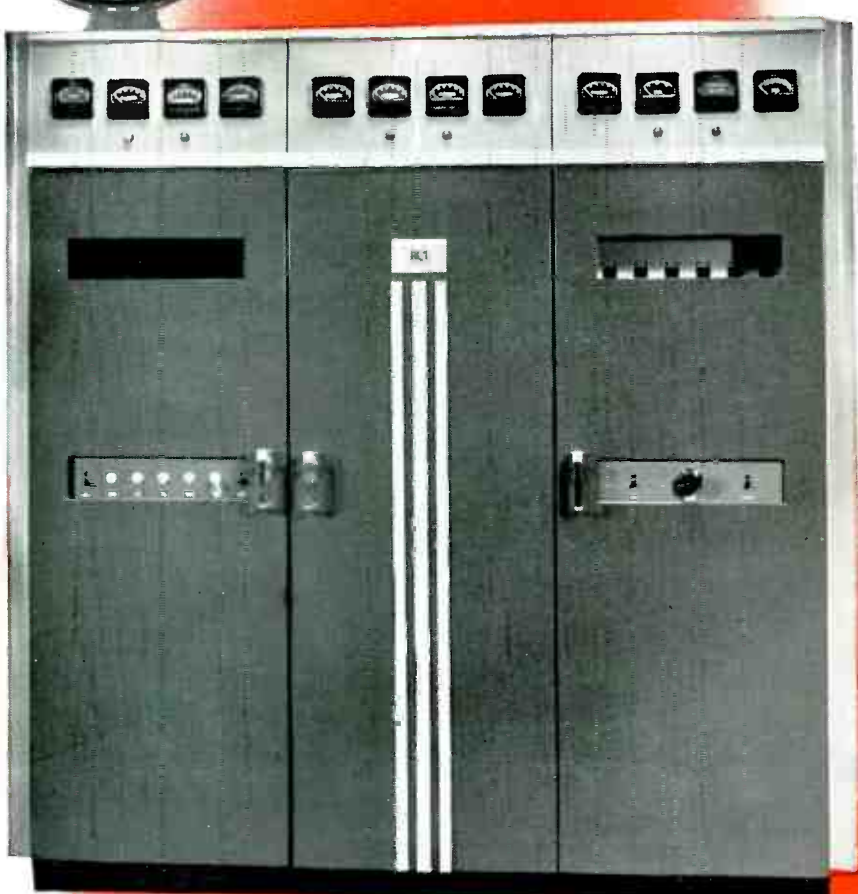
for NEW operating economy....

NEW RCA POLYDIRECTIONAL MICROPHONE

(Type 77D)—The polydirectional feature helps you obtain better balance, clarity, naturalness, and selectivity in studio pickups.

By means of a screw adjustment at the back of the microphone a variety of non-directional, uni-directional, and bi-directional characteristic patterns can be produced. Undesired sound reflections can be quickly eliminated merely by switching to the proper pattern. A three-position, VOICE-MUSIC switch permits the selection of the best operating characteristic.

This lightweight, multi-purpose microphone is finished in two-tone umber grey.



NEW RCA TRANSMITTERS

RCA's line of FM transmitters (250 watt, 1, 3, 10, 25, and 50 kw) are completely new from exciter to power amplifiers—new circuits, new tubes, and a new type of construction.

The frames of all power sizes have been standardized thus assuring uniformity of dimensions, appearance, and easing installation problems. When increased power is desired, you merely add an amplifier. Appearance is equal to that of a single unit. Curved-end pieces add to the finished appearance.

A new, hollow base frame provides space for inter-unit wiring, and eliminates the need of wiring through units or conduits in the floor.

Air filters, flush-mounted centralized control panels, and concealed hinges are other features of the new RCA construction—*standardized* to assure you a better product at lower cost.

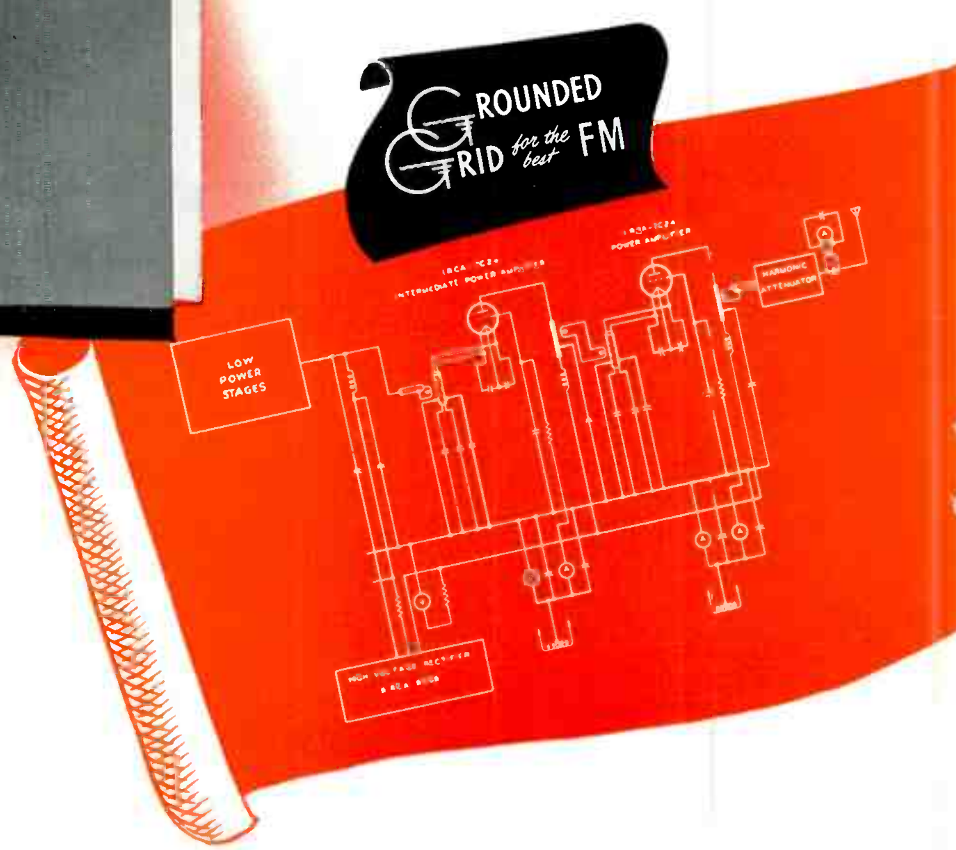
NEW CIRCUITS

The new RCA Grounded-Grid amplifier circuits are at once simpler and more stable than any heretofore employed. As the name indicates, the grid of the tube is at r-f ground potential (instead of the filament as in conventional transmitters). The drive is applied between cathode and ground, either element being at the necessary d-c bias potential.

Special tubes have been developed for these circuits. Neutralization is either unnecessary, depending on frequency, or, if necessary, very easily achieved.

Other advantages: easier tuning, fewer tube types to stock, smaller, less-expensive tubes, lower operating costs, less distortion, and better program quality.

RCA's new "Direct FM" circuit for the exciter is something entirely different, too.



—from MICROPHONE to ANTENNA

NEW convenience, and NEW performance

THE NEW RCA equipment shown here is merely indicative of the advances that have been made by RCA in FM broadcast equipment. Similar improvements have been made on every item that goes into a completed broadcast station, including test and measuring equipment, monitoring assemblies, turntables, and recorders.

The resumption of broadcast-equipment construction, after wartime restrictions, offered us a unique opportunity to design an entirely new line—integrated in every detail. The various units incorporate all the latest FM improvements that have grown out of RCA's advanced war work on communications equipment for the armed forces.

If you are planning to build a new FM station, we believe that "RCA all the way" will help you to make it a *better* station. You will be assured of the same efficiency, convenience, operating economy, and performance that have made RCA's AM equipment the undisputed first choice of broadcast stations for the past decade. Radio Corporation of America, Camden, N. J.

NEW RCA CONSOLETTE

(Type 76-B2)—Provides a complete high-fidelity audio system for FM, AM, and television at a price even the smallest station can afford.

Compact (39 by 17 by 10½ inches), it includes all the amplifying control and monitoring equipment needed to handle two studios, an announcement and a control-room microphone, two turntables, and six remote lines.

It enables simultaneous auditioning and broadcasting from any combination of the studios, turntables, or remote lines. The talk-back system is independent of program channel—no feed-back. Emergency amplifier and power supply circuits help prevent time off the air.

Differs from two previous RCA models now giving satisfactory service in more than 300 stations primarily in its frequency response—now extended to 15,000 cycles.

NEW RCA SUPER TURNSTILE ANTENNA

The advantages of this antenna make up an impressive list. A few include: high-gain, permits the use of a lower transmitter power for a given coverage, full performance at any frequency from 88 to 108 mc, handles up to 20 kw, easy to install, wide band, pretuned at factory, no field adjustments whatever, a standardized low-cost "packaged" item—comes complete, de-icer units easily added, fewer end seals, entire structure can be grounded.

In addition, it has the usual advantages of any turnstile antenna: an inherently circular field pattern, low wind resistance, and simple, inexpensive, single-pole mounting.

The antenna, because of its relatively high gain and extended band width, is also ideal for television. Naturally, since it is of the turnstile type, both sound and picture transmitters can be fed into the same antenna.

FM BROADCAST EQUIPMENT

RADIO CORPORATION of AMERICA

ENGINEERING PRODUCTS DIVISION, CAMDEN, N. J.

effects of mismatched antenna elements.

In determining the correct values for the lengths of antenna sections, or elements, the presence of standing waves can be detected and their magnitude measured by means of a series of small holes drilled in the outer conductor of the transmission line. The probe of a vacuum tube voltmeter can be inserted and voltage readings taken along the line over at least a quarter-wavelength. A perfect line, perfectly terminated, would show the same voltage along its entire length, indicating that no standing waves were present. Then there would be no reflected energy and no power loss in the line other than that due to normal attenuation. In practice, it is possible to hold the ratio of maximum to minimum standing-wave voltage to a value of 1.1 with the series-fed coaxial antenna as described previously. This represents a power loss, due to reflections, of less than 1%. A relatively slight increase or decrease in skirt length from the proper value has a marked effect on the standing wave ratio as shown in Fig. 7.

For the same typical aluminum coaxial antenna mentioned above, the length of the whip has been found to be about 95% of a quarter-wave. This value includes the whip proper and that portion contained within the insulating header. In other words, it is that length from the point where the center conductor of the coaxial line merges from its sheath to the upper end of the whip. The length is not critical, as Fig. 8 shows. While the length of the whip has a definite effect on the performance of the antenna, it can be seen that a variation from 92% to 98% of a quarter-wavelength has very little significant effect on the performance.

The values for skirt and whip lengths given above are for 52-ohm transmission line. If 72-ohm line is used, the skirt length

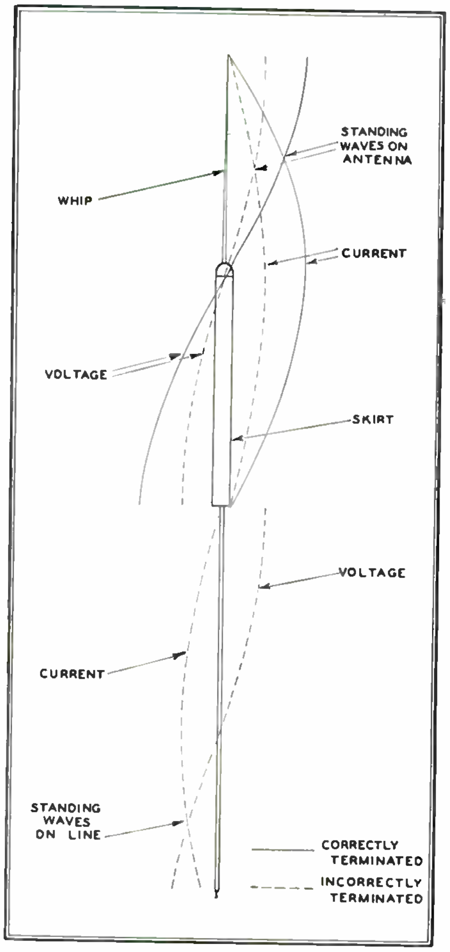


FIG. 6. EFFECTS OF CORRECT AND INCORRECT ANTENNA TERMINATIONS

should be almost 99% of a quarter-wave, and the whip, about 94% of a quarter-wave. For this typical antenna, as manufactured commercially, the values used are 98% of a quarter-wave for the skirt and 94% for the whip. The antenna can then be fed by 52- or 72-ohm coaxial transmission line, and the standing-wave ratio in either case would not exceed 1.25, representing a power loss due to reflections of not over 3%.

Actually, the optimum lengths of the skirt and whip for any given coaxial antenna will depend upon the material from which the elements are fabricated, the type and number of insulating rings inside the skirt, end effects of the skirt, and the ratio of the diameters of the support tube and the skirt tubing.

Colinear Coaxial Antennas ★ An adaptation or extension of the coaxial antenna is known as the *colinear coaxial antenna*. Fig. 9 shows an exterior view of this antenna and the placement of the elements. In some variations of these antennas, the lower skirt element is not driven or fed any power. Parasitic excitation of this element is questionable, since the additional skirt is not within the main radiation pattern of the series-fed coaxial antenna located above it.

In comparison with a properly matched coaxial antenna, tests have shown that any gain in radiated signal strength was barely measurable, and so small as to be within the limits of observational error. Furthermore, with the length of this auxiliary skirt and its distance from the upper skirt at their optimum values, the antenna performed only as well as a simple, properly-matched coaxial antenna. But if the length of the auxiliary skirt, or its distance from the upper skirt, or both, were varied from their optimum values, the colinear coaxial antenna performance dropped below that of a standard series-fed coaxial antenna.

Actually, colinear antennas are not by any means a new development. Fig. 10 shows a conventional colinear antenna. It should be noted that such an antenna can be constructed of wires or metal rods as

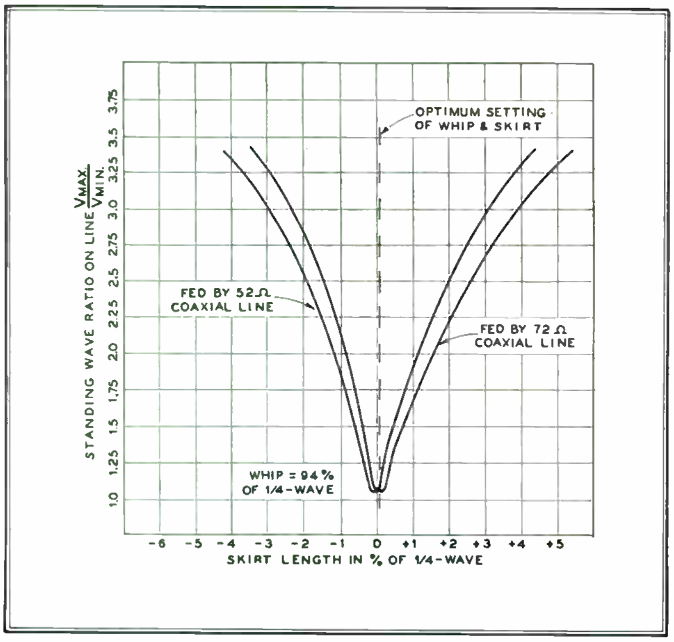


FIG. 7. EFFECT OF SKIRT LENGTH ON THE STANDING WAVE RATIO OF A SERIES-FED COAXIAL ANTENNA

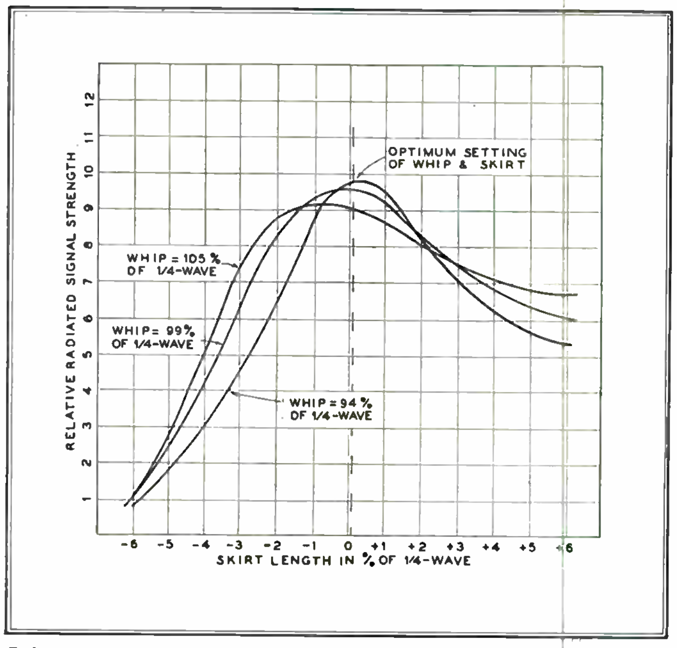


FIG. 8. EFFECT OF VARYING LENGTH OF WHIP FROM 92 TO 98 PER CENT OF ONE-QUARTER WAVE IS NOT CRITICAL

elements which are not necessarily coaxial. The theory behind this antenna array is sound, provided all elements are driven. The number of half-wave elements is not limited to two, and more can be used, up to practical limits.

Tests on a newly-designed series-fed colinear coaxial antenna, with all elements driven, indicate that a greatly improved signal can be radiated as compared with the standard series-fed coaxial. The design is extremely simple and workable for the 152- to 162-mc. band, and should prove highly advantageous.

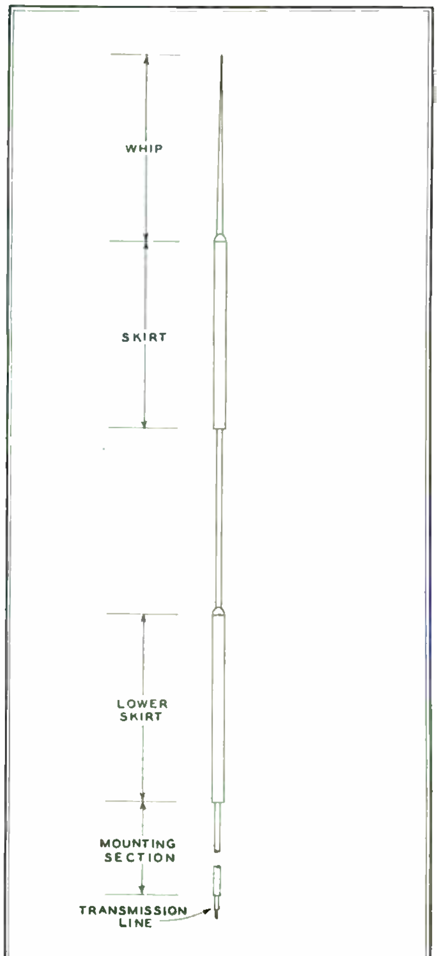


FIG. 9. NO POWER IS FED TO THE LOWER SKIRT OF THIS COLINEAR COAXIAL

As mentioned previously, a properly terminated coaxial antenna radiates almost 100% of the power delivered to it. The improvement in signal strength with a colinear coaxial, when all elements are driven, results from a lowered angle of radiation in the vertical plane and a compressed radiation pattern, as shown in Fig. 11. In any horizontal plane, the area included within the radiation pattern boundaries is an expression of the power radiated by the antenna in that plane. It is seen that if the vertical pattern is narrowed, the radial coverage is increased. This provides greater coverage for the same antenna input power.

In the 30- to 42-mc. band, the overall length of the colinear coaxial would be as much as 33 ft., excluding support tube. This would be an unwieldy structure. However, in the 152- to 162-mc. band, the length drops to less than 8 ft., and makes possible a mechanically sound structure.

Directional Arrays ★ In order to utilize antenna input power most effectively for communication between two fixed points, a beamed signal is desirable. Power radiated to other points serves no useful purpose. Directional antenna arrays can be used to boost the signal in any direction desired. This means that adequate signal strength can be delivered at a distant point with less transmitter power than would be required with a non-directional antenna. Another advantage is that the signal is not broadcast into areas where it might interfere with other services using the same or adjacent channels.

One of the oldest forms of directive antennas is the rhombic or diamond type. It is capable of substantial gain but, unfortunately, requires considerable space. Fig. 12 shows a full rhombic antenna.

Either vertical or horizontal polarization can be used for point-to-point transmission. That is because, at fixed locations, the receiving array can be made to match the polarization of the transmitting antenna. Although horizontally polarized waves generally travel over most types of terrain with less attenuation than those vertically polarized, a more important consideration is the structural advantage offered by one method of polarization over the other.

While a rhombic antenna can be arranged either horizontally or vertically, a vertical half-rhombic or inverted V antenna, Fig. 13, usually presents the least mechanical problems. The angle of tilt, designated A, is so chosen that the main radiation lobes 1 and 2 are horizontal. Lobes 3 and 4 then cancel each other and lobes 1 and 2 reinforce each other. The terminating resistor is used to eliminate the back radiation indicated by dotted lines. With this resistance omitted, the array would be bidirectional, showing about the same gain forward and backward. The angle of tilt may be adjusted by varying the height H or the length of the legs L.

The leg length is not critical, and can be 3 or more multiples of a wavelength at the operating frequency. While the antenna gain is increased with greater height, it is more dependent upon the leg length. To realize the gain of which the rhombic is capable, L should be at least 3 times the wavelength. However, as L is increased, the gain increases but the beam becomes more narrow. In fact, at 6 times the wavelength, the beam is so highly concentrated that the orientation of the array for maximum signal at the receiving site becomes very critical, and must be done with great care. A gain of 8 to 10 db can be realized with a properly constructed rhombic having a leg length L equal to 6 wavelengths. This means a power gain of about 8 to 1 as compared to a standard half-wave dipole.

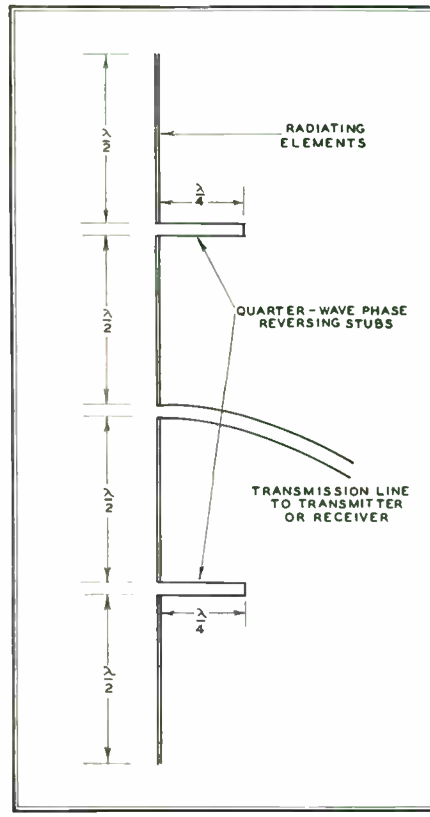


FIG. 10. SERIES-FED COLINEAR COAXIAL IS ADVANTAGEOUS AT 152 TO 162 MC.

The trigonometric computation of the angles and sides of this array is beyond the scope of this text. However, the following relations will produce rhombics that are efficient and will give very satisfactory performance.

Referring to Fig. 13, the proper tilt angle A is approximately 66°, and will be obtained if L is made 2.25 times the height H. Thus, if the operating frequency

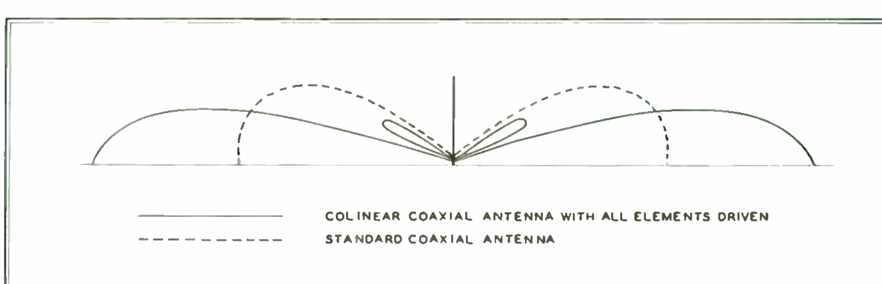


FIG. 11. LOWER ANGLE OF RADIATION GIVES COLINEAR COAXIAL GREATER RANGE

is 30 mc., and available space permitted a leg length equal to 5 wavelengths. L can be found as follows:

$$L = \frac{300,000 \times 3.28}{30,000 \text{ kc.}} = 32.8 \text{ ft.} = L$$

$$5L = 5 \times 32.8 \text{ ft.} = 164.0 \text{ ft.}$$

$$H = \frac{164}{2.25} = 73 \text{ ft.}$$

At the same frequency, with legs equal to 3 wavelengths, 3L would equal 98 ft. and H equal 43.5 ft. figuring as above.

At 50 mc. with L equal to 5 wavelengths, H becomes 43½ ft. and at 3 wavelengths for L, H becomes only 26 feet. It is seen that, beyond about 50 mc., the value of H becomes so small that the effective height of the antenna is seriously cut down. This can be overcome at higher frequencies by going to a full rhombic antenna. As shown in Fig. 12, a single pole can be used to support this array without complicating the mechanical problems to any appreciable degree.

Here the distance B can be made 2 times H as computed above, and the same method used to figure the array. As a typical example, at 75 mc. with legs equal to 5 wavelengths:

$$L = \frac{300,000 \times 3.28}{75,000 \text{ kc.}} = 13.08 \text{ ft.} = L$$

$$5L = 5 \times 13.08 = 65.4 \text{ ft.}$$

$$B = 2H = 2 \times \frac{65.4}{2.25} = 58.2 \text{ ft.}$$

The full rhombic should be as high above the ground as possible, consistent with the space available for the end guys.

With the half-rhombic, it is necessary to employ a counterpoise system. This can be simply a wire on or just below the ground, directly under the antenna. One end is connected to the terminating resistor and the other end is connected to the second conductor of the transmission line. As an alternative, a section of metal screening or simply two wires, one at right angles to, and the other parallel with the antenna can be located on the ground under each end of the array. If the two crossed wires are used, they should be crossed at their mid-points. This point or the center of the screening should then be connected to the transmission line shield at one end of the antenna and to the terminating resistor at the other end of the antenna. If a full rhombic is used, no counterpoise is necessary.

With either the half or full rhombic the following considerations apply equally: The supporting mast must not be of metal. A wood pole, tubular plywood mast, or other non-metallic construction must be used. The mast can be guyed with wires, provided they are approximately at right angles to the direction of transmission. The terminating resistor should have a value of between 500 and 800 ohms. This is not critical. It should also be non-inductive, and must have a wattage rating capable of safely dissipating one-half of the transmitter output power, since its function is to eliminate the rear half of the radiation pattern.

Both rhombics exhibit the same characteristics of gain and directivity when used for receiving as well as for transmitting. The end guys used with the full rhombic, Fig. 12, can be metal without affecting the radiation pattern.

The input impedance of either the half- or full-rhombic at its feed point is about 600 ohms. If fed by a low impedance coaxial line, a serious mismatch would result. This can be overcome by the use of an impedance matching transformer, Fig. 14. It is properly adjusted when the loading of the transmitter is unaffected by substituting for the rhombic antenna and impedance-matching transformer a dummy antenna having a resistance equal to the surge impedance of the transmission line. At this adjustment, the antenna current in either leg will also be at maximum.

If, in the case of a full rhombic antenna, it is desired to locate the impedance transformer at or near the ground, an open-wire 600-ohm line can be run from this point to the input end of the antenna. Such a line consists of two lengths of No. 12 wire, as might be used in the antenna, spaced 6 ins. apart by means of waxed wood, Lucite, or porcelain spreaders located every 2 ft. or so along the length of the line.

Parasitic Directive Arrays ★ Where space is not available for a rhombic antenna, or where a compact array is desired, a half-wave dipole with parasitic directors and reflectors can be used. Fig. 15 shows a horizontal dipole array.

These arrays present something of a structural problem in the 30- to 44-mc. band. Fortunately, while arrays for those frequencies have been built and are giving satisfactory service, most emergency service point-to-point work will be done on 72 to 76 and 152 to 162 mc.

In the majority of cases, these arrays can be so designed as to lend themselves readily to mounting on towers or pipe masts. They should be all metal for durability, preferably designed for single-point mounting, and should be self-supporting with no external braces.

Returning to Fig. 15, it is seen that the central portion is a half-wave dipole. It is usually fed by a coaxial transmission line with one quarter-wave element insulated from the central support and fed by the inner conductor of the line. The other quarter-wave element is grounded to the outer shield of the line and to the supporting structure. Minus the directors and reflectors, it has a radiation pattern as shown in Fig. 2.

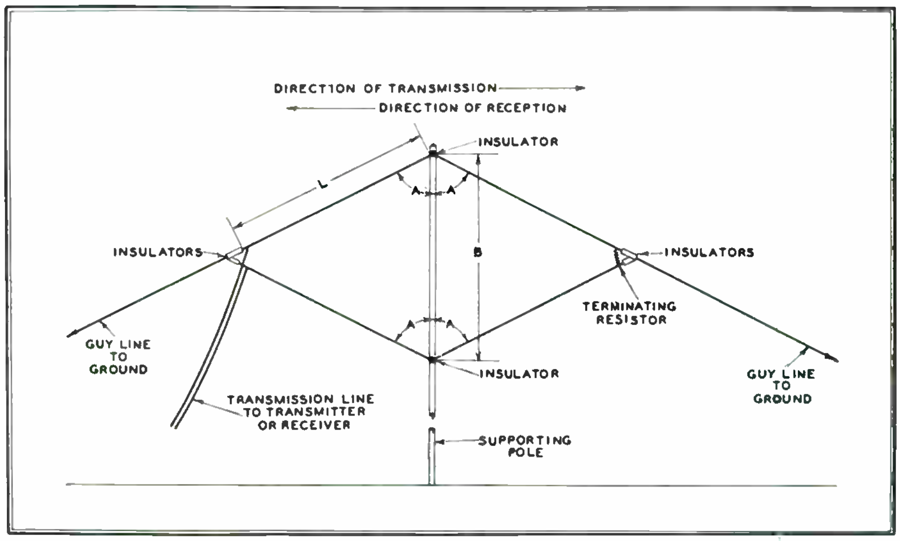


FIG. 12. FULL RHOMBIC IS FOR HIGHLY DIRECTIONAL TRANSMISSION OR RECEPTION

When tuned elements such as the directors and reflectors are added, they are located directly in the radiation field of the driven dipole. The metal support arms for these elements have no effect on the radiation pattern either with or without the director and reflector. The supports, directors, and reflectors are all grounded to the hub assembly and to the mast structure, and are therefore at DC ground potential. A horizontal radiation pattern of such an array is shown in Fig. 16.

The function of the directors and reflectors is to absorb RF energy from the field of the driven dipole and to re-radiate it. By varying the lengths of these elements, or by varying their distance from the driven dipole, the re-radiated energy can be caused to reinforce the signal in the desired direction, and cancel it in the opposite direction.

Referring to Fig. 15, it is seen that the reflector is located slightly less than ¼-wavelength to the rear, and that the director is slightly less than ¼-wavelength ahead of the driven dipole.

Since both are directly in the path of the waves emanating from the driven dipole, each wave cuts across these elements. In doing so, a voltage is induced in the element which is opposite in phase to the inducing voltage. Due to this voltage, the re-radiated wave from the director contains up to about 85% of the energy radiated to it by the driven dipole.

Considering the reflector only, the idea is to time this re-radiated wave so that, when it returns to the driven dipole, it is exactly in phase with the next wave being radiated by the driven dipole. Since the induced voltage in the reflector is 180° out of phase with the inducing field at the reflector, it is seen that about 90° in time are used for travelling to the reflector, 180° in time are added due to the reversal of phase at the reflector, and about another 90° are used in travelling from the reflector to the driven dipole. Thus the re-radiated energy from the reflector has undergone a 360° change of phase by the time it returns to the driven dipole. Thus, it is in phase with the next wave radiated from the driven dipole. The net result is that two waves are involved, so timed in space that they tend to cancel at the reflector and become additive at the driven dipole. Therefore, the circular pattern of the dipole alone is altered, and is built up in the direction from the reflector toward the driven dipole, and reduced in the opposite direction.

Since the spacing between the parasitic elements and the driven dipole is slightly less than 1/4 wavelength, it becomes necessary to produce a lag at the reflector in order to obtain the 360° phase relationship of the two fields. This can be accomplished with reflector elements slightly longer than an electrical quarter-wave. This makes the reflector look inductive, and introduces a lagging component of current in the element. By adjusting the length of the reflector element, an optimum value is obtained where the phasing of the radiated and re-radiated fields provides the maximum front-to-back ratio. This is the ratio of the radiated energy in the desired direction to the energy radiated in the opposite direction.

In an array as illustrated in Fig. 15, the reflector does most of the work of providing directivity, but the addition of a director will provide additional gain in the desired direction by causing the beam to become narrower in the horizontal plane. More than one director can be used, each spaced about a quarter-wave ahead of the other. When one reflector and two directors are used, the result is the familiar Yagi array.

In the case of the director, a leading component of current must be introduced in order to preserve the phasing of the radiated and re-radiated fields, and to provide maximum reinforcement in the desired direction. This is accomplished by making the director elements less than a quarter-wavelength long. This causes them to have capacitive reactance.

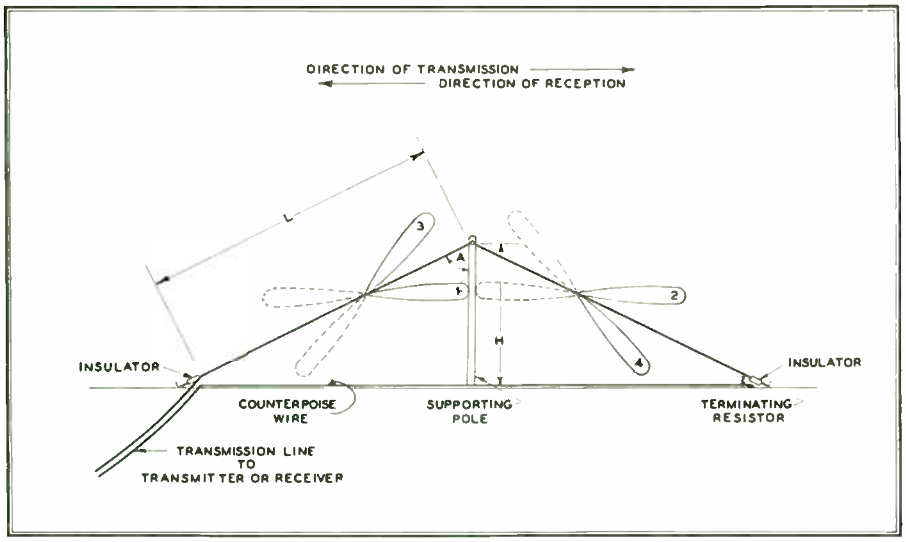


FIG. 13. THE HALF-RHOMBIC IS PREFERRED WHERE AVAILABLE SPACE IS LIMITED

While each added parasitic element increases the power gain in the desired direction, each one also takes away from the mechanical strength of the structure. Here again the choice must be reckoned in terms of power gain versus increased windage and ice loading on the structure. The array shown in Fig. 15 is capable of a 2.5 to 1 power gain and a front-to-back ratio of better than 4.5 to 1. This will be found adequate for most installations. Under conditions where more gain is necessary, additional parasitic elements may be required. In that case, more can be accomplished by additional directors located in the area of intensified field strength than by added reflectors in the area where the field strength has been purposely reduced.

While the following figures will be affected slightly by the type of construction, typical values for the lengths of horizontal dipole elements in terms of percent of a quarter-wave, are: Insulated driven dipole element, 95.5%; grounded dipole element, 95.5%; parasitic reflector and director spacing from driven dipole, 89%; reflector elements, 96%; director elements, 88%.

In an array consisting of a driven dipole with 1 director and 1 reflector with quarter-wave spacing, it should be noted that the impedance presented to the transmission line will remain close to the value presented by a single half-wave center-fed dipole. This value will be in the neighborhood of 70 ohms.

It is possible to construct this same array with as little as 0.1- to 0.15-wave spacing between the driven dipole and the director and reflector. It will be found that the impedance presented by the array to the transmission line will have dropped to less than 20 ohms, which becomes a serious impedance mismatch. If the array were to be fed by commercial 50- or 70-ohm concentric cable, the loss due to mismatch and consequent standing waves on the line might more than offset any possible gain attributed to the array.

The array shown in Fig. 15 provides a beam having horizontal polarization. A typical horizontal radiation pattern for such an array is given in Fig. 16.

If the array were rotated 90°, using the parasitic support arms as an axis, it would then radiate a vertically polarized wave. Such an array is readily built about a coaxial antenna such as shown in Fig. 4. In fact, quite a number of these arrays are in use and give highly satisfactory performance. A vertical array based on a central coaxial antenna is shown in Fig. 17. It will be seen that the parasitic support arms are carried by a hub which is fitted around the metal skirt-supporting header of the coaxial antenna.

The gain and front-to-back ratio of this array compares very closely with that of the horizontal array shown in Fig. 16.

Typical figures for the vertical coaxial array are presented in terms of percent of a quarter-wavelength as follows: Whip length, 94%; skirt length, 98%; spacing from coaxial antenna to director and to reflector, 100%; reflector elements, 103%; director elements, 84%.

Both the vertical and horizontal arrays described must have the various lengths and spacings of the elements accurately fixed for optimum performance, but from another standpoint they allow a surprising amount of latitude. A certain amount of droop or sag in the support arms can be tolerated without serious effect on their performance of the array. Also, in both arrays, the director, reflector and driven dipole should all be parallel to the same plane. Yet, misalignment, so that the elements are crisscrossed when viewed in the direction of transmission, up to almost as much as 30°, has little practical effect on the characteristics of the radiated pattern. While such conditions are not desirable, the fact is brought out that these arrays are not as critical as many suppose them to be.

Corner Reflector Antennas ★ Corner reflectors can be used to direct the radiation from either a vertical or horizontal dipole, as shown in Fig. 18. While this type of antenna is mechanically more complicated than those previously discussed, it is a relatively compact array. The central dipole is the only driven member, the other elements being used in place of two metallic sheets to form a corner reflector. Theoretically, each side of the angle should consist of a sheet of metal, which would simply be the ultimate case of having elements so numerous that they touched each other. Practically, if the spacing of the elements forming the sides is not over 1/10-wave, the performance of the array would not differ appreciably from that obtained with metal sheets.

The characteristics of the array can be altered in two ways. As the angle between the sides of a vertically polarized array is decreased, the beam becomes narrower, mostly in the horizontal plane, but to a certain extent in the vertical plane also. For a horizontal array, the narrowing effect on the beam as the corner angle is reduced is more pronounced in the vertical plane, although the pattern in the horizontal plane is also narrowed, but to a lesser degree.

Referring to Fig. 18, the half-wave dipole is always located on a line bisecting the corner angle. The distance A, out from the corner to the point where the dipole is

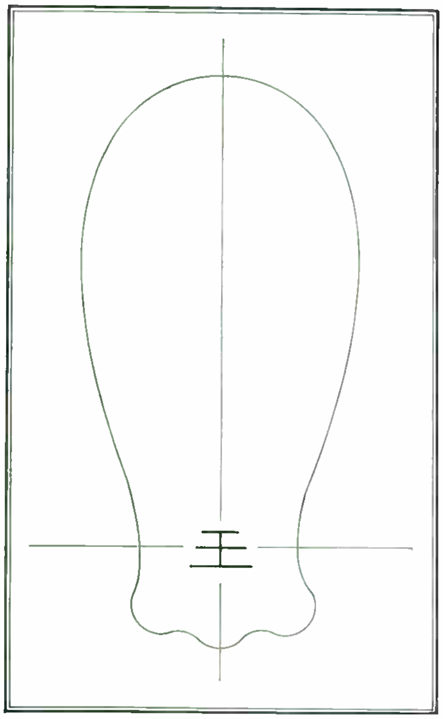


FIG. 16. RADIATION PATTERN OF THE HORIZONTAL REFLECTOR-DIRECTOR

located, controls the impedance of the array. The angle between the two sides can be varied between 45° and 180°. At 180° the result is a dipole located in front of a flat reflecting surface, which produces a very broad pattern forward. For any one angle however, there is a definite value for A which will produce a desired impedance. For 52-ohm transmission line, the antenna impedance will match the line at the following angles and values for A. For a 180° angle, A would be equal to 0.16 wavelength. At 90°, A becomes 0.3 wavelength and at 60°, A becomes 0.45 wavelength. For smaller angles, the impedance of the array becomes more difficult to match regardless of how much A is increased. Smaller angles also produce a pattern that is broken up into multiple lobes and shows a decrease in gain.

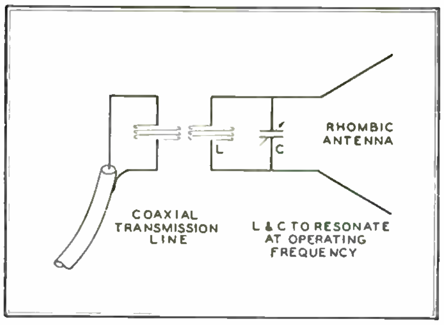


FIG. 14. SIMPLE MATCHING TRANSFORMER

To match a 72-ohm transmission line, the foregoing figures should be altered as follows. For angles of 180°, 90° and 60°, the values for A become 0.21, 0.35 and 0.5 wavelength respectively.

At any of the usual angles given above, smaller values for A decrease the impedance of the array, and larger values increase the impedance.

The value of H, the length of the elements forming the sides of the angle, is not critical but should be held to a value not less than the overall length of the driven dipole. As a matter of fact, the elements forming the sides of the angle are not parasitic elements in the usual sense, since they are not tuned. They should be made long enough so that they appear to have unlimited length as far as their effect on the array is concerned.

The length L of the sides of the corner reflector is not critical as long as they are not less than 3 or 4 times the value of A, Fig. 18. The sides can be carried out farther than this minimum value, but the slight improvement in pattern is not worth the increased size of the array and the attendant mechanical problems introduced thereby.

Corner reflector antennas, while admittedly more cumbersome, are capable of greater gain than the simpler parasitic arrays. Properly designed corner reflectors can be expected to give a power gain of 10 to 13 db as compared to a single half-wave dipole. This means radiation in the desired direction of 10 to 20 times greater than that afforded by a simple dipole.

Referring to Fig. 18, it should be noted that the corner reflector antenna can be mounted vertically or horizontally. When mounted vertically, the driven dipole can be used to good advantage as a coaxial antenna. When a vertical half-wave dipole is used instead of the vertical coaxial, the transmission line should be led horizontally from the center of the driven dipole to the vertex of the corner reflector before it drops vertically to the transmitter or receiver.

Mobile Antennas ★ As mentioned earlier, vertical antennas are particularly adapted to mobile installations. A quarter-wave whip is most frequently used. The method of installation on the vehicle is important. A prime consideration is the use of maximum height relative to the vehicle. This is limited by the overhead clearances encountered in the area where the vehicles are required to operate.

The ideal location on a passenger car would be the center of the roof. In this position, the radiation pattern is most nearly non-directional. If such an installation is made in a station-wagon or on a truck body where the roof is made of wood, it is necessary to sheath the under side of the roof with light copper sheet or copper screening, securely bonded to the chassis at several points. This then becomes a ground plane immediately below the whip antenna, such as would be provided by the metal roof of a passenger car.

Usually, to provide overhead clearance, the antenna must be mounted toward the rear of the car, somewhere near the rear mudguard. In this position, the radiated pattern is no longer non-directional. With

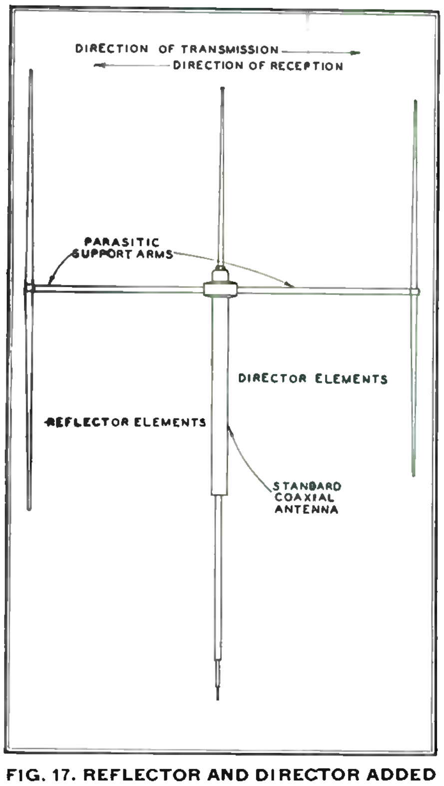
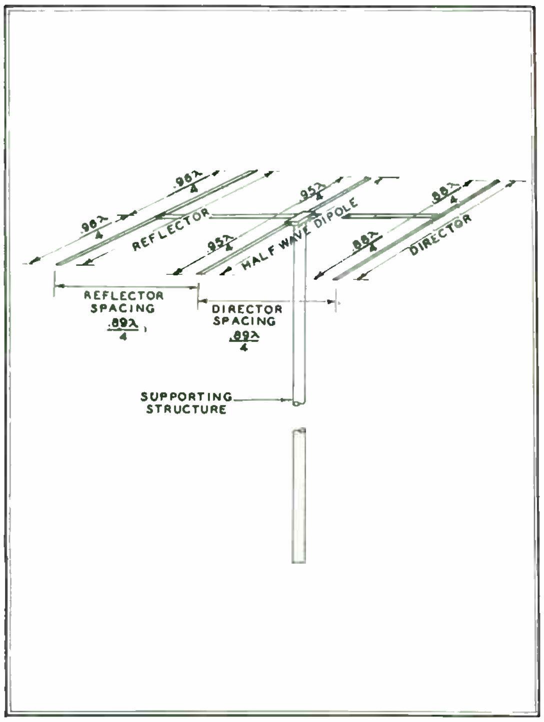


FIG. 17. REFLECTOR AND DIRECTOR ADDED TO A COAXIAL TYPE ANTENNA

a 30-mc. whip in the rear and at the left side of the car, it will be found that in most cases the greatest radiation and best reception will occur in a direction toward the right front corner of the car.

In the 72- to 76-mc. and 152- to 162-mc. bands, the center of the roof is the most logical location for the whip. At these frequencies the length of a quarter-wave whip is about 37 ins. and 18 ins. respectively, presenting no overhead clearance problem.



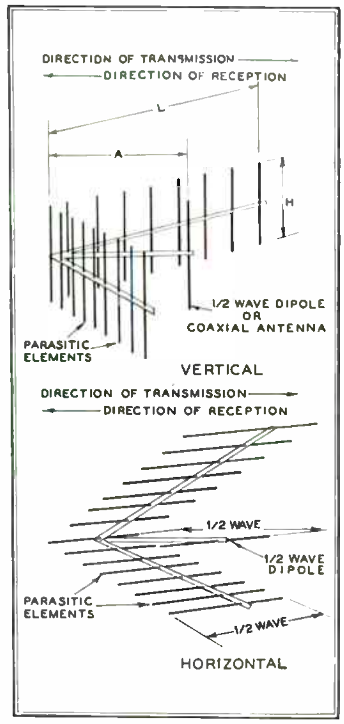


FIG. 15, LEFT: A HORIZONTALLY POLARIZED DIPOLE AND DIRECTIVE ARRAY. FIG. 18, RIGHT: VERTICAL AND HORIZONTAL TYPES OF CORNER REFLECTOR ANTENNAS

Mechanical Considerations ★ Obviously, all ferrous materials, unless heavily plated, should be ruled out for use in the construction of antenna arrays because of rust. Brass is easy to fabricate, withstands corrosion, and can be sweated for maximum electrical contact. Unfortunately, brass is a relatively heavy metal, and imposes a correspondingly heavier load on the array and on the supporting structure. Aluminum and its alloys are ideal because of their light weight. However, these materials are subject to corrosion from salt water and some acids. If this condition is encountered in the locality where an aluminum antenna or array is contemplated, certain precautions must be taken.

Aluminum corrosion is largely self-inhibiting. That is, as corrosion attacks the aluminum surface, a scale or oxide is formed which progressively halts further corrosion. This is true on an unbroken surface, but does not hold true where tubular or other joints occur. Here, in severe cases, moisture finds its way into the joint and freezes the connection. This, together with the corrosion, expands the outer member of the joint and eventually weakens it, causing poor electrical contact.

This can be overcome by using a vinylite sleeving or tape wrapped tightly over the joint, or by the application of some of the so-called stripping plastics used so successfully during the war to protect metal parts in ocean shipment. Where conditions necessitate this treatment, it is still worth the effort to take advantage of the lightweight, high-strength aluminum alloys.

The dead weight of the antenna or array is not the only factor to be considered. When high winds deflect an antenna, the moving mass of the system produces inertia effects that are proportional to the mass. Since windage increases with the exposed area of the elements, it is advantageous to keep the cross-section of the elements low. If the required strength can be realized in a given cross-section, it is wise to select the material that will give this strength with a minimum of weight.

Another important consideration is ice loading. In sections where this condition is likely to occur with some severity, it will be wise to decide on a vertical rather than horizontal antenna. This might not be the best choice from a radiation standpoint, but mechanically it would mean that heavily iced vertical members or elements would be subjected to compression or tension loads which are much more readily carried than the bending loads imposed by the same weight of ice on horizontal elements.

In every case, antennas for the emergency services should represent the best compromise between electrical efficiency and mechanical sturdiness. Above all, they must be dependable, since radio communication is of greatest value at times when weather conditions have put other means out of commission.

HIGHWAY RADIOPHONE SERVICE

OFFICIALS of the Bell Telephone System have announced plans for extensive service trials on mobile radiotelephone service along three inter-city highway routes, totalling nearly 1,000 miles. The routes are those between Chicago and St. Louis, via Ottawa, Peoria and Springfield, Ill.; between New York, Albany and Buffalo; and between New York and Boston.

When these services are established, it will be possible for suitably-equipped vehicles on highways along these routes, or boat on adjacent waterways, to make and receive calls to or from any telephone connected to lines of the Bell System. Transmitting and receiving stations required to provide the two-way voice communication will be located along the routes.

The Illinois Bell Telephone Company has already filed applications for authorization to establish the first stations along the Chicago-St. Louis route. It is expected that application for the other routes will be made soon. Initial operation of the new service will start within a few months after construction permits are granted. This interval is required to permit erection of transmitter-receiver stations and to equip vehicles with radiotelephone sets.

Highway mobile radiotelephone service, which will make it almost as easy to telephone to or from a moving vehicle on the road as between any two regular telephones, will be handled in the following manner:

Calls will be handled by mobile service telephone operators. Conversations will travel part of the way by telephone wire and part by radio. If a caller in Chicago wants to talk to the occupant of a certain automobile somewhere between Chicago and St. Louis, he will first reach Long Distance, ask for the mobile service operator, and give her the call number of the vehicle. She will route the call over telephone wires to one of the transmitting-receiving stations along the highway, from which a signal will be transmitted to the vehicle. The car occupant will receive an audible and visual signal indicating that he is wanted. He then will pick up his dashboard telephone and answer. Under his fingers, as he holds the telephone handset, will be a push-and-talk button to switch from listening to talking.

The motorist or truck driver will be able to originate calls merely by picking up his telephone, listening to make sure the circuit is not in use, and pushing the "talk" button. This will signal the mobile service operator, and she will come in on the line. He will give her the telephone number he wants and the call will go through.

It is planned to make the trials under actual operating conditions. A number of companies, including truck lines, bus lines, long distance movers, utilities and other organizations have indicated a desire to participate in the test. Accordingly it is expected that several hundred vehicles will be equipped initially to send and receive messages on the three routes.

Plans for Bell System mobile radio-

(CONCLUDED ON PAGE 72)

Part 1: MUNICIPAL & COUNTY EMERGENCY STATIONS

The Official Directory of Municipal and County Police Radio Transmitters Licensed Jan. 1, 1946

MUNICIPAL POLICE

ALABAMA

WRBD	Anniston	WE Mtr	33100 AM
WPFM	Birmingham	WE	2382 AM
		Link Mtr	30580 AM
		Mtr	30980 FM
WJZG		Comp	2382 AM
WADN	Decatur	Mtr	35900 FM
WKAD	Dothan	GE	35500 FM
WKCH	Florence	Mtr	35900 FM
WQIG	Gadsden	Mtr	2382 AM
		RCA	30580 AM
WMHA	Huntsville	Mtr	35900 FM
WPGW	Mobile	WE	2382 AM
		Kaar Mtr	30580 AM
WMPM	Montgomery	Coll	2382 AM
		Kaar	30580 AM
WDBZ	Northport	Mtr	35900 FM
WASP	Selma	WE	2382 AM
WBVS	Sylacauga	RCA	33500 AM
WQLH	Tuscaloosa	Mtr	35900 FM

ARIZONA

KRHS	Bisbee	Comp	2430 AM
		Mtr	35100 AM
KRQN	Casa Grande	SP	35100 AM
KFPX	Flagstaff	Mtr	35100 AM
KQOJ	Flagstaff (Co)	Teme	2430 AM
		Mtr	35100 AM
KRAC	Florence (Co)	SP	2430 AM
		Mtr	35100 AM
KRIZ	Mesa	Stne	2430 AM
		Mtr	30580 AM
KGZJ	Phoenix	deF	2430 AM
		Mtr	30580 AM
6XEJ		Mtr	118550 FM
KQXU	Phoenix (Co)	Mtr	35100 AM
KNHG	Prescott	Mtr	35100 AM
KQHM	Prescott (Co)	Mtr	2430 AM
		Mtr	35100 AM
KQEX		Comp	2430 AM
KRJA	Safford	Hftr	2430 AM
		Mtr	35100 AM
KEVZ	S. Tucson	Teme	35100 AM
KEYU	Tempe	Mtr	35100 AM
KQEP	Tucson	Comp	2430 AM
		PDL	31780 AM
KQPW	Tucson (Co)	Teme	2430 AM
		Mtr	35100 AM
		Kaar	31780 AM
6XEH		Comp	117350 AM
KRDW	Winslow	Hftr	2430 AM
		Mtr HM	35100 AM
KADF	Yuma (Co)	Comp	2430 AM
		Mtr SP	35100 AM

ARKANSAS

KSDC	Ark City (Co)	Bass	2406 AM
		Kaar Mtr	31500 AM
KPBA	Blytheville	Comp	2406 AM
		Stne	30580 AM
KPMA	" (Co)	Mtr	30580 AM
KSDD	Dumas (Co)	Bass	31500 AM
KRNQ	Fayetteville	Comp	2406 AM
		Comp	30580 AM
KNHA	Fort Smith	Comp	2406 AM
		Mtr	30580 AM
KQEH	Hot Spgs (Co)	Comp	2406 AM
		RCA Mtr	30580 AM
KQMC	" " Natl Pk	Kaar	2406 AM
KGHZ	Little Rock	RCA	2406 AM
		Mtr	30580 AM
KRGI	Little Rock (Co)	Mtr	31780 AM
		Mtr	31900 AM
KSDE	McGehee (Co)	Bass	31500 AM
KPDM	Monticello	Comp	2406 AM
		Mtr	30580 AM
KRAE	N. Little Rock	Mtr	33500 AM
		Mtr	35100 AM
KQGT	Pine Bluff (Co)	Comp	2406 AM
		Mtr	30580 AM
		Mtr	30580 FM
KTAP	Texarkana	RCA	2406 AM
		Harv Mtr	33220 AM

SPECIAL INFORMATION

1. So great has been the increase in emergency radio stations licensed during the past six months that state, zone, and interzone police, fire, forestry, and special emergency station listings will be published in Part 2 of this Directory, in our February issue.

2. Space limitations also made it necessary to omit the names of radio supervisors.

3. Correspondence should be addressed to Police Headquarters or, in the case of County stations, to County Sheriff's Office.

4. Listings are for fixed, portable, and portable-mobile transmitters, but portable and portable-mobile stations are not identified separately for, except in rare cases, they use the same call as the associated fixed station.

CALIFORNIA

KQBR	Alameda	Comp	30700 AM
		Kaar	35100 AM
KPDA	Alameda (Co)	Comp	1658 AM
		Kaar	35220 AM
KPDB		Comp	1658 AM
KRGE		Comp	1658 AM
KGWC	Albany	Mtr	37780 AM
KQAH	Alhambra	Mtr	31500 AM
KRBQ		Mtr	31500 AM
KQCL	Anaheim	Comp	33780 AM
KQAP	Arcadia	Comp	33500 AM
XQXC	Atherton	Kaar	33780 AM
KIBR	Azusa	Mtr	31100 FM
KGPS	Bakersfield	Comp	30580 AM
KACS	Bakersfield (Co)	Wstg	2414 AM
		Mtr	31780 AM
KQLY	Banning	Comp	30580 AM
KQHL	Banning (Co)	Mtr	2442 AM
KQJH	Beaumont	Comp	30580 AM
KBPC	Bell	Mtr	35500 AM
KQSN	Benicia	Comp	2422 AM
		Link	30980 AM
KGFM	Berkeley	Comp	37780 AM
KGIH		Comp	37780 AM
KGNL		Comp	37780 AM
KSW		Comp	1658 AM
		Mtr	37780 AM
KQAI	Beverly Hills	Mtr	37100 AM
6XHV	Black Mtn	Link	117350 FM
KQAD	Blythe (Co)	Mtr	2442 AM
KBMP	Brawley	Comp	2490 AM
KADQ	Brea	Comp	2490 AM
		Comp	33780 AM
KQBE	Burbank	Comp	33500 AM
KQCM	Burlingame	Comp	33100 AM
		Comp	37220 AM
KQFI	Carmel-by-the-Sea	PDL	33100 AM
		PDL	35220 AM
KQEO	Chico	RCA	31500 AM
KQKN	Chino	Comp	33220 AM
KQJG	Chula Vista	PDL CECr	33780 AM
		ComC	33780 AM
KQRY	Claremont	Mtr	33220 AM
KOFK	Coalinga	Mtr	33500 FM
KIHW		Mtr	35220 FM
6XHV		Link	117350 FM
KQVO	Colton	Comp	33220 AM
KQRO	Colusa (Co)	Comp	2422 AM
		Mtr	39380 FM
KQAQ	Compton	Comp	33100 AM
KRIV	Corona	PDL	2442 AM
		Comp	30580 AM
KQKV	Coronado	RCA Mtr	33780 AM
KPCM	Corte Madera	RCA	33220 FM
KIQH	Covina	Mtr	33220 AM
KPDC	Culver City	Comp	1730 AM
		Comp	30580 AM
		Comp	37500 AM
KEYG	Delano	Mtr	35900 AM
KEIJ	El Cajon	Mtr	33780 AM
KEZO	El Centro (Co)	Mtr	35100 FM
KNGJ	El Centro	Mtr	2490 AM
		Mtr	35100 FM
KQVN		Comp	2490 AM
KAMM	El Cerrito	Mtr	37780 AM
KROJ	El Monte	CECr	39500 AM
KQJL	El Segundo	PDL Mtr	37900 AM
KGTS	Elsinore	Comp	30580 AM
KQHX	Escondido	Comp	2490 AM
		Comp	33780 AM
KQRM	Eureka	Kaar	30700 AM
KHCP	Eureka (Co)	RCA	2422 AM
		GE	39780 FM
KDIC	Fairfax	RCA	33220 FM
KBRV	Fairfield (Co)	Link	35220 AM
6XHU	Fresno	Link	118550 FM
KGZA		deF	2414 AM
		Comp	37220 AM
		Link	35220 FM
KRDY		Comp	2414 AM
KQBN	Fullerton	Comp	33780 AM
KQEG	Gardena	SP	1730 AM
		Mtr	39100 AM
KROB	Gilroy	Kaar	1674 AM
KQZL	Glendale	PDL	33940 AM
KQCI		PDL Mtr	33220 AM
		PDL	33940 AM
6XGL	Grapevine (Co)	Comp	116150 AM
KGVC	Grass Valley	Comp	35220 AM
KEWB	Hanford (Co)	Mtr	2414 AM
		Mtr	37780 FM
6XIA		Mtr	117750 FM
KBJT	Hemet	Comp	30580 AM
KRMZ	Hermosa Beach	PDL	37900 AM
KANQ	Hillsborough	Comp	1674 AM
KHBP		Comp	1674 AM
KSPH		Comp	1674 AM
		Comp	33220 AM
KDHB	Hollister (Co)	Comp	1674 AM
		Mtr	35100 AM
KQAL	Huntington Bch	Mtr	33780 AM
KHPM	Huntington Pk	Mtr	39900 FM
KQHJ	Indio	Mtr	30580 AM
KQXL	Inglewood	RCA	39500 AM
KEVE	Inyokern (Co)	Wstg	2414 AM
KKFD	Kensington Pk	Comp	1658 AM
		Comp	35220 AM
KQEN	Laguna Beach	Comp	33780 AM
KAVL	Lakeport (Co)	Mtr	1610 AM
		Mtr	33220 FM
KEZT	La Mesa	Mtr	33780 AM
KQDD	Lancaster (Co)	Comp	31900 AM
KDII	Larkspur	RCA	33220 FM
KQPZ	La Verne	Mtr	33220 AM
KRIM	Lindsay	Mtr	37100 AM
KNGY	Lodi	Coll	2414 AM
		Link GE	39380 FM
KBQW	Long Beach	CECr	33100 AM
KQAO		REL PDL	33100 AM
		RCA Teme CECr	33100 AM
		REL	31780 AM
		CECr RCA Teme	31780 AM
KQST		Comp	33100 AM
KQXI		Comp	33100 AM
KQFU		Mtr	33100 AM
KGPL	Los Angeles	DeF RCA	1730 AM
		CECr	35100 AM
		CECr	35220 AM
		CECr	37220 AM
		CECr	37780 AM
		CECr	39380 AM
KNGX		Comp	1730 AM
KQJN		Comp	1730 AM
KQEF		Comp	37500 AM
KQJO		Comp	37500 AM
KQJP		Comp	1730 AM
KQBV	Los Angeles (Co)	Mtr	31900 AM
KRGU		PDL	31900 AM
KERL	Los Banos	Kaar	2414 AM
		Kaar	37220 AM
6XHA	Lyons Peak (San Diego)	Comp	117750 AM
KQHK	Lynwood	PDL	35500 AM
KFWH	Madera (Co)	Mtr	2414 AM
		Mtr	37780 FM
KRIB	Manhattan Bch	Mtr	37900 AM
KQKA	Martinez	Comp	35220 AM
KRBS	Martinez (Co)	Comp	1658 AM
KQCE		Link	1658 AM
		Link	35220 AM
KBQZ	Marysville (Co)	Mtr	39380 FM
KADS	Marysville	Comp	1722 AM
		Comp	30580 AM
		Mtr	39380 FM
KHNJ	Maywood	Mtr	35500 AM
KQXV	Menlo Park	Kaar	33780 AM
KQDP	Merced	Comp	2414 AM
		Mtr	37220 AM
KSOM	Merced (Co)	Comp	2414 AM
		Mtr	37220 AM
KDIC	Mill Valley	RCA	33220 FM
6XIJ	Modjeska Pk (Co)	Comp	117750 AM
KQDQ	Modesto	Comp	2414 AM
		Comp	39380 AM
KASE	Modesto (Co)	RCA	2414 AM
		Comp	39380 AM
KQAG	Monrovia	Mtr	33500 AM
KQFE	Montebello	PDL	37900 AM
KRLF	Monterey	Mtr	1674 AM
		Mtr	35220 AM
KGKR	Monterey Pk	Mtr	31500 AM
6XCD	Mt Diablo (Co)	Link	116150 FM
6XGQ	Mt St Helena	Mtr	117350 FM
6XGX	Mt Tamalpais (Co)	Link	117350 FM
6XHG	Mt Toro (Co)	Comp	117750 AM
KPNC	Napa	Comp	2422 AM
		Kaar Link	35100 AM
KNCC	Napa (Co)	Link	1610 AM
		Link	33220 FM
KQBF	National City	Comp	33100 AM
KQRN	Nevada City	Mtr	35220 FM
		Comp	35220 AM
KQAF	Newport Bch	Comp	33780 AM
KQRV	N. Sacramento	Comp	35220 AM
KALT	Oakland	GE	31100 FM
		Link	30580 FM
		GE	31780 FM
KADI	Oceanside	Mtr	2490 AM
		Mtr	33780 AM
KQKT	Ontario	Comp	33220 AM
KQBI	Orange	Comp	33780 AM
KBYQ	Oroville (Co)	Mtr	39380 FM
KONC	Oxnard	PDL	2414 AM
		Stne Kaar	39580 AM
KAZI	Pacific Grove	Kaar	1674 AM
		GE	30580 FM
KQAS	Palm Springs	PDL	37100 AM
KFHK	Palo Alto	Comp	1674 AM
		Kaar	33780 AM
KGJX	Pasadena	Comp	1714 AM
		Comp	33220 AM
KIDW	Perris	Comp	30580 AM
KQCY	Petaluma	Mtr	37100 AM
KQCP	Piedmont	Comp	33100 AM
		Comp	37220 AM
KQDW		Comp	33100 AM
6XHO	Pise Hill (Co)	Mtr	118150 FM
KQBT	Pittsburg	Comp	30700 AM
		Comp	35220 AM
KALM	Pomona	Comp	1714 AM
KNFJ		Comp	1714 AM
		Mtr	33220 AM
KQAU	Porterville	Comp	37100 AM
KBSV	Quincy (Co)	Mtr	1722 AM
		Mtr	39380 FM
		Mtr	35100 FM
KQFT	Redlands	Comp	33220 AM
KRAZ	Redwood City	Kaar	1674 AM
		Kaar	33780 AM
KRGX	Redwood City (Co)	Comp	1674 AM
		Mtr	30980 FM
KRCP	Reedley	RCA	33500 AM
KEYZ	Richmond	Link	31500 FM
		Link	33780 FM
KRLW		Link	31500 FM
		Link	33780 FM
KQJE	Riverside	PDL Mtr	30580 AM
KERC	Riverside (Co)	Comp	2442 AM
KQSG		Comp	2442 AM
		Comp	30580 AM
6XEI		PDL	116550 AM
KEZE		Comp	2442 AM
6XHD	Rocky Hill (Co)	GE	116550 FM
KRPD	Roseville	Comp	1722 AM
		Teme	35220 AM
KRPC	Ross	RCA	33220 FM
KNGF	Sacramento	WE	1722 AM
		PDL	35220 AM
KHSC		Comp	1722 AM
KSPD		Comp	1722 AM
KFPN	Sacramento (Co)	Comp	35220 AM
KQCO	Salinas (Co)	Coll	1674 AM
		Comp	35220 AM
KQHY	Salinas	Mtr	35220 AM
KQBP	San Anselmo	Comp	33100 AM
		Comp	35100 AM
KQAC	San Bernardino	Mtr	33220 AM
KSBC	San Bernardino (Co)	Comp	1714 AM
		Mtr	33220 AM
KACN	San Buenaventura	Comp	2414 AM
		Stne	30580 AM
		Kaar	30580 AM
KRGK	San Carlos	Kaar	33780 AM

KFWL	San Diego	Hftr	2490 AM
KGZD		Comp	2490 AM
		Link	33780 AM
KQOV	San Diego (Co)	WE CECr	33780 AM
KRMQ	San Fernando	Mtr	39500 AM
KGPD	San Francisco	WE	2466 AM
		Link	39380 AM
		GE RCA Link	39380 FM
KQBL	San Gabriel	Mtr	31500 AM
KQHV	San Jacinto	Comp	30580 AM
KGPM	San Jose	RCA	1674 AM
		PDL	35220 AM
KRAW	San Luis Obispo	RCA	30580 AM
KQDW	San Marino	PDL	35900 AM
KQDA	San Mateo	Kaar	37100 AM
KEZB	San Rafael (Co)	Comp	1610 AM
KRSC		Comp	1610 AM
		RCA	33220 FM
KSRP	San Rafael	RCA	33220 FM
KOCM	Santa Ana (Co)	Comp	2490 AM
KGHX		WE Coll	2490 AM
		Mtr	33780 AM
KQAK	Santa Ana	Mtr	33780 AM
KGZO	Santa Barbara	Comp	2414 AM
		Stnc Mtr	30580 AM
KSBP		Comp	2414 AM
KQIR	Santa Barbara (Co)	Stnc Kaar	30580 AM
KGZT	Santa Cruz	Comp	1674 AM
		Mtr	35100 AM
KSMP	Santa Maria	Comp	2414 AM
		Stnc Mtr	30580 AM
KQDF	Santa Monica	SP	33500 AM
KRMG		Comp	33500 AM
KSRM	Santa Rosa (Co)	Comp	1610 AM
		Mtr	33220 FM
KQDG	Santa Rosa	Link	31500 AM
		Link	37220 AM
KPSC	Sausalito	RCA	33220 FM
		Link	33220 FM
KQGX	Seal Beach	REL	31780 AM
KQPY	South Gate	Mtr RCA CECr	35500 AM
6XIB	South Mtn (Co)	Mtr	117350 FM
KBSP	S. Pasadena	Mtr PDL	33220 AM
KGIA	S. San Francisco	Mtr	1674 AM
		Link	30980 FM
KAPH	Stockton (Co)	Wstg	2414 AM
		GE	37220 FM
KQCR	Stockton	Comp	33100 AM
		Mtr	37780 AM
6XAB	Strawberry Pk (Co)	Comp	116150 AM
KAEX	Susanville (Co)	Mtr	1722 AM
		Mtr	39380 AM
KRMF	Torrance	Mtr	39100 AM
KACO	Tracy	Comp	2414 AM
		Comp	39380 AM
WPDA	Tulare	REL	2414 AM
		Mtr	30580 AM
KQCG	Turlock	Comp	2414 AM
KQJA	Tustin	Comp	33780 AM
KQKU	Upland	Mtr	33220 AM
KGPG	Vallejo	Comp	2422 AM
		Link	30980 AM
KFOJ	Ventura (Co)	Stnc Mtr	30580 AM
		Mtr	2414 AM
KQBQ	Visalia	RCA	37100 AM
KAZF	Visalia (Co)	Comp	2414 AM
		GE Mtr	35100 FM
		Dool	35100 AM
KWCP	Watsonville	Coll	1674 AM
		Comp	35220 AM
KREQ	W. Covina	Mtr	31100 FM
		Mtr	33220 AM
KGHY	Whittier	Comp	1714 AM
		PDL Mtr	33220 AM
KRKN		Mtr	1714 AM
KAGD	Woodland	Comp	1722 AM
KQGZ	Yreka City	Mtr	30580 AM
KBQZ	Yuba City (Co)	Mtr	39380 FM
KBQY	Yuba City	Mtr	39380 FM

COLORADO

KQGA	Boulder	Coll	2442 AM
		Mtr	33780 AM
KPCS	Colo. Springs	WE	31500 AM
KQHI	Denver	WE	2442 AM
KGPX		Coll	2442 AM
		RCA Mtr	33780 AM
KIUE	Englewood	Mtr	33780 AM
KAEU	Fort Collins (Co)	Mtr	33780 AM
KQFV	Fort Collins	Comp	2442 AM
		Mtr	33780 AM
KQXT	Grand Junction	Mtr	2442 AM
KPDG	Greeley	Comp	2442 AM
		Mtr	33780 AM
KPLJ	La Junta	RCA	2442 AM
KPDL	Longmont	Coll	2442 AM
		Coll	33780 AM
KQCX	Pueblo	Bass	2442 AM
		Comp	30980 AM
KRHY		RCA	2442 AM
KESY	Sterling	Comp	2442 AM
KEHM	Trinidad (Co)	Comp	2442 AM
		Stnc	30580 AM
KHRI	Trinidad	Comp	30580 AM

CONNECTICUT

WHNK	Bethel	Link	35900 AM
WLST	Bloomfield	Link	33100 AM
WPFW	Bridgeport	GE WE	2466 AM
		GE	30580 FM
WKEQ		GE	30700 FM
WJVO	Bristol	GE	31100 FM
WQYB		GE	37100 FM
WSRE	Danbury	Link	35900 FM
WQYB	Darien	GE	33780 FM
WBXC	E. Hartford	RCA GE	33100 AM
WKGF	Fairfield	GE	31100 FM
		GE	31780 FM
WKVQ	Glastonbury	GE Mtr	33100 AM
WQLE	Greenwich	GE	33220 AM
		GE	39900 FM
WWEF		GE	39900 FM
WIZY	Groton	GE	31900 FM
WHPD	Hamden	Link	37900 AM
WQRC	Hartford	GE RCA	33100 AM
		CECr Mtr	33100 AM
WRZP	Manchester	RCA	33940 AM
WKSM	Meriden	GE	35100 FM
		GE	35500 FM
WSKV	Middletown	WE	37900 AM
WBLD	Milford	RCA	31900 AM
WRAF	New Britain	RCA	37100 AM
WBKA	New Haven	Wstg	2466 AM
WQFA		WE	2466 AM
		Link	37100 FM
		Link	37780 FM
WAKB	New London	GE	31900 FM
WPLZ	Newington	Mtr	33100 AM
WKKD	North Haven	Link	37100 FM
		Link	37780 FM
WEIS	S. Norwalk	Link	35500 FM
WBXY	Norwich	Link	39900 FM
WHHL	Terryville	GE	31100 FM
WPHH	Stamford	Link	37500 AM
WSVL		Link	37500 AM
WCHH	Stratford	GE	30700 FM
		GE	30980 FM
WKSC		GE	30700 FM
		GE	30980 FM
WCSM	Suffield	HW	30700 AM
WCSO		HW	30700 AM
WBMW	Thompsonville	Link	39100 AM
WKPJ	Torrington	Link	3990 FM
WJUY	Trumbull	GE	30980 FM
WMIR	Wallingford	GE	39900 FM
WJYX	Watertown	Link	39100 FM
WMPW	Waterbury	Link	39100 FM
WABT	Weathersfield	RCA	33100 AM
WQJI	W. Hartford	RCA	31500 AM
WBLB	W. Haven	Mtr	33500 FM
WBLT	Westport	GE	33940 FM
WEGJ	Willimantic	GE	31100 FM
WLSY	Windsor	Mtr	33100 AM
WHUO	Winsted	Mtr	30700 FM
WAQX	Woodbridge	Link	37780 FM

DELAWARE

WAZO	Dover	Mtr	33500 AM
WMDM	Milford	Mtr	37500 AM
WRPF	Wilmington	Harv	31500 AM
WWPD		Harv RCA	30580 AM
		Comp	31500 AM
		Harv RCA	33220 AM

DISTRICT OF COLUMBIA

WDCS	Washington	Mtr RCA Link	39500 FM
WJHJ		Link	39500 FM
WPDW	Washington	WE	2422 AM
		Mtr Link	37220 FM
		WE	37220 AM

FLORIDA

WRMO	Bradenton	RCA Mtr	37100 AM
WAKG	Clearwater (Co)	Wstg	2466 AM
		Link	30580 FM
WAJT	Clearwater	Mtr	30580 AM
WQOI	Clearwater	Mtr Link	30580 AM
		Link	30580 FM
WQHE	Dade	Mtr	31100 FM
WQXM	Dania	Mtr	37100 AM
WRHQ	Daytona Bch	RCA Mtr	37100 AM
WBLE	Dunedin	Link	30580 AM
WMUW	Fernandina (Co)	Mtr	31100 FM
WAKO	Ft Lauderdale	RCA	2442 AM
		Stnc RCA	30580 AM
WFMF	Ft Myers	RCA	37100 AM
WFPF	Ft Pierce	RCA Mtr	33500 AM
WBSM	Gainesville (Co)	Mtr	30580 AM
WQFC	Gainesville	Comp	2466 AM
		Mtr	30580 AM
WQUT	Gulfport	Mtr	33500 AM
WSVE	Hallandale	Comp	37100 AM
WBJE	Holly Hill	Mtr	37100 AM
WQNL	Hollywood	Link	37100 AM
WPFG	Jacksonville	WE	2442 AM
		WE RCA Mtr	30580 AM
		Kaar ComC	30580 AM
WJBH	Jacksonville	Bch Mtr	30700 FM
WPFT	Lakeland	RCA	31500 AM
WLWP	Lake Worth	RCA	31500 AM
4XJY	Miami	Mtr	118550 FM
4XKK		Mtr	118550 FM
		Mtr	152510 FM
WDHI		RCA Mtr	31500 FM
WPFZ		RCA	2442 AM
		Comp	30580 AM
WRLU		Comp	30580 AM
		Comp	2442 AM
WQMA	Miami Beach	Mtr	30980 AM
		RCA	33100 AM
WBTW	Ocala	Mtr	35900 FM
WKWP	Ocala (Co)	Mtr	31100 FM
WPHM	Orlando	RCA Mtr	33500 AM
		Mtr	33780 FM
WMJI	Ormond	Mtr	37100 AM
WPFX	Palm Beach	Bass	2442 AM
		Bass RCA	30580 AM
WSSR	Palm Beach (Co)	Mtr	31100 FM
WKRE	Panama City (Co)	Mtr	31100 FM
WAZU	Panama City	Mtr	37100 FM
WPFR	Pensacola (Co)	Mtr	31100 FM
WRGP	Pensacola	WE	33500 AM
WBUW	Pinellas	Mtr	33500 AM
WRFP	Plant City	GE	35500 FM
WQSU	St Augustine	RCA	33100 FM
WQMZ	St Petersburg	RCA	33500 AM
		Mtr Link	33500 AM
WQRA	Sanford	RCA Mtr	33100 AM
WEAG	Sarasota	RCA	31500 AM
WBYI	Sarasota (Co)	Mtr	30700 AM
WQSX	Tallahassee	RCA Mtr	33100 AM
WFPT	Tampa	Comp	2466 AM
WPHX		WE	2466 AM
		Link	30580 AM
		Mtr	37780 FM
		Mtr	37900 FM
WRDM	Tampa (Co)	GE	35500 FM
WRZY	W. Palm Bch	RCA	37100 AM
WQFN	Winter Haven	Mtr	35900 FM

GEORGIA

WDKK	Albany (Co)	Mtr	30980 FM
WGYI	Albany	Mtr	30580 AM
WRJW	Americus	Coll	2414 AM
WPDY	Atlanta	WE	2482 AM
		Comp	30580 AM
		Comp	30580 FM
		Link	30980 AM
WQFV	Augusta	GE	2414 AM
		Mtr	31780 FM
WQTC	Brunswick	RCA	33100 AM
WBLV	Columbus	Stnc	2414 AM
WPFI		Comp	30580 AM
		WE	2414 AM
		Link	30580 FM
WHNX	Gainesville	GE	35500 FM
WQTZ	LaGrange	Mtr	37100 AM
WQFB	Macon	Comp	2414 AM
		Comp	30580 AM
WANT	Marietta	GE	33940 FM
WRDL	Newman	Mtr	35900 FM
WQNQ	Rome	WE Mtr	33100 AM
WQTR	Savannah	Mtr	33100 FM
WROH	Thomasville	RCA Mtr	37100 AM
WBYB	Valdosta	Mtr	33500 AM
WMPF	Waycross	Mtr	35900 FM

HAWAII

KENU	Hana (Co)	Comp	1714 AM
KADK	Hilo (Co)	TRad	1682 AM
			1714 AM
		Mtr	35100 AM
KAFR	Honokaa (Co		1714 AM
KFAV	Honolulu	TRad	1714 AM
KFJC		Mtr	37100 FM
KFJD		Mtr	37100 FM
KFJJ		Mtr	37100 FM
KFJO		Mtr	37100 FM
KFJP		Mtr	37100 FM
KFJR		Mtr	37100 FM
KFJY		Mtr	37100 FM
KGPQ		Mtr RCA	1714 AM
		Mtr	35100 AM
KFIV		Mtr	37100 AM
KFKF		Mtr	37100 AM
KFKK		Mtr	37100 AM
KFLS		Mtr	37100 AM
KRHZ		Hftr	1714 AM
KHAB	Kaneohe (Co)	Comp	1714 AM
KRLB	Kaunakakai Molokai (Co)	Stnc	1714 AM
KIRU	Kealakekua (Co)		1714 AM
KENW	Lahaina (Co)	Stnc	1714 AM
KBSN	Lanai City (Co)	Comp	1714 AM
KCKT	Lihue (Co)	Mtr	37900 FM
KQXY	Paia (Co)	RTel	1714 AM
KHAC	Pearl City (Co)	Comp	1714 AM
KHAA	Wahaiwa (Co)	Comp	1714 AM
KAPM	Wailuku (Co)	Stnc	1714 AM
		Stnc	30580 AM
KCKU	Waimea (Co)	Mtr	37900 FM

IDAHO

KAHP	Boise (Co)	Mtr	37220 FM
KQBD	Boise	Mtr	2458 AM
		Mtr	37220 FM
KEHK	Caldwell (Co)	Mtr	2458 AM
		WE Mtr	30580 AM
KQGE	Cocur d'Alene (Co)	Spok	2414 AM
		Spok	30580 AM
KFEM	Emmett	Mtr	37220 FM
KNFB	Idaho Falls	Wstg	2458 AM
		Mtr	30580 AM
KRNO	Lewiston	Spok	30580 AM
KRLG	Lewiston (Co)	Comp	2414 AM
		Spok	30580 AM
KQJF	Moscow (Co)	Coll	2414 AM
		Coll	30580 AM
KQZS	Nampa	WE	2458 AM
		WE	30580 AM
KRBL	Pocatello	Spok	2458 AM
		Mtr	30580 AM
KRDZ	Twin Falls	WE	2458 AM
		WE	30580 AM

ILLINOIS

WQSR	Alton	WE	30700 AM
WSKE	Argo (Co)	D & F	31900 AM
WJVI	Argo	Mtr	39100 FM
WBNQ	Arlington Hgts	Dool	33780 AM
WQRM	Aurora	WE	33100 AM
WBOF	Bartonville	RCA	33500 AM
WEDV	Batavia	Mtr	35500 AM
WQTG	Belleville	RCA	37100 AM
WSKO	Belvidere (Co)	Comp	2458 AM
		Mtr	31500 AM
WJHG	Bensenville	Link	37220 FM
WSVH	Berwyn	Mtr	33500 AM
WQRI	Bloomington	RCA	31900 AM
WAZV	Bloomingdale Twp (Co)	Comp	37500 AM
WDBL	Broadview	GE	31500 FM
WIPC	Cairo	Coll	2458 AM
		Mtr	30980 AM
WKXZ	Cairo (Co)	Mtr	39500 FM
WKJN	Calumet City	Mtr	39100 FM
WEWG	Calumet Pk	Mtr	33780 AM
WHNB	Canton	Mtr	37100 FM
WSKZ	Centralia	Comp	2458 AM
		Bass Mtr	30580 AM
		Mtr	33940 FM
WSKA		Mtr	33940 FM
WQIB	Champaign	Coll	31500 AM
WPDB	Chicago	WE	1714 AM
WPDC		WE	1714 AM
		REL Mtr	35100 FM
		REL Mtr	35220 FM
WPDD		WE	1714 AM
WQJF		Bndx RCA Mtr	31100 AM
WQXZ	Chicago Hgts	Mtr	31500 FM
		Harv	33220 FM
WRHC	Cicero	Comp	33500 AM
WMPJ	Clinton (Co)	RCA	2458 AM
		Mtr	30580 FM
		Comp	30580 AM
WBEP	Collinsville	Mtr	39100 FM
WRGQ	Danville	Hftr	2458 AM
		WE	30580 AM
WASB	Decatur (Co)	RCA	2458 AM
		Mtr	30580 FM
WQTF	Decatur	RCA D & F Mtr	33100 AM
WAAO	Decatur (Pk)	Mtr	33100 AM
WRLJ	Des Plaines	D & F Dool Mtr	37900 AM
WBVY	Dolton	Mtr	33780 AM
WRIW	Downers Grove	D & F	37220 AM
		D & F	37500 AM
WJVM	E. Peoria	RCA	33500 AM
WSTX	E. St Louis	Mtr	33100 AM
WQRY	Edwardsville (Co)	RCA	33100 AM
WJYL	Elgin	WE	33100 AM
WQNO		WE Mtr	33100 AM
WQJX	Elmhurst	Hird Mtr	37220 AM
		Mtr	37500 AM
WIEG	Elmwood Pk	Mtr	31500 FM
WQLO	Evanston	Mtr	30700 FM
WBKL	Evergreen Pk	Mtr	33780 AM
WEXB	Flossmoor	Mtr	33780 AM
WBXG	Forest Pk	Mtr	37100 AM
WJWT	Franklin Pk	Mtr	31500 FM
WKGI	Freeport (Co)	Mtr	33940 FM
WBYF	Galesburg	Mtr	37100 FM
WDAA	Geneva (Co)	WE	35500 AM
WQLN	Glencoe	WE Mtr	35900 MA
WAEX	Glen Ellyn	Mtr	37220 AM
WGLI	Glenview	Erco	37100 AM
WQYC	Granite City	Mtr	30580 FM
		Comp	31100 AM
WMQW	Harrisburg (Co)	Mtr	33940 FM
WALG	Harrisburg	Mtr	33940 FM
WSOK	Harvey	B & D	37900 AM
WQRE	Highland Pk	Mtr	35900 AM
WROG	Hinsdale	Mtr	37220 AM
		Mtr	37220 FM
		Mtr	37500 FM
WSKD	Homewood	D & F	31900 AM
WBHY		B & D	33780 AM
WQLW	Joliet	Mtr	33100 FM
WJKO	Joliet (Co)	Mtr	33100 FM
WSTU	Kankakee (Co)	D & F	2458 AM
		D & F	30580 AM

WKPD	Kenilworth	Hird	D & F	35900 AM
WAFC	LaGrange	Mtr		31500 FM
WMHZ	LaGrange Pk	Mtr		31500 FM
WQLK	Lake Forest	Ecph	Dool	30980 AM
		Comp		31500 AM
WBMG	Lansing	Mtr		33780 AM
WQKR	LaSalle	Mtr		30700 FM
WQGV	Lawrenceville	Mtr		33940 FM
WLIS	Lewistown (Co)	Mtr		33940 FM
WSYW	Libertyville	Dool		33220 AM
WDBT	Lincoln	RCA		31900 AM
WDBU	Lincoln (Co)	RCA		31900 AM
WSKR	Lincolnwood	D & F		33780 AM
WDCV	Lyons	GE	Mtr	31500 FM
WMQK	Madison	Mtr		39100 FM
WSCI	Main Twp (Co)	D & F		31900 AM
WQHX	Marion	Mtr		33940 FM
WBZB	Maywood	GE		31500 FM
WSGQ	McLean (Co)	RCA	Mtr	31900 AM
WJNF	Midlothian	B & D		33780 AM
WAON	Moline	Mtr		33500 AM
WMQS	Monmouth	Mtr		33780 FM
		Mtr		33940 FM
WMHH	Monmouth (Co)	Mtr		33780 FM
		Mtr		33940 FM
WSKJ	Morton Grove	D & F		33780 AM
WMTV	Mt Vernon	RCA		39500 FM
WLEB	Mt Vernon (Co)	Mtr		33940 FM
WAJS	Mundelein	Mtr		33220 AM
WMKU	Nameoki	Comp		31100 AM
WROA	Naperville	RCA		37500 AM
WQJR	Normal	RCA		31900 AM
WSVI	Nashville (Co)	Mtr		39500 FM
WRLN	N. Chicago	D & F		33220 AM
WIWZ	Oak Lawn	Dool		33780 AM
WQFL	Oak Park	Mtr		1714 AM
		D & F	Mtr	30580 AM
WSRZ	Oglesby	Mtr		33940 FM
WMQD	Oquawka (Co)	Mtr		33940 FM
WQKN	Ottawa	Mtr		37100 AM
WQFZ	Ottawa (Co)	Mtr		33940 FM
WBZD	Park Ridge	GE		30700 FM
WSTO	Pekin	RCA		33500 AM
WANU	Pekin (Co)	RCA		33500 AM
WOOP	Peoria	RCA		33500 AM
WRIM		RCA		33500 AM
WRNK	Peoria (Co)	RCA		33500 AM
WMWZ	Peoria Hgts	RCA		33500 AM
WQKM	Peru	Mtr		37100 AM
WKPS	Princeton (Co)	Mtr		33940 FM
WBHZ	Quincy	RCA		33500 AM
WBMQ	Riverdale	Mtr		33780 AM
WOIN	River Forest	Comp		37900 AM
WRIX		Comp		37900 AM
WJWS	River Grove	Mtr		31500 FM
WCEV	Riverside	GE		31500 FM
WPWC	Rockford (Co)	Comp		2458 AM
		Comp		31500 AM
		Mtr		33940 FM
WPGD	Rockford	Comp		2458 AM
		RCA	Dool	30580 AM
WBDI	Rock Island	Mtr		31500 AM
WBXM	Salem (Co)	Mtr		33940 FM
WAQL	Salem	Mtr		33940 FM
WQXL	Skokie	Link		37100 AM
WBNP	S. Beloit	RCA		31500 AM
WQXJ	Springfield	WE	RCA	31500 AM
		Mtr	D & F	31500 AM
WRSC	Springfield (Co)	Mtr		39500 FM
WOKE	Streator	Mtr		37100 AM
WSTY	St Charles	WE		35500 AM
WJYF	Taylorville (Co)	Mtr		33780 FM
		Mtr		33940 FM
WAGR	Urbana	Coll		2458 AM
		Mtr		30580 AM
WBQY	Vandalia (Co)	Mtr		33940 FM
WJAA	Venice	Mtr		39100 FM
WBWJ	Vermilion (Co)	Mtr		30580 AM
WBLS	Villa Park	Mtr		37220 AM
		Mtr		37500 AM
WQFX	Waukegan (Co)	D & F	Hird	1714 AM
		D & F	Ereo	33220 AM
		Mtr		33220 FM
WQLM	Waukegan	Hird		33100 AM
		Mtr		33220 FM
WJEC		Comp		33100 AM
WDCR	W. Chicago	Mtr		37220 FM
WKYZ	Western Spgs	GE		31500 FM
WQJV	Wheaton	Comp		39380 AM
		Link		39500 FM
WQJW	Wheaton (Co)	Mtr		37220 FM
		Mtr		37220 AM
		Mtr		37500 FM
WDEY	Wilmette	Mtr		30700 FM
WQFO	Winnetka	RCA		35900 AM

INDIANA

WEDX	Alexandria	Comp		2442 AM
		Mtr		33220 AM
WBMK	Anderson (Co)	Mtr		33220 AM
WMPI	Anderson	Comp		2442 AM
		Comp		33220 AM
WHUM	Angela (Co)	Comp		2490 AM
WANU	Auburn (Co)	Mtr		30580 AM
WANT	Auburn	Bass		2490 AM
		Mtr		30580 AM
WBIP	Bedford	Teme		2442 AM
		Mtr		30580 AM
WBPD	Bloomington	RCA		2442 AM
		Stne		30580 AM
WAMI	Bluffton	Comp		2490 AM
		Mtr		30580 AM
WBJH	Columbia City (Co)	Mtr		30580 AM
WGHQ	Columbia City	Kaar		30580 AM
WRJF	Columbus	Teme		2442 AM
		Mtr		30580 AM
WAMB	Connersville	Coll		2442 AM
		Stne		33220 AM
WBVG	Crawfordsville (Co)	Stne		30580 AM
WCIP	Crawfordsville	Teme		2442 AM
		Mtr	Stne	30580 AM
WAGT	Crown Pt (Co)	Mtr		37100 FM
WRQT	E. Chicago	D & F		33940 AM
		Dool		33940 FM
WSGP		D & F		33940 AM
WBVH	Elkhart	Bass		2490 AM
		Bass	Mtr	30580 AM
WASF	Elwood	Comp		2442 AM
		Comp		33220 AM
WBXF	Evansville (Co)	Link		30700 AM
WETS	Evansville	Link		30700 AM
WQKB		Link	WE	30700 AM
		Harv	RCA	30700 AM
WBST	Ft Wayne	Comp		2490 AM
WPDZ		RCA		2490 AM
		Mtr	RCA	30580 AM
WBTJ	Frankfort (Co)	Mtr		30580 AM
WAKK	Frankfort	Bass		2490 AM
		Link		30580 AM
WAEE	Gary	GE		39100 FM
WSRY	Goshen (Co)	Mtr		2490 AM
		Mtr		30580 AM
WSKI	Goshen	Mtr		30580 AM
WHHB	Greencastle (Co)	Mtr		35100 AM
WQYK	Hammond	D & F	Mtr	30700 AM
WRGW		Comp		30700 AM
WAKA	Huntington	Bass		2490 AM
		Mtr		30580 AM
WSTA	Huntington (Co)	Mtr		30580 AM
WSIF	Indianapolis (Co)	Mtr		35220 AM
WMDZ	Indianapolis	WE		2442 AM
		Mtr		35220 AM
WLSM		Comp		2442 AM
WJAI	Jasper	Link		30700 AM
WBXD	Kokomo (Co)	Mtr		30580 AM
WPDT	Kokomo	Comp		2490 AM
		Mtr		30580 AM
WQFQ	Lafayette	Comp		2490 AM
		Mtr		30580 AM
WMPL	LaPorte	Bass		2490 AM
		Mtr		30580 AM
WBRM	LaPorte (Co)	Mtr		30580 AM
WSKG	Lima (Co)	Mtr	RCA	30580 AM
WSLH	Logansport (Co)	RCA		30580 AM
WMPQ	Logansport	RCA		2490 AM
		RCA		30580 AM
WRAY	Marion	Teme		2490 AM
		Teme		30580 AM
WSVF	Michigan City	Mtr		31500 AM
WSKP	Mishawaka	Bass		2490 AM
		Bass	Mtr	30580 AM
WBTY	Mt Vernon	Link		30700 AM
WMHY	Mt Vernon (Co)	Mtr		39100 FM
WPGP	Muncie	Hygd		2442 AM
		RCA		23320 AM
WBWX	New Albany	Mtr		39100 FM
WBNC	New Castle	Teme		2442 AM
		Mtr		33220 AM
WKUO	Noblesville	Teme		2442 AM
		Mtr		33220 AM
WSVP	Noblesville (Co)	Mtr		33220 AM
WASC	Peru	Bass		2490 AM
		Bass		30580 AM
WPDH	Richmond	Link	Mtr	33220 FM
		Harv	Stne	33220 AM
		Link		33500 FM
WERI		Comp		2442 AM
WRIP	Richmond (Co)	Harv		33220 AM
		GE	Link	33220 FM
			Link	33500 FM
WSTL	Shelby (Co)	Bass		30580 AM
WDPS	Shelbyville	Teme		2442 AM
		Mtr		30580 AM
WPGN	South Bend	RCA		2490 AM
		Bass		30580 AM
WQOF	Terre Haute	Link		33100 AM
WBVT	Valparaiso (Co)	Bass		30580 AM
WMPV	Valparaiso	Comp		2490 AM
		Harv		30580 AM
WQKT	Vincennes	Link		33100 AM
		Harv		33100 AM
WBIE	Wabash	Bass		2490 AM
		Mtr		30580 AM
WBIH	Wabash (Co)	Mtr		30580 AM
WJEM	Warsaw	Mtr		30580 AM
WHCR	Warsaw (Co)	Teme		2490 AM
		Mtr		30580 AM
WRMW	W. Lafayette	Comp		30580 AM
WQKD	Whiting	Mtr		37100 FM

IOWA

KQFW	Ames	Coll		2466 AM
		Coll		31780 AM
KHQD	Atlantic (Co)	Mtr		35220 FM
KQAR	Burlington	Coll		2466 AM
		Coll	Mtr	31780 AM
		Mtr		31780 FM
KHGX	Burlington (Co)	Mtr		31780 AM
KFLZ	Cedar Rapids	Coll		33220 AM
KGOZ		Comp		2466 AM
		Coll		33220 AM
KRIX	Clinton	Mtr		2466 AM
		Mtr		31780 AM
KBIE	Corning (Co)	Mtr		35220 FM
KPCB	Council Bluffs	Mtr		33780 FM
KGPN	Davenport	Coll		2466 AM
		Coll	Mtr	31780 AM
KIGR	Des Moines (Co)	Mtr		35220 FM
KGZG	Des Moines	Coll	RCA	2466 AM
		Coll	D & F	30580 AM
		RCA	Mtr	30580 AM
KQDT	Dubuque	Coll		2466 AM
		Coll		31780 AM
KQZF	Fort Dodge	Coll		2466 AM
		Coll		33220 AM
KBYS	Fort Madison	Mtr		33500 AM
KAWP	Iowa City	Coll		2466 AM
		Coll	Mtr	33220 AM
KRHL	Marshalltown	Coll		2466 AM
		Coll		31780 AM
KQAE	Mason City	Mtr		2466 AM
		Mtr		31780 FM
KQJI	Oskaloosa	Coll		2466 AM
		Mtr		30580 AM
KPDO	Ottumwa	Coll		2466 AM
		Mtr		31780 AM
KGPK	Sioux City	Mtr		2466 AM
		RTL	Mtr	31780 AM
KRMJ	Waterloo	Mtr		37900 FM

KANSAS

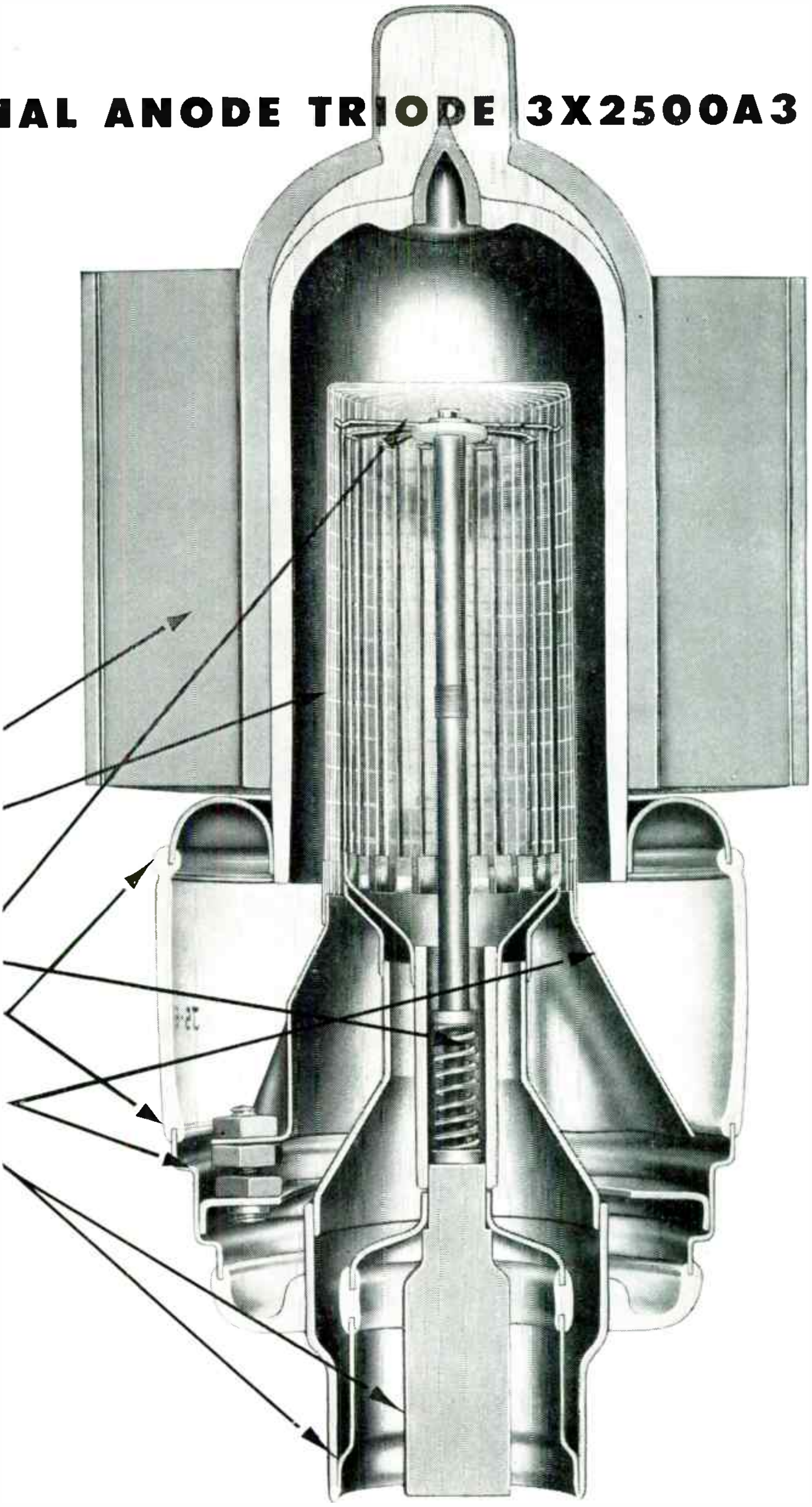
KACA	Atchison	Comp		2422 AM
		Mtr		30980 AM
KGZF	Chanute	Comp		2450 AM
		Mtr		33220 AM
KGZP	Coffeyville	Comp		2450 AM
		Mtr		30980 AM
KNGH	Dodge City	Hftr		2474 AM
		RCA		33220 AM
KAPD	Eldorado	RCA		2450 AM
		RCA		30580 AM
KQUJ	Emporia	Coll		2450 AM
		Mtr		30980 AM
KNFH	Garden City	Comp		2474 AM
KRHU	Girard (Co)	Mtr		31500 AM
KBQN	Great Bend	Comp		2474 AM
		Comp		30580 AM
KGHN	Hutchinson	RCA	WE	2450 AM
		Link		35100 FM
KREJ		WE		2450 AM
KAPG	Iola	Coll		2450 AM
		Mtr		30980 AM
KQBH	Kansas City	Link		33100 AM
		Link	RCA	35100 AM
KROK		RCA		33100 AM
KQJK	Kansas City (Co)	RCA		35100 AM
KAEQ	Lawrence (Co)	GE		31500 FM
KQBM	Lawrence	GE		31500 FM
KNFF	Leavenworth	Comp		2422 AM
		WE		37780 AM
KRJC	Manhattan	Comp		2422 AM
		Comp		30580 AM
KANH	Oswego (Co)	Mtr		35220 FM
KGKD	Parsons	Mtr		2450 AM
		Mtr		35220 FM
KPGK	Pittsburg	Mtr		31500 AM
KNGV	Salina	Comp		2422 AM
		GE		30580 FM
KGZC	Topeka	WE		2422 AM
		Mtr		30580 AM
KGPZ	Wichita	WE	RCA	2450 AM
		RCA	Mrt	33220 AM

KENTUCKY

WMHD	Anchorage	Mtr		30700 AM
WSAG	Ashland	RCA		2430 AM
		Mtr		35100 AM
WRNM	Bowling Green	Mtr		30700 AM
		WE		30700 AM

Eimac TUBES THE COUNTERSIGN OF DEPENDABILITY IN ANY ELECTRONIC EQUIPMENT

NEW EIMAC EXTERNAL ANODE TRIODE 3X2500A3



Rugged mechanical construction
Outstanding electrical efficiency

In the new 3X2500A3, Eimac engineers have developed a highly efficient external anode triode which, in Class C service, delivers up to 5 KW output at a plate voltage of only 3,500 volts. The mechanical design is radically simple, incorporating a "clean construction" which gives short, low inductance heavy current connections that become an integral part of the external circuits at the higher frequencies.

The external anode, conservatively rated at 2500 watts dissipation, has enclosed fins so as to facilitate the required forced air cooling.

Non-emitting vertical bar grid does not cause anode shadows ordinarily created by heavy supports in the grid structure.

Thoriated tungsten filament. Note unusually large filament area, and close spacing.

Filament alignment is maintained throughout life of the tube by special Eimac tensioning method.

New glass-to-metal seals do not have the RF resistance common to iron alloy seals, nor the mechanical weaknesses of the feather-edged types.

Grid ring terminal mounts a cone grid support which acts as a shield between plate and filament.

A coaxial filament stem structure forms the base of the tube. This makes possible proper connections to the filament lines.

Grid and filament terminal arrangements make it possible to install or remove the 3X2500A3 without the aid of tools.

The new mechanical and electrical features of the Eimac 3X2500A3 external anode triode make it valuable for use on the VHF as well as low frequencies. More complete data and information yours for the asking.

TYPE 3X2500A3 — MEDIUM MU TRIODE

ELECTRICAL CHARACTERISTICS

Filament: Thoriated Tungster	
Voltage	7.5 volts
Current	48 amperes
Amplification Factor (Average)	20
Direct Interelectrode Capacitances (Average)	
Grid Plate	20 uufd.
Grid Filament	48 uufd.
Plate Filament	1.2 uufd.
Transconductance (iB =830 ma., EB = 3000 v.)	20,000 umhos

1123

FOLLOW THE LEADERS TO

Eimac REG. U. S. PAT. OFF. TUBES

EITEL-McCULLOUGH, INC., 1123 San Mateo Ave., San Bruno, Calif.

Plants located at: San Bruno, Calif. and Salt Lake City, Utah

Export Agents: Frazar and Hansen, 301 Clay St., San Francisco 11, Calif., U. S. A.

WKXC	Covington	Mtr		33940 FM
WMHK	Hazard	GE		39500 FM
WQTT	Henderson	Link		30700 AM
WKKZ	Henderson (Co)	Link		30700 AM
WRPE	Hopkinsville	Link		30700 AM
WQOB	Lexington (Co)	WE		37100 AM
WPET	Lexington	RCA		1706 AM
		Link		37780 AM
WKJC	Louisville (Co)	Comp		30700 AM
WPDE	Louisville	Mtr		37100 FM
WKYP	Madisonville (Co)	Link	Mtr	30700 AM
WMKY	Madisonville	Link		30700 AM
WRPG	Maysville	Mtr		31500 AM
WRGJ	Mitchell Hill (Co)	RCA		30700 AM
		Link	Mtr	30700 AM
WRPJ	Owensboro	RCA	Mtr	30700 AM
WQNP	Paducah	Mtr		30700 AM
WSYK	Shively	Mtr		30700 AM

LOUISIANA

KHML	Alexandria (Par)	Mtr		39500 FM
KPAL	Alexandria	GE	Mtr	33220 AM
		Comp		2430 AM
WAME	Baton Rouge (Par)	Mtr		39500 FM
WBPR	Baton Rouge	Wstg		2430 AM
		RCA	Stnc	33220 AM
WFKK	Bogalusa	Mtr		33500 FM
WKKO	Franklinton (Co)	Mtr		33500 FM
KANX	Houma (Par)	Mtr		39500 FM
KLFN	Lafayette (Par)	Mtr		39500 FM
KNCL	Lafayette	Mtr		39500 FM
KRKP	Lake Charles	Hftr		1714 AM
		Stnc	Mtr	37220 AM
KPML	Monroe	RCA		2430 AM
		RCA		33220 AM
KRAV	New Iberia	Mtr		33500 AM
WPEK	New Orleans	Comp		2430 AM
		Comp		31780 AM
KNGO	Shreveport	Comp		2430 AM
KNGP		Comp		2430 AM
		Harv		33220 AM
KHBM	St Martinville	Mtr		39500 FM

MAINE

WSAH	Auburn	Harv		30700 AM
WALR	Augusta	Mtr		39100 FM
WJTM	Bangor	Link		39100 FM
WLBM	Bath	Link		39100 FM
WLDU	Houlton	GE		39100 FM
WRQH	Lewiston	RCA	Mtr	33500 AM
WPFU	Portland	Mtr		37500 AM
		Mtr		37780 AM
WPIN	Presque Isle	GE		39100 FM
WMQT	Saco	Mtr		39500 FM
WMHB	Sanford	Mtr		39500 FM
WCAD	S. Portland	Link	Mtr	39100 FM
WJYE	Waterville	Mtr		39100 FM

MARYLAND

WAMD	Annapolis	Comp		2422 AM
		Mard		35100 AM
WPFH	Baltimore	Comp		2466 AM
		Comp		33220 AM
WMHF	Bel Air (Co)	Link		35900 FM
WJYO	Brooklyn (Co)	RSWF		31900 AM
WMPY	Catonsville (Co)	Link		37500 FM
WMEY	Cumberland	Link		39500 FM
WMQG	Dundalk (Co)	Link		37500 FM
WMHE	Edgemere (Co)	Link		37500 FM
WHRP	Eastport (Co)	Comp		31900 AM
WMPT	Essex (Co)	Link		37500 FM
WJHS	Ferndale (Co)	RCA		31900 AM
WAUM	Frederick	Mard		35500 AM
WMPU	Fullerton (Co)	Link		37500 FM
WHRO	Galesville (Co)	RCA		31900 AM
WABV	Greenbelt	Link		39900 FM
WHMD	Hagerstown	Mtr		31100 AM
WQUA	Hagerstown (Co)	Link		39100 FM
WMQE	Halethorpe (Co)	Link		37500 FM
WJLW	Hyattsville (Co)	Link		39900 FM
WAOL	Hyattsville	Link		35500 FM
		Link		39900 FM
WMPP	Pikesville (Co)	Link		37500 FM
WMQA	Reisterstown (Co)	Link		37500 FM
WKYX	Rockville (Co)	Link		37900 FM
WBVQ	Salisbury	GE		35500 FM
WHMM	Silver Spg (Co)	Link		37900 FM
WPFL	Towson (Co)	Link		37500 FM
WJLU	Upper Marlboro (Co)	Link		39900 FM
WMPX	Woodlawn (Co)	Link		37500 FM

MASSACHUSETTS

WITY	Acton	RCA		35900 AM
WBVC	Attleboro	HW		33500 AM
		Link		33500 FM
WMKZ	Agawam	Mtr		39380 FM
WBRJ	Andover	Mtr		39100 AM
WPED	Arlington	Link		30580 FM
		Link		30700 FM
WBJA	Athol	Link		30700 FM
WBHC	Auburn	HW		33780 AM
WRAQ	Barnstable (Co) Harv	HW	Mtr	39900 AM
WRAR		Harv	Mtr	39900 AM
WAMQ	Barre (MDC)	GE		37500 AM
WRJZ	Belmont	Game	RCA	33940 AM
WBMP	Beverly	RCA		33940 AM
WAGJ	Boston	GE		35500 AM
WQIP		GE		35500 AM
WRAS		GE		30980 AM
		Temco		35500 AM
WQRG	Boston (MDC)	Comp		37500 AM
		Link		37500 FM
WRAG	Bourne (Co)	Harv		39900 AM
WBUA	Braintree	Stnc		37900 AM
WMPB	Brockton	Comp		1714 AM
		Comp		30980 AM
WQKK	Brookline	Link	GE	33500 FM
WQWL	Buzzards Bay	Mtr		31340 FM
WQLF	Cambridge	Link		33100 FM
		Link		39380 FM
WKWU		Link		33100 FM
WEWE	Chatham (Co)	Mtr		39900 AM
WSTI	Chelmsford	WE		37100 AM
WAFL	Chelsea	Link		31100 FM
WBMT	Chicopee	Game		30580 AM
		Wstg		39900 AM
WBGV	Clinton (MDC)	RCA		37500 AM
WPGU	Cohasset	Comp		1714 AM
		Comp		37780 AM
WRAC	Concord	RCA		37900 AM
WRAU	Danvers	Harv	Mtr	33100 AM
WRJT	Dartmouth	Harv		31500 AM
WRNU	Dedham	WE		30700 AM
WDBI	Duxbury	Link		31900 FM
WAMT	Easthampton	Mtr		31780 FM
		Mtr		31900 FM
WAKF	Everett	Wstg		1714 AM
	GE Wstg	Game	Mtr	37780 AM
WFMP	Fairhaven	GE		30700 FM
WAKV	Fall River	Wstg		1714 AM
		Wstg		39380 AM
WQTL	Falmouth (Co)	Harv	Mtr	39900 AM
WPHA	Fitchburg	WE		2466 AM
		WE	Mtr	33220 AM
WKMF	Foxboro	GE		33780 AM
		GE		33940 AM
WFKB	Franklin	Link		37900 FM
WBWZ	Gardner	WE		33940 AM
WGMP	Gloucester	Comp		2422 AM
		Comp		31780 AM
WKQT	Greenfield	GE		39900 FM
WQTM	Harwich (Co)	Harv	Mtr	39900 AM
WHAV	Haverhill WE	HW	Link	31900 AM
WQTI	Hingham	Mtr		37100 AM
WQIF	Holyoke	Harv		31500 AM
		Harv		37780 AM
WEHB	Hudson	Comp		31500 AM
		Comp		31780 AM
WQYD	Hull	Comp		37100 AM
WQYE		Comp		37100 AM
WRJH	Hyannis (Co)	Harv		39900 AM
WMJQ	Ipswich	Mtr		37900 AM
WKDX	Kingston	Link		31900 FM
WBLC	Lawrence	RCA	Mtr	39900 AM
WBND	Leominster	WE		33500 AM
WBTZ	Lexington	RCA	Mtr	39900 AM
WBOQ	Lincoln	RCA		35900 AM
WBUI	Longmeadow	Wstg		33100 AM
		Game		37220 AM
WQNR	Lowell	WE		37100 AM
WKLM	Lynn	GE		30700 FM
WLDP	Lynnfield	Link		35900 FM
WSVC	Malden	Comp		1714 AM
		Comp		33220 AM
WBRT	Manchester	RCA		33940 AM
WAQO	Mansfield	Mtr		33780 AM
		Mtr		33940 AM
WBVZ	Marblehead	RCA		33500 AM
WKWS	Marion	Comp		37900 AM
WJHU	Marshfield	Mtr		31900 FM
WPHG	Medford	Comp		1714 AM
		WE		31780 AM
WMEJ	Melrose	Link		39900 FM
WBGA	Methuen	Link		30700 FM
WQRF		Link		37500 FM
WMAH	Middleboro	Link		30580 FM
		Link		30700 FM
WQRT	Milton (MDC)	Link		35220 FM
		Link		37500 FM
WRBA	Milton	Harv		31500 AM
		Harv	Mtr	35100 AM
WBYJ	Nantucket (Co)	Mtr		39900 AM
WQJH	Natick	Harv		39380 AM
		Harv		39500 AM
WMPN	Needham	Harv		1714 AM
	Harv	Mtr	WE	33220 AM
WPFN	New Bedford	Mtr		31100 FM
WBMF	Newburyport	Link		37900 FM
WBSW	Newton	Comp		1714 AM
WPFA		Comp		1714 AM
		Wstg	GE	31780 AM
WFZL	Norfolk	Link		37900 FM
WQOV	North Adams	RCA		37100 AM
WEIL	North Andover	Mtr		31500 AM
		Mtr		35100 AM
WBMB	Northampton	Mtr		31780 FM
		Mtr		31900 FM
WCET	Norwood	Link		31100 FM
WAVN	Pembroke	Link		31780 FM
WEIW	Phillipston	Comp		31780 AM
		Comp		31900 AM
WJKH	Pittsfield	GE		30580 FM
		GE		31100 FM
WQYJ	Plymouth	Link		31900 FM
WQRP	Quincy	Comp		37220 AM
		REL		39100 AM
WQID	Reading	RCA		37900 AM
WMPR	Revere	Wstg		1714 AM
		Wstg		33780 AM
WQYI	Rockport	Harv		33100 AM
		Harv		33220 AM
WRCG	Salem	Mtr		31500 AM
		Mtr		39380 AM
WHNS	Salisbury	Link		37900 FM
WAYU	Saugus	Harv		31900 AM
		Harv		35100 AM
WQOJ	Scituate	Comp		37100 AM
WQSO	Sharon	Harv		33100 AM
WBOG	Shrewsbury	Link		37900 AM
WPEH	Somerville	Mtr		31500 FM
		Mtr		35100 FM
WAXX	Southboro (MDC)	GE		37500 AM
WBTV	Southbridge	HW		31100 AM
WQMD	Springfield	Comp		33500 AM
		Wstg		39380 AM
		Mtr		39380 FM
WRHB	Stoneham	RCA		31100 AM
WKTB	Taunton	GE		37220 FM
		GE		39100 FM
WQTY	Tewksbury	WE		37100 AM
WKWM	Wakefield	Link		30580 FM
		Link		30700 FM
WHNQ	Walpole	Link		31100 FM
WRNA	Waltham	Wstg		1714 FM
		Wstg		37780 AM
WAGL	Ware (MDC)	RCA	GE	37500 AM
WSTW	Wareham	Hftr	Harv	37900 AM
WBNE	Watertown	GE		31900 FM
WMKW	Webster	HW		33220 AM
		HW		33500 AM
WQJG	Wellesley	Harv	WE	33780 AM
		Harv		37100 AM
WPBM	Wellfleet (Co)	Mtr	Harv	39900 AM
WWBM	W. Bridgewater	Mtr		30980 AM
WAKW	Westfield	Mtr		37900 AM
WBVI	Westford	WE		37100 AM
WHTE	Weston	Link		33940 FM
WMWP	Westport	Comp		1714 AM
WFLL	W. Springfield	Mtr		39380 FM
WKYA	Westwood	GE		31100 FM
WGBU	W. Yarmouth (Co)	Mtr	Harv	39900 AM
WRLQ		Harv		39900 AM
WBVN	Weymouth	RCA		39900 AM
WJHQ	Winchendon	Link		31100 FM
WJYI	Wilmington	Mtr		37900 AM
WQSV	Winchester	GE		37100 FM
		GE		37220 FM
WAKZ	Woburn	Mtr		33780 AM
		Mtr		39100 AM
WPGX	Worcester	Wstg		2466 AM
		Link		33780 AM
WMGT	Wrentham	Link		37900 FM

MICHIGAN

WARZ	Albion	Link		33100 FM
WSKH	Allen Park	Comp		31500 AM
		GE		31500 FM
WQKV	Alpena	Mtr		31500 AM
WQRK	Ann Arbor	Comp		2466 AM
		Mtr		35100 AM
		Mtr		35100 FM
WBJG	Ann Arbor (Co)	Mtr		35100 FM
WQGS	Bad Axe (Co)	Mtr		33100 FM
WRLM	Battle Creek	Mtr		33100 FM
		Comp		33220 AM
WPGA		Comp		31780 AM
WMLU	Battle Crk. Twp.			33100 FM
WPGA	Bay City	Comp		2466 AM
WEKA	Bay City (Co)	Kaar		31780 AM
WSVO	Benton Harbor	Mtr		33100 FM
WRIZ	Berkley	Mtr		35500 AM
		Comp		39380 AM
WRIY	Birmingham	Comp		33500 FM
WQOG	Bloomfield Hills	Comp		31100 AM
		Comp		35100 AM
WBNR	Center Line	Harv	Mtr	39900 AM
WGBX		Mtr		39900 AM
WHNA	Charlotte (Co)	Mtr		33100 FM
WRJA	Clawson	Comp		35500 AM
		Comp		39380 AM
WQND	Dearborn	Comp		33100 AM
		RCA	Game	37780 AM
		Dool	Mtr	37780 FM
WCK	Detroit	Coll		2430 AM
		Comp		30700 FM
		Mtr		31780 AM
		Link		31780 FM
		Mtr		33780 AM
		Link		33780 FM
	Mtr	Link	REL	35220 FM
		Mtr	Link	37220 FM
WPDX		WE		2430 AM
		Link		39100 FM
WJHK	Dowagiac	Mtr		33100 FM
WAEZ	East Detroit	Mtr		39900 AM
WQMH	Ecorse	Mtr		35900 FM
WAYA	Escanaba	Mtr		35900 FM
WDBK	Ferndale	Mtr		35500 AM
WQFL		D & F	Mtr	1714 AM
WRJB		Comp		35500 AM
WQZY	Flat Rock	Mtr		37500 FM
WPDF	Flint	Coll		2466 AM
		Mtr		31780 AM
WAYG	Flint (Co)	Mtr		39500 FM
WSOJ	Grand Haven	Bass		2442 AM
		Bass		33780 AM
WOMN	Grand Haven (Co)	Mtr		33100 FM
WCPX	Grand Rapids	Comp		2442 AM
WPEB		RCA		2442 AM
		Mtr		33100 FM
		Comp		33780 AM
WQMT	Grosse Pointe	WE		37100 AM
WRDR		Comp		2466 AM
		Comp		30580 AM
WQTD	Hamtramck	Comp		37900 AM
WHUJ	Hart (Co)	Mtr		33100 FM
WAVQ	Hastings	Mtr		33100 FM
WAVO		Mtr		33100 FM
WJUG	Hazel Park	Comp		39380 AM
		Comp		35500 AM
WQVX	Hazel Park	Mtr		35500 AM
WMIO	Highland Park	Mtr		2414 AM
		Mtr		33220 AM
WHBM	Holland	Mtr		33100 FM
WRJC	Huntington Wds.	Mtr		35500 AM
		Mtr		39380 AM
WPHP	Jackson	GE		33100 FM
WAUK	Jackson (Co)	GE		33100 FM
WAMG	Kalamazoo	Coll		2442 AM
		Mtr		33220 AM
WBVU	Kalamazoo (Co)	Mtr		33220 AM
WKWQ	Lansing	Comp		2442 AM
WPDL		Mtr		33100 FM
WQLL	Lincoln Park	GE		31500 FM
		Comp		31500 AM
WSLJ	Marquette	Mtr		30700 AM
WBPK	Marshall (Co)	Mtr		33100 FM
WDBM	Marysville	Comp		31780 AM
WMLF	Mason	Mtr		33100 FM
WRZQ	Menominee	Mtr		33500 AM
WBLA	Midland	Mtr		31500 AM
WQTB	Monroe	Comp		33220 AM
		Comp		37900 AM
WSRQ	Mount Clemens	Mtr		39900 AM
WRPV	Mt. Clemens (Co)	Mtr	Harv	39900 AM
		Mtr		39900 FM
WPFC	Muskegon	Comp		2442 AM
		Mtr		30580 AM
WBSU	Muskegon (Co)	Mtr		39380 FM
WBKD	Muskegon Hts.	Mtr		30580 AM
WBHW	New Haven	Comp		39900 AM
WRQF	Niles	Bass		2442 AM
		Bass		30580 AM
WQRZ	Pontiac (Co)	Comp		31100 AM
		Comp		35100 AM
WAQM	Ovid	Mtr		33100 FM
WDDI	Owosso	Comp		2466 AM
		Mtr		33780 FM
WBXO	Parchment	Mtr		33220 AM
WRJD	Pleasant Ridge	Comp		35500 AM
		Comp		39380 AM
WQMG	Pontiac	Bass	Mtr	31100 AM
		Bass	Mtr	35100 AM
WPGB	Port Huron	Comp		2466 AM
		Mtr		31780 AM
WSPV	Port Huron (Co)	Comp		31780 AM
WROQ	River Rouge	Comp		33500 AM
		Comp		35100 AM
WRIR	Roseville	Mtr		39900 AM
WBWM	Royal Oak	Mtr		35500 AM
WQMB		Comp		35500 AM
		Comp		39380 AM
WPES	Saginaw	Comp		2442 AM
		Comp		31780 AM
		Link		31780 FM
WRNH	Saginaw (Co)	Comp		31780 AM
WAGP	St. Clair Shs.	RCA	Mtr	39900 AM
WSQM	St. Joseph	Mtr		33100 FM
WSTJ	St. Joseph (Co)	Mtr		33100 FM
WCBQ	Slt. St. Marie	Mtr		37900 FM
WRMB	Traverse City	Thor		2442 AM
		Comp		37220 AM
WQWN	Trenton	GE		31500 FM
WQMF	Wayne (Co)	REL		30980 FM
		REL		33940 FM
WRHV	Wyandotte	GE		39500 FM
WQOK	Ypsilanti	Mtr		31780 AM
		Comp		37100 AM

MINNESOTA

KQBG	Austin	WE		37100 AM
WRJP	Brainerd	Coll		2406 AM
		Mtr		30980 AM
WFJC	Cloquet	Mtr		37100 AM
KKNF	Duluth (Co)	WE		30580 AM
KNFE	Duluth	WE		2382 AM
		WE		30580 AM
KQRK		Comp		2382 AM
KQED	Faribault	Comp		33500 AM
		Comp		37780 AM
KPDW	Hastings (Co)	RCA		33940 AM
WJUI	Hibbing	Mtr		33500 AM


10"
12"
8"
New Jensen
PM SPEAKERS with
ALNICO 5
Newly designed in every detail . . . magnets, housings, magnetic structures, voice coils and cones . . . and incorporating the new and powerful ALNICO 5 magnet material, this new family of PM speakers will add an imposing and important series of speakers to the JENSEN line.
These new models are now being tooled for production and, when ready, complete specifications and prices will be issued to the trade in Data Sheet TD-133. . . . Watch for other postwar innovations soon to come from the JENSEN laboratories.
JENSEN RADIO MANUFACTURING COMPANY, 6609 S. Laramie Ave., Chicago 38, Ill.
IN CANADA: Copper Wire Products, Ltd., 138 Oxford St., Guelph, Ont.
Jensen
SPEAKERS WITH
ALNICO 5
Specialists in Design and Manufacture of Fine Acoustic Equipment

KIJW	Hopkins	Mtr		39900 FM
KQAA	Mankato	Comp		31500 AM
		Comp		39380 AM
KGPB	Minneapolis	WE		2430 AM
		Mtr		30580 FM
		Mtr		30700 FM
		Mtr		30980 FM
	WE	Link	Mtr	31780 AM
KGPR		WE		2430 AM
		Mtr		30700 FM
KANN	Minneapolis (Co)	Mtr		39900 FM
KQDB	Red Wing	Mtr		33500 AM
KQAM	Rochester	Mtr		37100 FM
KQFY	St. Cloud	RCA		31500 AM
WPDS	St. Paul	RCA	Mtr	33940 AM
KQKW	St. Paul (Co)	RCA		33940 AM
WQKW		Mtr		33940 AM
KQGR	S. St. Paul	RCA	Mtr	33940 AM
WDCX	Virginia	Mtr		31500 AM
KRIN	Willmar (Co)	Stne		31500 AM
KBZB	Winona	RCA		35900 FM

MISSISSIPPI

WJJN	Biloxi	Mtr		35900 FM
WMPG	Greenville	Mtr		35900 FM
WSRW	Greenwood	Mtr		33500 AM
WGPP	Gulfport	Mtr		33500 FM
WJYG	Gulfport (Co)	Mtr		33500 FM
WBJC	Hattiesburg	RCA		33500 AM
WJEU	Jackson (Co)	Mtr		31780 AM
WAMK	Jackson	Wstg		2490 AM
		Game		31780 AM
WLCP	Laurel	Comp		2490 AM
		Mtr		30980 FM
WAMJ	Natchez	Comp		2490 AM
		Comp		31780 AM
WRNC	Vicksburg	Coll		2490 AM
		GE		35100 FM

MISSOURI

KQBS	Cape Girardeau	Mtr		2482 AM
		Mtr		30980 AM
KQDE	Columbia	Mtr		2482 AM
		Mtr		30980 AM
KQRU	Hannibal	Mtr		2482 AM
		Mtr		30980 AM
KRLK	Independence	GE		35900 FM
KQAJ	Joplin	D&F		2482 AM
		D&F		30580 AM
KGPE	Kansas City	WE	RCA	2422 AM
		RCA	Mtr	30580 AM
KRHW	Kansas City (Co)	Mtr	RCA	30580 AM
KQOU	Ladue	Mtr		33500 AM
KQCD	St. Charles	Mtr		31900 FM
KRMB	St. Charles (Co)	Mtr		39780 FM
KQBW	St. Joseph	WE	Mtr	33100 AM
KGPC	St. Louis	WE		1706 AM
		Mtr		33220 AM
KAME	Sedalia	Mtr		2482 AM
		Mtr		30980 AM
KQBO	Springfield	Mtr		33100 AM

MONTANA

KQHU	Anaconda	RCA		2406 AM
		RCA		39380 AM
KQIZ	Billings	RCA		2406 AM
		RCA		39380 AM
KBSO	Bozeman	Coll		2406 AM
		Dool		39380 AM
KROI	Bozeman (Co)	Dool		39380 AM
KBPD	Butte	WE		2406 AM
		WE	Mtr	39380 AM
KPGF	Great Falls	Comp		2406 AM
		Harv	Mtr	39380 AM
KHMP	Helena	Teme	D&F	2406 AM
KGKC	Kalispell	Coll		2406 AM
		Dool		39380 AM
KHMP		Coll		39380 AM
KFMW	Miles City	Teme		2406 AM
		Teme		39380 AM
KGRC	Miles City (Co)	Mtr		39380 AM
KQKD	Missoula	Coll		2406 AM
		Coll		39380 AM

NEBRASKA

KANB	Alliance	GE		33940 FM
KRNX	Clearview (Co)	GE		37100 FM
KRAF	Falls City (Co)	Comp		2422 AM
		Mtr		30580 FM
KQAV	Grand Island	RCA	Mtr	33100 AM
KRLX	Hastings	Mtr		30700 FM
KGZU	Lincoln	Coll		2490 AM
		Mtr		30580 AM
KNGN	Norfolk	Comp		2490 AM
KRGW	North Platte	Mtr		33500 AM
KGPI	Omaha	Mtr		33780 FM
		Mtr		33940 FM
KSDZ		Mtr		33940 FM
KRNY	Omaha (Co)	GE		37100 FM
KRKV	Scottsbluff	Mtr		33500 AM
KQWD	S. Sioux City	Mtr		31780 AM

NEVADA

KGHG	Las Vegas	Comp		2474 AM
		Mtr		30580 AM
KGHM	Reno	Comp		2474 AM
		Mtr		30580 AM
		Mtr		39380 FM
KKWC	Reno (Co)	Mtr		39380 FM
KGHC	Sparks	Mtr		30580 AM
		Mtr		39380 FM

NEW HAMPSHIRE

WKTX	Claremont	Mtr		33500 FM
WRJV	Concord	WE	Mtr	37900 AM
WMYQ	Dover	Mtr		30700 AM
WJLR	Keene	Mtr		33500 FM
WKUY	Keene (Co)	Mtr		33500 FM
WOOT	Laconia	Mtr		30700 FM
WQLQ	Manchester	WE	Mtr	31500 AM
WPHB	Nashua	WE	RCA	39500 AM
WKSA	Portsmouth	Mtr		33500 FM
WGAZ	Rochester	Mtr		39380 FM
		Mtr		39500 FM

NEW JERSEY

WMQZ	Allenhurst	Link		39900 FM
WQRO	Alpine	Link		37780 AM
WSOE		Link		31900 FM
		Link		31780 FM
WABM	Asbury Park	Link		31100 AM
WIYB	Atlantic City	Comp		33100 AM
WLDN		Comp		33100 AM
WQIY		REL	Link	33100 AM
WJZB	Atlan. Highlands	Link		37780 FM
WETQ	Audubon	RCA		39900 FM
WBSK	Avon by the Sea	Link		39900 FM
WIZN	Bay Head	Link		37780 FM
WQXN	Bayonne	Link		33500 AM
WBQX	Belleville	Mtr		33100 FM
WQNT	Belmar	Link		37100 AM
WRJU	Bergenfield	Link		35900 AM
WAKH	Bloomfield	Wstg		2430 AM
		Link		37220 AM
WAKD	Bloomingdale	Bod		37100 AM
WHUA	Bogota	Link		39500 AM
WFUA	Boonton	Link		37900 FM
WQKA	Bound Brook	Link		37900 AM
WQHW	Bradley Beach	Link		39900 FM
WSKA	Bridgeton	RCA		31100 AM
WDBX	Brielle	Link		37780 FM
WJVN	Brigantine	Link		33100 AM
WQNA	Budd Lake	Link		33100 AM
WBSX	Burlington	RCA	Mtr	37900 AM
WANZ	Butler	Bod		37100 AM
WAFP	Caldwell	Link		37900 FM
WQNI	Camden	RCA		37100 AM
WKVZ	Carlstadt	Link		37780 AM
WAYE	Carney's Point	Mtr		35500 AM
		Mtr		35500 FM
WANV	Carteret	Link		33100 FM
WAWX	Cedar Grove	Link		33100 FM
WBVX	Cliffside Pk	Mtr		35500 AM
WSQO	Clifton	Link		31100 AM
WRLZ	Closter	REL	Bod	39500 AM
WFZG	Collingswood (Co)	RCA		33500 AM
WQNG	Collingswood	RCA		33500 AM
WQMC	Cranford	GE		35900 AM
		Comp		39380 AM
WRPR	Cresskill	Link		39900 AM
WQOQ	Deal	REL		33100 AM
WBTT	Deepwater	Mtr		35500 AM
		Mtr		35500 FM
WDHM	Dover	Link		33500 FM
WBNW	Dumont	Mtr		37500 AM
WQKI	East Orange	Link	WE	39500 AM
WFJV	Eatontown	Link		37780 FM
WBOO	Edgewater	Link		39100 FM
WRAD	Elizabeth	REL		39100 AM
WHBA	Emerson	Link		37900 AM
WQIK	Englewood	Link		33500 AM
WBMC	Englewood Cliffs	Link		37780 AM
WJJE	Englishtown	Link		37780 FM
WCAK	Fair Lawn	Link		37900 FM
WQYZ	Fanwood	RCA		31500 AM
WSRL	Florham Park	Link		35900 AM
WBYC	Fords	Link		37500 AM
WBKN	Fort Lee	Mtr		35500 AM
WAJI	Freehold	Link		37780 FM
WAKC	Freehold (Co)	Wstg		2366 AM
		Link		37780 FM
WRQE	Garfield	Link		39100 AM
WGIP	Garwood	Mtr		39380 AM
WQIJ	Hackensack	Link		37500 AM
WPFK	Hackensack (Co)	Link		2430 AM
		Mtr	Link	37780 AM
WRBJ	Haddonfield	RCA		39500 AM
		RCA		39500 FM
WRAN	Haddon Hgts	RCA		35900 AM
WBTK	Haledon	Link		35500 AM
WETX	Hanover	Mtr		35900 AM
BYX	Hasbrouck Hgts	Link		33100 FW
WRGN	Hawthorne	Link		39900 AM
WBXL	Highland Pk	GE		33940 FM
WSYZ	Hillside	Link		35500 AM
WMFH	Hoboken	Mtr		35900 FM
WSRP	Hohokus	Link		37780 AM
WAAG	Interlaken	Link		37780 FM
WLSN	Irvington	Link		35900 FM
WQRS	Jersey City	Link		31900 AM
WRMJ		Link		31900 AM
WRPH	Kearny	WE		39900 AM
WDOM	Keyport	Link		37780 FM
WRBT	Lakewood	REL	Link	37900 AM
WQJN	Lawrenceville	RCA		33100 AM
WSTB	Leonia	Link		35900 AM
WRBO	Lincoln Pk	Link		31500 AM
WAJQ	Linden	WE		31100 AM
WJKI	Little Falls	Link		33100 FM
WFAB	Little Silver	Link		37780 FM
WQMK	Livingston	RCA		35900 AM
WQNF	Long Branch	Link		37100 AM
WQMP	Longport	REL	Mtr	37100 AM
WSOM	Lyndhurst	Link		37500 AM
WQJU	Madison	Link		35500 AM
WCBB	Mahwah	Bod		31100 AM
WMMJ	Manasquan	Mtr		37780 FM
WBYR	Manville	Mtr		31900 AM
WAPK	Maplewood	Link		37500 FM
WRLY	Margate City	REL		37100 AM
WCBL	Matawan	Link		37780 FM
WKZB	Matawan	Link		37780 FM
WQMX	Maywood	Link		39100 AM
WQLT	Metuchen	WE		37100 AM
WFZD	Middlesex	Link		37900 AM
WBXZ	Middletown	Link		37780 FM
WRBX	Midland Park	Link		33500 AM
WQKJ	Milburn	Link		37100 FM
WRHR	Millville	RCA		33940 AM
WQMO	Montclair	RCA	Link	33220 AM
WKPM	Montville	Link		37100 AM
WGNQ	Moorestown	RCA		37500 AM
WQXK	Morristown	WE		39100 AM
WBXE	Mountainside	Mtr		37220 AM
WBOD	Mt Holly	RCA		30700 AM
WBYD	Neptune	Link		31900 FM
WKKG	Neptune City	Link		37780 FM
WNHT	Newark	Comp		30700 AM
WQIE		Stne	WE	30700 AM
WQRV	New Brunswick	Wstg		33500 AM
		Game		39380 AM
WGCS	New Milford	Link		37900 AM
WQJY	New Market	Link		39900 AM
WBRZ	N. Arlington	Link		31500 AM
		Link		31780 AM
WAHG	N. Bergen	Link		31100 FM
WBVF	N. Haledon	Link		3500 AM
WQJS	N. Plainfield	Bod		39500 AM
WRHG	Nutley	WE		37100 AM
WBGU	Oakland	Bod		37100 AM
WRMG	Oaklyn	RCA		33500 AM
WHTV	Ocean City	Mtr		39100 FM
WCBU	Oceanport	Link		37780 FM
WGMU	Oradell	Link		37900 AM
WQTS	Orange	WE		39500 AM
WPPP	Palisades Pk	Mtr		37100 AM
WSOE		Link		31780 FM
		Link		31900 FM
WBKE	Paramus	Link		33780 AM
WQKH	Passaic	Link		35900 AM
WRGO	Paterson	Link		35500 AM
WSPT	Pennsauken	RCA		39100 AM
WBSL	Penns Grove	Mtr		35500 AM
		Mtr		35500 FM
WANX	Pequannock	Bod		37100 AM
WFTK	Perth Amboy	Link		37900 FM
WENX	Phillipsburg	Link		39500 FM
WAOW	Pitman	Mtr		39900 AM
WQKG	Plainfield	RCA		31500 AM
WQMQ	Pleasantville	Comp		37100 AM
WAXV	Pt Pleasant	Link		37780 FM
WSWI	Pompton Lakes	Bod		37100 AM
WQTA	Princeton	Link		37100 AM
WRBI	Princeton	Link		37100 AM
WBTL	Prospect Pk	Link		35500 AM
WFZQ	Rahway	Mtr		31500 AM
WQYG	Rahway	WE		31500 AM
WQJC	Raritan	Link		37220 AM
		Link		39500 AM
WIEJ	Red Bank	Link		39100 FM
		Link		39380 FM
WBKP	Ridgefield	Mtr		37500 AM
WSKM	Ridgefield Pk	Link		39500 AM
WBKE	Ridgewood	Link		33780 AM
WQYF	Ridgewood	Link		33500 AM
WAKJ	Ringwood	Bod		37100 AM
WDYY	River Edge	Link		37780 AM
WQMY	Roselle	Link		35500 AM
WQJQ	Roselle Pk	Link		37500 AM
WQKQ	Rumson	RCA		35900 AM
WBMJ	Rutherford	Link		37900 AM
WMHT	Saddle River	Link		37780 AM
WSQK	Salem	RCA		35500 AM
WSPP	Scotch Plains	Arve		2430 AM
		Arve		37220 AM
WFUO	Sea Girt	Link		37780 FM
WQIL	Secaucus	Link		37100 AM
WRSO	Somerville	Mtr		3100 FM
WBJD	S. Belmar	Link		37780 FM
WBXJ	S. Bound Brook	Link		37900 AM
WABU	S. Plainfield	Mtr		39900 AM
WSLG	Sparta	Bod		31500 AM
WBHG	Springfield	Link		39100 FM
WRAZ	Spring Lake	Comp		35500 AM
WSLL	Spring Lake Hgts	Link		37780 FM
WQRX	Summit	RCA		39900 AM
WQJO	Teaneck	Link		31500 AM
WGVZ		Link		31500 AM
WRGI	Tenafly	Link		39900 AM
WJKC	Totowa	Link		31500 AM
WRKY	Trenton	RCA		33100 AM
WQIZ	Trenton	RCA		33100 AM
WRPI	Trenton	RCA		33100 AM
WQJM	Trenton	RCA		33100 AM
WQJB	Union	Link		37900 AM
WQNY	Union City	Bod	REL	33100 AM
WQKX	Ventnor City	REL		37100 AM
WBWH		Comp		37100 AM
WLDR		Comp		37100 AM
WQYH	Verona	Link		37900 FM
WAKM	Wanaque	Bod		37100 AM
WSPE	Watchung	Bod		39500 AM
WSLC	Wayne	Link		31500 AM
WKGL	Wehawken	Mtr		31500 FM
WPHL	West Belmar	Link		37780 FM
WSQN	W. Caldwell	RCA		35900 AM
WQOM	Westfield	WE		33100 AM
WBWI	W. Keensburg	Link		37780 FM
WFOV	W. Long Branch	Link		37780 FM
WBNG	W. Milford	Bod		37100 AM
WBKH	Westmont	RCA		33500 AM
WQRN	W. New York	Link		37900 AM
WSKN	West Orange	WE		39500 AM
WIUO	W. Paterson	Link		31500 AM
WRMZ	Westwood	Link		37900 AM
WLSH	Whippany	Mtr		35900 AM
WBOJ	Wildwood	Link		31500 AM
WQJE	Woodbridge	Link		37500 AM
WRLV	Woodbury	RCA		31900 AM
WPYV	Woodlynne	RCA		33500 AM

NEW MEXICO

KGZX	Albuquerque	GE		39100 FM
KNFA	Clovis	Comp		2414 AM
KRNM	Roswell	RCA		33220 AM
		RCA		2414 AM
KRHQ	Roswell (Co)	RCA		33220 AM
KGPF	Santa Fe	Comp		2414 AM

NEW YORK

WPGH	Albany	WE		2458 AM
WHDI	Amityville	Erco		35900 AM
WKNI	Amsterdam	GE		37900 FM
WMLG	Arcade	Mtr		37900 FM
WPDN	Auburn	deF		2382 AM
		SP		39380 AM
WROI	Babylon	Erco		35900 AM
WRJS	Batavia	RCA	GE	33500 AM
WEJZ	Bath (Co)	Mtr		37900 FM
WJXL	Bear Mountain	REL	Link	31900 FM
		REL	Link	31780 FM
WBZN	Binghamton (Co)	Link		37900 FM
WHTZ	Binghamton	Link		37900 FM
WPGL		WE		2442 AM
WBDN	Briarcliff Manor	Bod	BRL	37100 AM
WQOY	Bronxville	RCA		37900 AM
WMJ	Buffalo	RCA		2422 AM
		Mtr	RCA	30580 AM
WKQO		Mtr		37500 FM
WCAV	Canandaigua (Co)	Mtr		37900 FM
WKJX	Canton (Co)	Link		2414 AM
WEKU	Chappaqua	Mtr		39100 FM
WBLF	Clarkstown	Bod	Mtr	31100 AM
WEPI	Corning	Mtr		37900 FM
WBID	Cortland	Comp		2382 AM
		Stan		35100 AM
		GE		35100 FM
WALK	Dunkirk	Mtr		37900 FM
WQLC	Eastchester	Bod		33100 AM
WHTU	Easthampton (Co)	Link		31900 FM
WKVI	East Hampton	Link		37500 FM
WANK	Ellicott (Co)	Mtr		31500 FM
		Mtr		31780 FM
WBLL	Elmira	Mtr		37900 FM
WIKE	Endicott	Link		33500 AM
WBDO	Floral Park	Link		31500 AM
WHOH	Fonda (Co)	Mtr		37900 FM
WAFR	Freeport	Erco		37900 AM
WBIC	Fulton	Mtr		33500 AM
WQKO	Garden City	Erco		37100 AM
WAZS	Geneseo (Co)	Mtr		37900 FM
WQOU	Geneva	Mtr		31500 AM
WRJG	Glen Cove	Erco		2490 AM
		Erco		33780 AM
WQHS	Goshen (Co)	Mtr		37900 FM
WBVK	Grand View on Hudson	Erco		31100 AM
WMQO	Great Neck	Link		35100 FM
WQKZ	Greenburgh	Bod		33100 AM
WSRN	Hanover	Mtr		37900 FM
WQLN	Harrison	Bod		37500 AM
WBLG	Haverstraw	Bod		31100 AM
WQTK		Bod		31100 AM
WQKP	Hempstead	Erco		39500 AM
WAKN	Herkimer	Comp		2414 AM
WBOY	Hillburn	Bod		31100 AM
WRAP	Hornell	GE		37900 FM
WPGO	Huntington	Comp		2490 AM
		Link		39380 FM
WHTI	Islip (Co)	Link		31900 FM
WQNS	Ithaca	GE		31500 AM

Meets all FCC requirements for the emergency services. AC-DC operation

The Completely New Model S4

BROWNING FREQUENCY METER

You'll be as proud to use a BROWNING Model S4 Frequency Meter as we are to offer it as a product of the BROWNING LABORATORIES.

It has all the new conveniences that supervisors of emergency radio systems have wanted—plus new refinements born of our war experience in designing high-precision radar test equipment.

For your convenience, we have added an antenna which also serves as a carrying handle. For still greater accuracy, we have changed to a laboratory-type scale and added a vernier. New knobs are large enough for you to grasp when it's too cold to take off your gloves.

The case is larger now, to accommodate internal changes which further increase the stability by the use of improved circuits.

The crystal-controlled BROWNING Model S4 meets FCC requirements of plus-or-minus .00025% accuracy. Operating on both AC and DC, this instrument is designed to check both FM and AM equipment.

It is calibrated for 1 to 5 different frequencies at any points from 1.5 to 120 mc., according to your requirements.

For information on prices and deliveries, write:

BROWNING LABORATORIES, Inc.

WINCHESTER • MASSACHUSETTS

WJNY	Jamestown	Mtr		37900 FM
WMOJ	Johnson City	Link		37900 FM
WQXP	Kingston	RCA	Mtr	37100 AM
WQJT	Larchmont	WE		33100 AM
WRIO		WE		39100 AM
WROJ	Lindenhurst	Erco		35900 AM
WAXZ	Little Valley	Mtr		37900 FM
WKAF	Lockport	Link		39500 FM
WKAG		Link		39500 FM
WKAH		Link		39500 FM
WKHR		Mtr		37900 FM
WLOC		Link		39500 FM
WLOD		Link		39500 FM
WQEZ	Mahopac	Link		39900 FM
WSNK	Mamaroneck	Bod		39100 AM
WMJX	Massena	Mtr		37900 FM
WBIF	Mayville (Co)	Mtr		31500 FM
		Mtr		37900 FM
WSRN	Middletown	Link		31900 AM
WANG	Mineola	WE		2490 AM
WBPS		Erco		2490 AM
WRMF		WE		2490 AM
WFTV		Erco		2490 AM
WITX		Erco		2490 AM
WPGS		WE		2490 AM
		Link	WE	35100 AM
		Link		35100 FM
WQLV	Mt Vernon	WE		35500 AM
WEUA	Newburgh	Link		39900 FM
WQIM	New City (Co)	Bod		31100 AM
WQKC	New Rochelle	WE		31500 AM
WBIS	New York	RTL		33940 AM
WBIT		RTL		33940 AM
WBKF		RTL		33940 AM
WMNY		RCA		33940 AM
WNYM		RTL		33940 AM
WPEE		WE		2450 AM
		RCA		33940 AM
		RCA		30980 AM
WPEF		WE		2450 AM
		Comp		33940 AM
WPEG		WE		2450 AM
		RCA		33940 AM
		RCA		30980 AM
		Link		30980 AM
		Link		33940 AM
		Mtr		33940 AM
WRFN		Link		33940 FM
WRGS		RTL		33940 AM
WRQC		WE		30980 AM
		WE		33940 AM
		WE		2450 AM
WRQD		WE		33940 AM
		WE		30980 AM
		WE		2450 AM
WNFP	Niagara Falls	Comp		2422 AM
		Mtr		37100 FM
		Comp		30580 AM
WBAW		Mtr		37100 FM
WBBS		Mtr		37100 FM
WBBT		Mtr		37100 FM
WBBY		Mtr		37100 FM
WBCB		Mtr		37100 FM
WBCN		Mtr		37100 FM
WBCY		Mtr		37100 FM
WETY	Nissequogue	Mtr		31900 AM
WQLD	North Pelham	Bod		37100 AM
WBXN	N. Tarrytown	Bod		37100 AM
WBTI	N. Tonawanda	Mtr		35900 FM
WRGM	Nyack	Bod		31100 AM
WQMV	Olean	Mtr		37900 FM
WJAM	Oneida	Comp		2414 AM
		Stne		35100 AM
WQFJ	Oneonta	Comp		2414 AM
		Link	Harv	30580 AM
WSWJ	Orangetown	Bod		31100 AM
WQNH	Ossining	Bod		37100 AM
WMVE		BRL		37100 AM
WJZX	Oswego (Co)	Mtr		37900 FM
WJXL	Palisades Pk	Link		31780 FM
		Link		31900 FM
WRNE	Patchogue	Arve		2490 AM
		Arve		37780 AM
WBZW	Peekskill	RCA		31500 AM
WDAG	Pelham	Bod		37100 AM
WQOT		Bod		37100 AM
WJFU	Pelham Manor	Link		37100 AM
WQOS		Link		37100 AM
WRHE	Piermont	Bod		31100 AM
WDGS	Plattsburg	GE		37100 FM
WRSY	Port Chester	Link		33500 AM
WRND	Port Jefferson	Arve		2490 AM
WQXY	Port Jervis	Link		33100 AM
WABN	Port Wash.	Erco		35220 AM
		Erco		2490 AM
WRCV	Poughkeepsie	RCA	Mtr	30700 AM
WBLH	Ramapo	Bod		31100 AM
WJPV	Riverhead (Co)	Link		31900 FM
WPDR	Rochester	RCA	WE	2422 AM
	RCA Harv	Link	Mtr	30580 AM
WKHZ	Rome	Mtr		37900 FM
WQKU	Rye	Bod		31900 AM
WBSB	Salamanca	GE		31100 FM
		GE		37930 FM
WQHZ	Sands Point	Erco		35900 AM
WQKL	Scarsdale	Bod		33100 AM
WQRB	Schenectady	GE		37100 FM
WBGJ	Schenectady (Co)	GE		39500 FM
WBWN	Sloatsburg	Bod		31100 AM
WAFV	Smithtown Br.	Mtr		31900 AM
WHTS	Southampton (Co)	Link		31900 FM
WHTT	Southold (Co)	Link		31900 FM
WBVR	South Nyack	Bod		31100 AM
WBLI	Spring Valley	Bod		31100 AM
WBLM	Suffern	Bod		31100 AM
WBVJ	Syracuse	WE		30980 AM
		Mtr		33780 FM
WPEA		WE	GE	2382 AM
		Mtr		37500 FM
	GE	RCA	WE	30980 AM
		Mtr	GE	37780 FM
WBLN	Tarrytown	Mtr		35500 FM
WRCD	Troy	RCA		33100 AM
WQJD	Tuckahoe	Bod		33100 AM
WBLO	Upper Nyack	Bod		31100 AM
WPGJ	Utica	GE		31500 FM
WQJK	Viola (Co)	Bod	Mtr	31100 AM
WMLJ	Warsaw	Mtr		37900 FM
WBPE	Warsaw Twp (Co)	Mtr		37900 FM
WCDX	Watertown	GE		37100 FM
WMJN	Watervliet	Mtr		37900 FM
WCDX		GE		37100 FM
WJKS	White Plains (Co)	Mtr		30580 FM
		Mtr		30700 FM
WQKS	White Plains	WE		37100 AM
WRNJ	Williamsville	Link		31500 FM
WPFY	Yonkers	WE		2442 AM
		Link		37200 FM

NORTH CAROLINA

WQMJ	Asheville	Comp		30580 AM
WPFS	Asheville (Co)	Comp		2474 AM
		Comp		30580 AM
WRJE	Burlington	Link		33500 AM
WPDY	Charlotte	GE		35900 FM
WRPL		Link		30580 AM
		Link		33940 AM
WSLF	Charlotte (Co)	Link		37900 FM
WQNE	Concord	Link		33100 AM
WDMP	Durham	Coll	Link	33100 AM
WBIV	Elizabeth City	Link	RCA	33500 AM
WROS	Fayetteville	Link		33500 AM
		Link		33500 FM
WQNZ	Gastonia	Coll	WE	37100 AM
		Link		37100 FM
WABQ	Goldsboro	Link		35900 FM
WJDZ	Goldsboro (Co)	Link		35900 FM
WQMR	Greensboro	Link		37100 AM
WLSG	Greensboro (Co)	Link		37100 AM
		Link		37220 FM
WRGY	Hickory	Link		37500 AM
WHPP	High Point	Link		39500 FM
WRCD	Kings Mtn.	Link		37500 AM
WQLR	Kinston	Link		33500 FM
WBJF	Leakesville (Co)	Link		37500 AM
WBNL	Lenoir	RCA	Mtr	37500 AM
WRNT	Lexington	Link		33100 AM
WKZM	Monroe	GE		39500 FM
WBXT	Morganton (Co)	Mtr		37500 AM
WADX	New Bern	GE		35900 FM
WBTX	Newton (Co)	Mtr		37500 AM
WQLY	Raleigh	Link		31500 FM
WRPW	Reidsville	Link		37500 AM
WQLI	Rocky Mount	RCA		33500 AM
WATU	Rutherfordton (Co)	Link		33500 FM
WQLU	Salisbury	Link		33100 FM
WANY	Shelby	Link		37500 AM
WDBS	Statesville	RCA		33940 FM
WDBR	Statesville (Co)	RCA		33940 FM
WETO	Thomasville	Link		39500 FM
WDPW	Wilmington	Link	Mtr	39380 FM
		Link	Mtr	39500 FM
WQNU	Wilson	Link		35900 FM
WQMS	Winston-Salem	Link	RCA	33500 AM
WRPU	" " (Co)	RCA		33500 AM

NORTH DAKOTA

KQRL	Bismarck	RCA		33500 AM
KNHN	Fargo	Coll		2442 AM
KQSO	Grand Forks	RCA		33500 AM

OHIO

WPDO	Akron	RCA	Wstg	2458 AM
	Game Mtr	RCA	Temc	35100 AM
		Mtr		37900 FM
WCAY	Akron (Co)	RCA		30700 AM
WAAL	Lime (Co)	Mtr		37900 FM
WJUK	Alliance	Link		33940 FM
WBIU	Amberly	RCA		31500 AM
WANC	Ashland	RCA		37900 FM
WSTK	Ashtabula	RCA		37100 AM
WMPZ	Athens	Mtr		37900 FM
		Mtr		39780 FM
WJGD	Barberton	Link		31900 AM
WANW	Beachwood	Mtr		37900 FM
WBOF	Bedford	Comp		31500 AM
WBTR	Bexley	Mtr		37220 FM
WQTQ	Bucyrus	Temc		2474 AM
		Mtr		30980 AM
WQKW	Canton	Link	WE	33100 AM
WBYZ	Canton (Co)	Link		39380 FM
		GE		39500 FM
WJJO	Chardon (Co)	Mtr		37900 FM
WRIC	Chillicothe	Temc		2430 AM
		Temc		33220 AM
WKDU	Cincinnati	RCA		1706 AM
		RCA	Mtr	30580 AM
		Mtr		35220 FM
		Mtr		35500 FM
WRBH	Cleveland	WE		2458 AM
		RCA		30580 AM
		RCA		39980 AM
		RCA	Mtr	31780 AM
		Mtr		31780 FM
		RCA	GE	33100 FM
		GE		33500 FM
		RCA		33780 AM
		GE	Mtr	33780 FM
		GE	Mtr	35500 FM
WENB		Bndx		2458 AM
		GE		33100 AM
		GE		33100 FM
		Comp	RCA	33500 AM
WRPD		RCA		33500 AM
WSNO	Cleveland Hgts	GE		37500 FM
WLDO	Clyde	Comp		30580 AM
WPDI	Columbus	RCA	Wstg	2430 AM
		Mtr		37220 AM
		Mtr		37220 FM
WJKB	Columbus (Co)	Mtr		37900 FM
WLOZ	Colerain Twp (Co)	Mtr		37900 FM
WSRS	Cross Creek (Co)	RCA		33100 AM
WBUJ	Cuyahoga F'ls	WE	Mtr	35900 AM
WPDM	Dayton	Comp		2430 AM
		Mtr		31780 AM
WBAV	Dayton (Co)	Mtr		31780 AM
WHIV	Delaware	Mtr		37900 FM
WHNL	Delaware (Co)	Mtr		37900 FM
WMSZ	E. Cleveland	RCA		31100 AM
WMLC	E. Liverpool	Mtr		37900 FM
WRNS	Elyria	RCA		31500 AM
WBYO	Elyria (Co)	Mtr		37900 FM
WLSD	Euclid	Link		39900 FM
WMHX	Fairfield	Mtr		31780 AM
WKOI	Forestville (Co)	Mtr		37900 FM
WMPK	Fremont	Comp		2474 AM
		Comp		30580 AM
WBTU	Fremont (Co)	RCA		30580 AM
WRQM	Galion	Comp		2474 AM
		Link		30980 FM
WQZC	Greenville	Mtr		37900 FM
WQZC	Greenville	Mtr		37900 FM
WQOX	Hamilton	GE		31700 AM
WRSI	Hills & Dales	WE		33100 AM
WQST	Indian Hill	Link		33100 AM
WBVL	Ironton	Mtr		31500 AM
WSPX	Jackson (Co)	Comp		2430 AM
WSIG	Jefferson (Co)	Link		37500 AM
WKMP	Kenton	Comp		2474 AM
		Comp		37220 AM
WHTL	Lakewood	Mtr		37900 FM
WQFO	Lancaster	Temc		2430 AM
		Mtr		33220 FM
WAFU	Lima	RCA	Wstg	2474 AM
		Wstg		37220 AM
		Mtr		37900 FM
WBOH	Logan	RCA		31500 AM
WLOP	Lorain	Mtr		37100 FM
WQRL	WE	Mtr	RCA	37100 AM
WMGW	Mansfield (Co)	Link		37500 FM
WQFY	Mansfield	Mtr		37900 FM
WMVH	Maple Heights	Mtr		37900 FM
WRGL	Marietta	RCA		31500 AM
WJJI	Marion	Temc		2474 AM
		Temc		30980 AM
WBGT	Massillon	Link		37100 AM
WMOP	Mentor	RCA		31500 AM
WAIS	Mentor-on-the-Lake	Mtr		31500 AM
WBVB	Middletown	Mtr		35900 AM
WQRW	Newark	RCA		2430 AM
		D&F		30580 AM
		Mtr		30580 FM
WHHA	Newark (Co)	Mtr		30580 FM
WRQL	Niles	Link		37500 AM
WJUM	Norwalk	Mtr		37900 FM
WBYG	Norwood	Mtr		39500 AM
WBKC	Oakwood	Mtr		33500 AM
WQOL	Ottawa Hills	GE		31500 FM
WKHL	Painesville	Mtr		37900 FM
WBOK	Painesville (Co)	RCA		31500 AM
WKYF	Perrysburg	Mtr		37900 FM
WQTP	Piqua	Mtr	WE	37100 AM
WSTM	Port Clinton	Mtr		37100 AM
WPGI	Portsmouth	Comp		2430 AM
		Stne		30580 AM
WFRK	Ravenna (Co)	Link		37900 FM
WRAA	Ravenna	Mtr		37900 FM
WCDE	Reading	Mtr		37900 AM
WAFX	Rocky River	Link		39500 FM
WJSB	St Bernard	Mtr		37500 AM
WAKL	St Clairsville (Co)	Comp		2430 AM
		Mtr		33100 AM
WBGW	Salem	Link		37100 FM
WAKI	Sandusky	Comp		2474 AM
		GE		30980 AM
WALU	Sandusky (Co)	GE		30980 FM
WQHN	Shaker Heights	Mtr		37900 FM
WAMH	Shelby	Comp		2474 AM
		Comp		30980 AM
WSGO	Sidney	RCA		31500 AM
WQMI	Springfield Link	Mtr	REL	33100 AM
WPHD	Steubenville	Comp		2458 AM
		RCA		33100 AM
WBNA	Tiffin (Co)	RCA		31780 AM
WKTP	Tiffin	RCA		2474 AM
		RCA		31780 AM
WRDQ	Toledo	WE		2474 AM
		GE		35220 FM
WBIZ		Comp		2474 AM
WMFO	Toledo (Co)	GE		30700 FM
WRIL	Toronto	RCA		33100 AM
WQTX	Troy	RCA		33500 AM
		Mtr		37900 FM
WMGV	Troy (Co)			37900 FM
WJVQ	Urbana	Mtr		37900 FM
WJWO	Urbana (Co)	Mtr		37900 FM
WAFE	Warren (Co)	Link		37780 FM
WCBK	Warren	Link		37780 FM
		Link		37900 FM
WEMX	Wayne Twp (Co)	Comp		33100 AM
WMPO	Wellsville	Link		33100 AM
WKMZ	Westlake	Comp		3458 AM
		Kaar		39380 AM
WJZV	Wickliffe	Mtr		31500 AM
WQHM	Willoughby	Mtr		31500 AM
WQWO	Will-O-Wick	RCA	Mtr	31500 AM
WQHM	Willoughby	Mtr		31500 AM
WBYA	Wyoming	GE	Mtr	33500 FM
WPDG	Youngstown	Comp		2458 AM
		Link		37220 AM
WRMY	Youngstown (Co)	Link		37220 AM
WPHO	Zanesville	Wstg		2430 AM
		Comp		33220 AM

OKLAHOMA

KNHC	Ada	RCA		2450 AM
KACL	Altus	Comp		2450 AM
		Comp		30598 AM
KARD	Ardmore	RCA		2450 AM
		Mtr		33220 AM
KQFM	Bartlesville	Comp		2450 AM
KEZY	Blackwell	Comp		2450 AM
		Comp		33220 AM
KOKB	Bristow	Comp		2450 AM
KACF	Chickasha	Comp		2450 AM
		Mtr		33220 AM
KAPB	Cushing	Comp		2450 AM
KNGK	Duncan	Coll		2450 AM
KRBK	Durant	RCA		2450 AM
		RCA		33220 AM
KRHT	Edmond	Comp		30580 AM
KBYH	El Reno (Co)	Mtr		31500 FM
KQAB	El Reno	RCA		2456 FM
		Mtr		31500 FM
		Mtr		30580 FM
		RCA		33220 AM
KAPK	Enid	Comp		2450 AM
		Mtr	Stne	33220 AM
KGOP	Guthrie	RCA		2450 AM
		Comp		33220 AM
KPMZ	Hugo (Co)	Mtr		31500 FM
KGHP	Lawton	Comp		2450 AM
		Kaar		33220 AM
KNCE	Miami	Mtr		31500 FM
KNGT	Muskogee	Mtr		31500 FM
KQTV	Newkirk (Co)	Mtr		33220 AM
KQDI	Nichols Hills	Comp		33226 AM
KAPE	Norman (Co)	Comp		2450 AM
KRAY	Norman	Stne		33220 AM
KQDS	Okla. City	RCA	Mtr	33220 AM
KETG	Okla. City (Co)	DeF		2450 AM
KGPH		Comp		2450 AM
		Comp		33220 AM
		GE		35100 FM
KAPF	Okmulgee	Comp		2450 AM
KOPM	Pawhuska	Mtr		31500 FM
KQFL	Pawnee	Coll		2450 AM
KACP	Ponca City	RCA		2450 AM
KPDS	Sapulpa	Comp		2450 AM
		Comp		30580 AM
KACR	Seminole	RCA		2450 AM
KWCM	Shawnee	Coll		2450 AM
		Comp		33220 AM
KSWP	Stillwater	RCA		2450 AM
		RCA		30580 AM
KQEI	Tulsa	RCA		2450 AM
		RCA	Mtr	30580 AM
		Mtr		31500 FM
KWMP	Wewoka	Comp		2450 AM

OREGON

KIAO	Albany	Mtr		33500 FM
KQKX	Astoria	Comp		2442 AM
		Mtr		30980 AM
KSAD	Beaver Creek	Mtr		33500 FM
KQIN	Bend	Comp		2442 AM
		Mtr		35220 AM
KSAB	Canby	Mtr		33500 FM
KFZO	Corvallis	Mtr		33500 FM
KADV	Eugene	RCA		2442 AM
KSAG	Gladstone	Mtr		33500 FM
KRJB	Hillsboro (Co)	Mtr		30980 AM

KGZH	Klamath Falls		Comp		2442 AM
			Comp		35220 AM
KRLA	McMinnville		Mtr		30980 AM
KRIQ	Medford		Comp		2442 AM
KSAK	Milwaukie		Mtr		33500 FM
KEHJ	Molalla		Mtr		33500 FM
KSAH	Oak Lodge		Mtr		33500 FM
KBSX	Oregon City (Co)		Mtr		30980 AM
			Mtr		33500 FM
			Kaar		30980 AM
KGQQ	Oregon City		Mtr		33500 FM
KIAD	Oswego		Kaar		30980 AM
KPOL	Pendleton		Mtr		33500 FM
KQJR	Portland (Co)	RCA	Mtr	Kaar	30980 AM
			Mtr		30580 AM
KGPP	Portland		Comp		2442 AM
			Mtr		30580 AM
			Kaar		30980 AM
KPFD			Kaar		33100 AM
KQEJ			Comp		33100 AM
			Comp		30980 AM
KORM	Salem (Co)		Comp		30980 AM
KGZR	Salem		Comp		2442 AM
			Comp		30980 AM
KSAJ	Sandy		Mtr		33500 FM
KHNX	The Dalles		Mtr		33500 FM
KHWL	West Linn		Mtr		30980 AM
			Mtr		33500 FM

PENNSYLVANIA

WQXW	Abington		Link		33940 FM
			RCA		33940 AM
WRIK	Aliquippa		RCA		33500 AM
WQJZ	Allentown		RCA		37100 AM
			RCA		30580 AM
WSRD	Altoona		Link		35900 FM
WRHZ	Ambridge		Link		35500 FM
WQXX	Ardmore		WE		35500 AM
WJVY	Beaver (Co)		RCA		30700 AM
WQQB	Beaver		Link		37100 AM
WRHA	Beaver Falls		Link		37100 AM
WKJH	Berwick		GE		37500 FM
WPEZ	Bethlehem (Co)		RCA		31900 AM
WQJJ	Bethlehem		Temc		33500 AM
WBRA	Bradford		Mtr		37900 FM
WHRL	Bristol		RCA		31500 AM
WQOR	Brookline		RCA		31100 AM
WBRH	Broomall		Mtr		31780 AM
WMBT	Butler		GE		35900 FM
WMCB	Chambersburg		Mtr		39500 AM
WKWY	Charleroi		Link		39500 FM
WKLC	Chester		GE		37500 FM
WQRD	Clairton		RCA		31500 AM
WBRS	Clifton Hghts		RCA		39500 AM
WBRV	Coatesville		Mtr		33100 AM
WBEV	Collingdale		Comp		37900 AM
WSRC	Coraopolis		RCA		37900 AM
WPMG	Crafton		Link		37500 FM
WDSN	Dormont		Link		39380 FM
WQON	Elkins Park		Mtr		31100 FM
WKMG	Ellwood City		GE		33940 FM
WBHV	Ephrate		Mtr		31500 FM
WQLS	Erie		Wstg	RCA	37100 AM
			Dool	Mtr	37100 AM
WBOI	Essington		Mtr		31780 AM
WKKX	Folcroft		Comp		37900 AM
WBKV	Folsom		Mtr		31780 AM
WSVN	Ft Washington		RCA		33940 AM
WRJX	Glenolden		Comp		37900 AM
WQHP	Hanover		Link		35900 FM
WQOD	Harrisburg		REL		37900 AM
WBWA	Huntingdon Valley		RCA		33940 AM
			Link		33940 FM
WREZ	Ingram		Link		37500 FM
WRMA	Jeannette		RCA		33500 AM
WBKO	Jenkintown		RCA		33940 AM
			Link		33940 FM
WRHW	Kingston		RCA		31100 AM
WQTW	Lancaster		Mtr		37100 FM
WQNB	Lansdowne		RCA		39500 AM
WRLH	Latrobe		RCA		35900 AM
			Link		35900 FM
WBMV	Lebanon		Mtr		33500 AM
WBXR	Lewistown		RCA		33500 AM
WBSN	Lock Haven		Mtr		33500 AM
WQIC	McKeesport		RCA		33100 AM
WRGZ	Meadville		RCA		37100 AM
WBLP	Media		Mtr		31780 AM
WBRX			Mtr		31780 AM
WDBF	Milton		GE		35500 FM
WQFF	Monessen		Link		39500 FM
WIEQ	Monongahela		Link		39500 FM
WRMC	Morrisville		RCA		33100 AM
WPGT	New Castle		Comp		2482 AM
			Link		37780 FM
WLDI	New Kensington		GE		31900 FM
WMCN	Norristown (Co)		RCA		2366 AM
			RCA		30580 AM
		Mtr	RCA	Link	30580 FM
WQMU			RCA		33500 AM
WRHY	Norwood		Comp		37900 AM
WPHZ	Oil City		Comp		2482 AM
WBJI	Parkside		Mtr		31780 AM
WBQW	Philadelphia		RCA		2474 AM
			Mtr		30980 FM
WQNJ	Phoenixville		RCA		30700 AM
WREY	Pittsburgh		Link		39380 FM
WMLK			Link		37500 FM
WPDU			WE		1714 AM
WPIM			Link		39900 FM
			Link		39380 FM
WJPP	Pottsville		Link		35900 FM
WSTQ	Prospect Pk		Comp		37900 AM
WPFE	Reading		RCA		2442 AM
			WE		33220 AM
WABH	Ridley Pk		Comp		37900 AM
WBHE	Rose Valley		Mtr		31780 AM
WQTY	Scranton		RCA	Link	33100 AM
WBXP	Sewickley		WE		31100 AM
WQIA	Sewickley Hgts		WE		33100 AM
WQFU	Sharon		Link		31500 FM
WQOC	Sharon Hill	CECo	RCA	GE	37900 AM
WRMU	Southampton		Link		30580 FM
WFUQ	Spring City		Link		30580 FM
WSRT	Springfield (Co)		CECo		31780 AM
WJZD	State College		Mtr		37900 FM
WPFQ	Swarthmore		Comp		2474 AM
			Comp		31780 AM
WQTN	Uniontown		Link		39100 FM
WANE	Wallingford		Mtr		31780 AM
WENZ	Warren		Link		31100 FM
WKYR	Washington		Link		39500 FM
WHCY	Waynesboro		Mtr		33500 AM
WQNV	West Chester		RCA		33100 AM
WMII	West Mifflin		Link		37500 FM
WTQD	West View		Link		39380 FM
WQFM	Wilkes-Barre		Wstg		2442 AM
WQOH	Williamsport		RCA	Mtr	33100 AM
WSVB	Willow Grove		RCA		33940 AM
			Link		33940 FM
WRLO	Yeadon		Comp		39500 AM
WKVS	York		Mtr		37780 AM
WAKX			RCA		2442 AM
			RCA		37780 AM

RHODE ISLAND

WBRI	Bristol		Comp		1714 AM
WKAA	Central Falls		Mtr		39380 AM
WPKG	Cranston		Comp		2466 AM
			Link		31780 FM
WPEI	E. Providence		Comp		1714 AM
		Harv	Mtr	Game	33220 AM
WMPH	Newport		Comp		1714 AM
			Comp		30580 AM
WPFV	Pawtucket		Wstg		2466 AM
			Wstg		39380 AM
WPGF	Providence		RCA	WE	1714 AM
			RCA		30580 AM
IXVI			Abbt		116150 AM
			Abbt		116550 AM
			Abbt		116950 AM
			Abbt		117350 AM
WJAF	Wakefield		Comp		1714 AM
WPIA	Warren		Comp		1714 AM
WSYV	Warwick		HW		2466 AM
			Mtr		37780 FM
WNHZ	Wickford		Link		37100 FM
WPEM	Woonsocket		Mtr		39900 FM
			Mtr		35100 FM

SOUTH CAROLINA

WRJQ	Anderson		Link		37500 AM
WCPD	Charleston		Wstg		2430 AM
WCMP	Columbia		Wstg		2430 AM
			Link		39380 FM
WMYR	Florence		Link		37500 FM
WQLG	Greenville		RCA	Mtr	33100 AM
WSVQ	Greenwood		Mtr		33500 AM
WJKE	Rock Hill (Co)		Mtr		37780 AM
WPRH	Rock Hill		Wstg		2430 AM
			Mtr		37780 AM
WSSC	Spartanburg		Coll		2430 AM
			Coll	Mtr	33220 AM
WLAH	Sumter		Link		33100 FM

SOUTH DAKOTA

KAWC	Aberdeen		Dool		39100 AM
			Mtr		39100 FM
KRQA	Aberdeen (Co)		Mtr		39100 FM
KVPB	Huron		Coll		2450 AM
KQSP	Mitchell		Mtr		31500 AM
KNGM	Rapid City		Comp		2450 AM
			Mtr		39380 FM
KBTY	Sioux Falls		Mtr	D&F	33100 AM
KQJM	Watertown		Mtr		37900 AM
KQXR	Yankton		Mtr		31500 AM

TENNESSEE

WRCK	Chattanooga		Coll	RCA	33100 AM
WFJN	Chattanooga (Co)		Link		33100 AM
WBSV	Dyersburg		Link	WE	39500 AM
			Link		2422 AM
WPHY	Elizabethton (Co)		Comp		2474 AM
WRSJ	Jackson		Mtr		31500 FM
WPGZ	Johnson City		Comp		2474 AM
			GE		35100 FM
WQTJ	Kingsport		Harv		37100 AM
WPFO	Knoxville		RCA		2474 AM
			Link		30580 FM
WPEC	Memphis		RCA	WE	2466 AM
		Mtr	Link	RCA	30580 AM
WBYH	Nashville		GE		37100 FM
WRHT	Nashville (Co)		Comp		2422 AM
			Link		33780 AM
WBTB	Paris		Mtr		37100 AM
WRLX	Union City		RCA		37900 AM

TEXAS

KADR	Abilene		Mtr		2458 AM
			Mtr	RCA	30980 AM
KAER			Stne		2458 AM
KQZW	Alamo Heights		Mtr		33220 AM
KQDH	Amarillo		Comp		2466 AM
			Comp		30580 AM
KFTX	Anahuac		Comp		1714 AM
			Kaar	Link	37220 AM
KGHU	Austin		Comp		2442 AM
			Comp		33220 AM
KGPJ	Beaumont		Comp		1714 AM
		RCA	Link	HM	37220 AM
		Mtr	Stne	WE	37220 AM
KETB	Beeville (Co)		Comp		1714 AM
KFEA	Big Spring (Co)		Comp		33220 AM
KACM	Big Spring		Comp		2458 AM
			Kaar		33220 AM
KGCV	Borger		Mtr		2466 AM
			Mtr		30580 AM
KNGW	Brownwood		Comp		2458 AM
			Comp		30580 AM
KGHT	Brownsville		Comp		2382 AM
			Mtr		35100 AM
KPBR	Bryan		Coll		1714 AM
KNGE	Cleburne		Comp		1714 AM
			Mtr		35100 AM
KGHV	Corpus Christi		Coll		2382 AM
			Mtr		33220 AM
KRGA	Corsicana		Comp		1714 AM
			Comp		30980 AM
KVPA	Dallas		WE		1714 AM
			Mtr		33220 AM
KRMB	Dallas (Co)		Mtr		33220 AM
KQAT	Denison		Mtr		31500 AM
KHNF	Denton		Mtr		1714 AM
			Mtr		37100 AM
KPDE	Electra		Comp		2458 AM
			Comp		30580 AM
KGZM	El Paso		Comp		2414 AM
			Comp		33100 AM
KRHV	El Paso (Co)		Comp		33100 AM
KRGC	Floresville (Co)		Comp		33220 AM
KQAN	Fort Worth		Mtr		33100 AM
KRLJ			Comp		33100 AM
KADM	Gainesville		Coll	RCA	1714 AM
			Comp		30580 AM
KGCT	Galveston (Co)		Link		33220 AM
KRPW	Galveston		Comp		1714 AM
			Link	RCA	33220 AM
KHGC	Goose Creek		Comp		1714 AM
			Comp		33220 AM
KQGS	Highland Pk		RCA		37100 AM
KHPR	Houston		RCA		1714 AM
KHTP			Comp		1714 AM
			Link	RCA	33220 AM
		Mtr	Link	RCA	33780 AM
KHQK			Comp		33220 AM
KHCZ	Houston (Co.)		GE		35500 FM
KKPD	Kilgore		Comp		1714 AM
			Comp		33220 AM

HIGH-QUALITY REPRODUCTION

(CONTINUED FROM PAGE 31)

to give overall quality equal to that of the low-impedance triode.

The outcome of this work was the A-323 amplifier which uses beam power 6L6 or 6V6 Tubes in the output stage. This unit is shown in Fig. 8, with the schematic in Fig. 10.

Early work indicated that the output transformer was the limiting factor. Therefore, an output transformer was designed for very low phase shift, high self-impedance, accurate balance between windings, low distributed capacity, and a high coupling factor to reduce leakage.

Intermodulation and harmonic distortion tests reveal that the A-323 amplifier has considerably less distortion with beam power tubes than with triodes of similar power rating. This decreased distortion exists regardless of whether or not feedback is used, thereby indicating that feedback is not necessary to reduce the distortion to a tolerable value. The feedback in the A-323 amplifier is used for the purpose of adjusting the effective output impedance to match that of the loudspeaker.

Intermodulation curves for this amplifier are shown in Fig. 9. Curve A was obtained from an amplifier using 2A3 triode tubes, whereas curve B is for the amplifier using beam power tubes. The same quality of transformer was used for each test. It will be observed that with the beam power tubes there was very low initial intermodulation distortion as compared to that obtained with the triodes. These curves represent the average of six pairs of tubes in each amplifier, so that they may be considered as average conditions with respect to the selection of tubes.

The intermodulation test frequencies were 60 cycles transmitted simultaneously with 1000 cycles, 12 db below the 60-cycle amplitude. The test is therefore representative of the 60-cycle distortion of the amplifier.

This amplifier has a gain of 104 db with an input impedance of 500,000 ohms. A selector switch is provided so that the amplifier can be switched to either the high gain position, Input No. 1, or to low gain, Input No. 2, which removes the first stage. On the low-gain setting, the amplifier has a gain of 74 db. An input transformer is also available which is tapped to work from 30-, 250-, or 500-ohm sources. This transformer has a 90 db shield so that, in the region of strong magnetic fields, shield will eliminate noise pickup.

The first stage has a 6SJ7 tube, pentode connected. The second stage has a 6SJ7 tube, pentode connected, driving a phase inverter of the cathodyne type, using a 6SJ7 tube, triode connected. This inverter is capable of supplying 30 volts of driver

(CONCLUDED ON PAGE 59)

KACU	Longview (Co)	Comp		1714 AM
		Comp		31780 AM
KGZW	Lubbock	Coll		2458 AM
		Mtr		33220 AM
KQDN	Lufkin	Comp		1714 AM
		Mtr		37220 AM
KTWP	McKinney	Comp		1714 AM
		Mtr		37220 AM
KADT	Marshall	Comp		1714 AM
		Comp		33220 AM
KQXW	Mexia	Comp		1714 AM
KRLE	Midland	Comp		2458 AM
		Kaar		33220 AM
KRAN	Nacogdoches	RCA		1714 AM
		RCA		37220 AM
KWSP	Newgulf (Co)	Kaar		30700 AM
KBGC	Odessa	Kaar		2458 AM
		Kaar		35100 AM
KEZU	Orange	Comp		1714 AM
		Kaar	Link	37220 AM
KOTP	Olmos Pk.	Comp		33220 AM
KPAM	Pampa	Mtr		2466 AM
		Mtr	Kaar	30580 AM
KOKM	Paris	Comp		1714 AM
KPPD	Pasadena	Link		33220 AM
KRKQ	Plainview	Comp		2458 AM
KPAT	Port Arthur	RCA		1714 AM
	Mtr	RCA	Link	37220 AM
KASD	San Angelo	RCA		2442 AM
		Comp		33220 AM
KBPT	San Antonio (Co)	Mtr		33220 AM
KGZE	San Antonio	Comp		2482 AM
		RCA	Mtr	33220 AM
KQJB		Comp		33220 AM
KFNL	Sherman (Co)	Mtr		31500 AM
KQIS	Sherman	WE		33500 AM
KAPJ	Sweetwater	RCA		2458 AM
KRKW	Temple	Comp		2442 AM
		Comp		30580 AM
KTWL	Texas City	Comp		1714 AM
		Comp		33220 AM
KQCF	Tyler	Mtr		31900 FM
KOZI	University Pk	GE	Mtr	31500 AM
KHGZ	Vernon	Comp		30580 AM
KBLB	Vernon (Co)	Comp		2458 AM
		Comp		30580 AM
KEPL	Victoria (Co)	Comp		1714 AM
WGZQ	Waco	Comp		1714 AM
		Comp		30580 AM
KQIH	Waxahachie	Mtr		35100 FM
KRKC	Waxahachie (Co)	Mtr		1714 AM
		Mtr		35100 FM
KRIW	Westover Hills	Comp		33100 AM
KWSO	Wharton (Co)	Link		1714 AM
		Link		33220 AM
KGZI	Wichita Falls	Comp		2458 AM
		Comp		30580 AM

UTAH

KBUO	Brigham City	Mtr		37500 FM
KBIJ	Farmington (Co)	Mtr		35780 FM
KHGB	Helper City	Mtr		35900 FM
KHQW	Logan	Mtr		37500 FM
KBGZ	Logan (Co)	Mtr		37500 FM
KSHA	Midvale	GE		35780 FM
KIKN	Murray	GE		35780 FM
KQCH	Ogden	Comp		2406 AM
		Teme	GE	30580 AM
		Mtr		30580 FM
KCBJ	Price (Co)	Mtr		35900 FM
KPGB		Mtr		35900 FM
KPMU	Provo	Mtr		33500 FM
KGPW	Salt Lake City	RCA		2406 AM
		Mtr		30580 AM

VERMONT

WBQG	Brattleboro	Mtr		33500 FM
WRCW	Burlington	RCA		35900 AM
WBMI	Rutland	GE		39100 FM
WIUF	Springfield	Mtr		39100 FM

VIRGINIA

WAVA	Alexandria	Link		31100 FM
WPAV	Arlington (Co)	GE		33500 FM
WBCL	Bedford (Co)	Link		39380 FM
WPHV	Bristol	Comp		2450 AM
		Comp		30580 AM
WROM		Comp		2450 AM
WQSL	Buckingham (Co)	Link		39380 FM
WQTE	Charlottesville	Link		33940 FM
WMSO	Chesterfield	Link		39100 FM
WAVP	Colonial Hgts	Mtr		37900 FM
WRGU	Danville	RCA		33100 AM
WMFC	Fairfax (Co)	GE		35900 FM
WRQG	Fredericksburg	Link		33100 FM
WELH	Hampton	RCA		33100 AM
WTPH	Hampton (Co)	Link		37500 FM
WBNS	Harrisonburg	RCA		33100 AM
		Mtr		37900 FM
WMMG	Harrisonburg (Co)	Mtr		37900 FM
WQOZ	Hopewell	RCA		37100 AM
WLOV	Lorton	RCA		39500 FM
WQFH	Lynchburg	GE		2450 AM
		GE		35100 FM
WHTJ	Martinsville	GE		39100 FM
WRIV	Newport News	WE	RCA	35900 AM
WQNK	Norfolk GE	Stne	Kaar	37100 AM
WBSJ	Orange (Co)	Link		39380 FM
WOFI	Petersburg	Mtr		37900 FM
WPVL	Portsmouth	Mtr		37900 FM
WMVP	Radford (Co)	RCA		2450 AM
		RCA		30580 AM
WEUG	Richmond (Co)	Mtr		31780 AM
WPHF	Richmond	WE		2450 AM
		RCA	Mtr	31780 AM
WSYC		Comp		2450 AM
WQFG	Roanoke	GE		2450 AM
		Comp		30580 AM
WHTG	S. Norfolk	Kaar		37100 AM
WHNJ	Stafford (Co)	Link		35100 FM
WRID	Staunton	Mtr		37100 FM
WRGV	Suffolk	Link		39590 FM
WADB	Virginia Beach	RCA		30700 AM
WIGV	Waynesboro	RCA	Harv	30700 AM
WAOJ	Williamsburg (Co)	Link		33100 FM
WKYT	Williamsburg	Link		33100 FM
WAPT	Winchester (Co)	Mtr		37900 FM
WSKQ	Winchester	Comp		2422 AM
		Mtr		30980 AM
		Mtr		37900 FM

WASHINGTON

KGZV	Aberdeen	Comp		2414 AM
		Mtr		31780 AM
KBSM	Asotin (Co)	Comp		2414 AM
		Spok		30580 AM
KACK	Bellingham	Comp		2414 AM
		Kaar		30580 AM
KASF	Bremerton	Nrad		2414 AM
		Mtr		33500 FM
KREB	Camas	Comp		30980 AM
KGHW	Centralia	Mtr		35500 FM
KQWA	Chehalis (Co)	Nrad		2414 AM
KHBX	Clarkston	Spok		30580 AM
KOKC	Colfax	Mtr		30580 AM
KQDM	Colfax (Co)	RLab		2414 AM
		RLab	Spok	30580 AM
KAEV	Davenport (Co)	Spok		30580 AM
KABI	Ephrata (Co)	Teme		2414 AM
		Spok		30580 AM
KNFP	Everett	RLab		2414 AM
		Mtr		37100 FM
KAPL	Hoquiam	Comp		2414 AM
		Mtr		30580 AM
KQEQ	Kelso	Mtr		35500 FM
KBJA	Kelso (Co)	Comp		2414 AM
		RLab	Mtr	30580 AM
KNFI	Mt Vernon (Co)	Mtr		35500 FM
KRHM	Olympia (Co)	Stne	Mtr	30580 AM
KACE	Olympia	Comp		2414 AM
		Stne		30580 AM
KIBS	Pasco	Mtr		35590 FM
KPAP	Port Angeles	Nrad		2414 AM
		Nrad		30580 AM
KADL	P't Orchard (Co)	Comp		2414 AM
		Mtr		33500 FM
KQEC	P't Townsend (Co)	Nrad		2414 AM
		Kaar		30580 AM
KOVP	Pullman	Spok		30580 AM
KPWP	Puyallup	Mtr		35900 FM
KGLB	Renton	Mtr		35500 FM
KRAU	Ritzville (Co)	Nrad		2414 AM
		Mtr		30580 AM
KAFO	Seattle	Mtr		37900 FM
KGPA		WE		2414 AM
		Comp		37780 FM
KATH		Mtr		37900 FM
		GE	Mtr	37780 FM
KHLD	Shelton	Mtr		35500 FM
KHKE	Shelton (Co)	Mtr		35500 FM
KBTO	Spokane (Co)	Teme		2414 AM
		Mtr	Spok	30580 AM
KRLI		Comp		2414 AM
KGHS	Spokane	Comp		2414 AM
		Mtr		30580 AM
7XHC		Comp		116150 AM
KOBA	Tacoma (Co)	Mtr		35900 FM
KGZN	Tacoma	Comp		2414 AM
		Mtr		35900 FM
		Mtr		30580 AM
KRDL	Vancouver (Co)	Mtr	Kaar	30980 AM
KRDM	Vancouver	Mtr	Kaar	30980 AM
KACV	Walla Walla	Coll		2414 AM
		Coll		30580 AM
		Mtr		35500 FM
KWWN	Walla Walla (Co)	Mtr		33500 FM
KHGW	Wenatchee	Mtr		35500 FM
KACJ	Wenatchee (Co)	Comp		2414 AM
KNGU	Yakima	WE		2414 AM
		Mtr		30580 AM

WEST VIRGINIA

WKHK	Beckley	GE		35500 FM
WBWV	Bluefield	Comp		2490 AM
		GE		33100 FM
WPHI	Charleston	Mtr		37900 FM
WPFP	Clarksburg	Comp		2490 AM
		Mtr		30580 AM
WPHJ	Fairmont	Coll		2490 AM
		Mtr		35100 AM
WSLE	Follansbee	Comp		33100 AM
8XZK	Grant (Co)	ArAs		116150 AM
WRHF	Hollidays Cove	Link		37100 AM
WQOW	Huntington	Link		33100 FM
WAEF	Keyser	Comp		2490 AM
WCHD	Martinsburg	Comp		2490 AM
WJWZ	Morgantown	GE		35900 FM
WPHQ	Parkersburg	Wstg		2490 AM
		Stne		31780 AM
WSTH	Princeton	Mtr		31500 AM
WEIR	Weirton (Co)	Link	RCA	33100 AM
WRIN	Wellsburg	Comp		33100 AM
WRGH	Wellsburg (Co)	Mtr	RCA	33100 AM
WQTU	Wheeling	WE		33100 AM

WISCONSIN

WOWS	Antigo	Mtr		37900 FM
WBIO	Appleton (Co)	Mtr		30580 AM
WJZH	Arpin (Co)	Mtr		31900 AM
WJCP	Baraboo (Co)	Mtr		31500 AM
WKLG	Baraboo	Mtr		31500 AM
WSTG	Beaver Dam	Mtr		31500 AM
WRNI	Beloit	Coll	Mtr	31500 AM
WBVE	Blooming Grove	Comp		39580 AM
WGUN	Chenequa	Mtr		33500 AM
WKLF	Chilton (Co)	Mtr		33500 AM
WHNP	Depere	Mtr		33220 AM
WBHT	Eau Claire	RCA		33500 AM
WBHU	Eau Claire (Co)	RCA		33500 AM
WFNO	Elderton	WE		31500 AM
WMPE	Elkhorn (Co)	RCA		2382 AM
		RCA	Mtr	30580 AM
WSUB	Evansville	Mtr		31500 AM
WFDW	Fond Du Lac (Co)	Mtr		2382 AM
		Mtr		30980 AM
WRLP	Ft Atkinson	Comp		31500 AM
WHNO	Green Bay (Co)	Mtr		33220 AM
KNHB	Green Bay	WE		2382 AM
		Comp		33220 AM
WRNQ	Janesville	RCA		31500 AM
WRIT	Janesville (Co)	RCA		31500 AM
WRAJ	Jefferson (Co)	Coll		31500 AM
WONO	Juneau (Co)	Coll		31500 AM
WPEP	Kenosha	WE		2450 AM
		Mtr		31500 AM
WOTH	La Crosse	Bndx	RCA	37100 AM
WCCP	La Crosse (Co)	Mtr		31500 AM
WSTF		Mtr		31500 AM
WORJ	Lake Geneva	Mtr		30580 AM
WTNR	Madison (Co)	RCA		30580 AM
WASD	Madison (City)	Coll		2382 AM
		Comp		30580 AM
WSVY	Madison (Town)	Comp		30580 AM
WBSY	Manitowoc (Co)	Mtr		33500 AM
WRNF	Maple Bluff	Comp		30580 AM
WMLF	Marinette	Mtr		37100 AM
WPDK	Milwaukee	WE		2450 AM
		Mtr		35100 FM
		Mtr		35220 FM
		Mtr		37220 FM
		Mtr		33780 FM
WSWH	Monona	Comp		39580 AM
WRJM	Monroe	RCA		30580 AM
WRJK	Monroe (Co)	Comp		2382 AM
		RCA		30580 AM
WMVS	Montello (Co)	Mtr		37900 FM
WFUD	Neenah	Mtr		33500 AM
WJWR	Neillsville (Co)	Mtr		37900 FM
WCJR	Oshkosh	Mtr		30580 AM
WAKE	Oshkosh (Co)	WE		2382 AM
		Mtr		30580 AM
WKOL	Plymouth	Mtr		33500 AM
WSOR	Portage (Co)	RCA		31500 AM
WHIX		Comp		31500 AM
WRJL	Pt Washington	Mtr	RCA	33500 AM
WQLJ	Racine	RCA	Mtr	31500 AM
WRNP	Racine (Co)	Comp		31500 AM
WBMY	Richland Ctr (Co)	Mtr		31500 AM
WQMW	Sheboygan	RCA		33500 AM
WBOA	Sheboygan (Co)	Mtr		33500 AM
WMRQ	Sparta (Co)	Mtr		37900 FM
WRNG	Stevens Pt	RCA	Mtr	31500 AM
WKZQ	Sturgeon Bay (Co)	Mtr		33500 AM
WSWE	Superior	WE		30580 AM
WDCJ	Two Rivers	Dool		33500 AM
WBWL	Viroqua (Co)	Mtr		31500 AM
WRHX	Watertown	Coll		31500 AM
WQML	Waukesha	WE	Mtr	30580 AM
WMPD	Waukesha (Co)	WE		2450 AM
		WE	Mtr	30580 AM
WBDX	Wausau (Co)	Mtr		31900 AM
WRPQ	West Bend (Co)	Coll		33500 AM

WYOMING

KEYD	Casper	Mtr		33220 AM
KQOI	Cheyenne	Mtr		2382 AM
		Mtr		33220 AM
KQRZ	Cheyenne (Co)	Mtr		33220 AM
KRTQ	Laramie	Mtr		33220 AM
KEYB	Rawlins	Mtr		33220 AM
KEYI	Rock Springs	Mtr		33220 AM
KEYJ	Sheridan	Mtr		33220 AM

HIGH-QUALITY REPRODUCTION

(CONTINUED FROM PAGE 57)

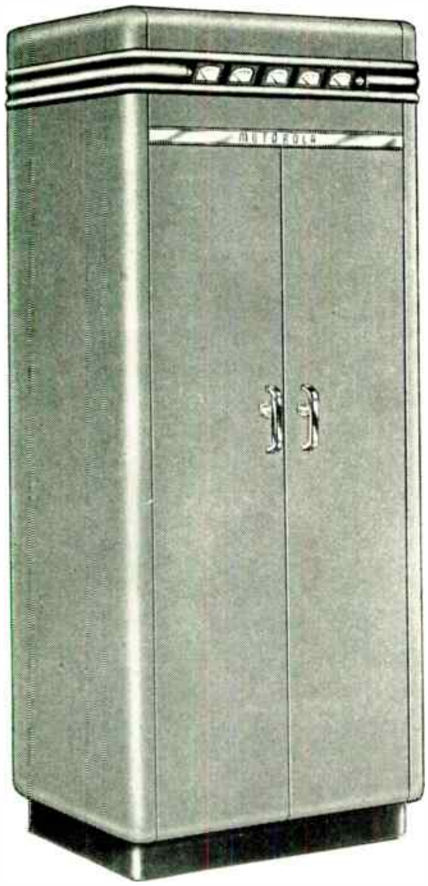
power to the last stage. Excellent balance over a long period of time is obtained with this type inverter. The output hum level is 30 db below the 0.001-watt reference in the high gain position, and 38 db in the low-gain position.

It is customary for manufacturers to rate the frequency range of their amplifiers without regard to maximum power capacity. This practice implies that an amplifier will have its rated frequency range up to its rated power. In virtually all cases, it will be found that the rated frequency range can only be obtained at some power output 6 to 10 db below the maximum power specified.

The frequency characteristics of the A-323 amplifier under two separate conditions are shown on Fig. 11. It will be noted that the lower curve is approximately 60 db below the upper curve. Since these curves are identical, it is obvious that the amplifier, and particularly the output transformer, are capable of operating over a 60-db range with no change in frequency characteristics. Usually, output transformers will have considerably less bass response at low levels because of the decreased inductance for low current values.

If this amplifier is compared directly with another amplifier not meeting the foregoing specifications, it will be observed that, when driving a high quality speaker, the A-323 amplifier, with flat response, will have more actual bass energy at high levels than the comparison amplifier, even though the latter has been provided with considerable bass boost. The reason for this difference is due to the fact that the usual 15-watt amplifier will not develop more than two or three watts at the lower frequencies. As a result, no amount of boost can conceivably yield more bass power. The A-323 amplifier will deliver 15 watts at 400 cycles, and in the range from 40 to 10,000 cycles the output power will vary less than 1 db from the 400-cycle value. The output power will be flat within 1 db from 20 to 20,000 cycles over a 60-db volume range, subject to the power capacity stated above. The frequency range will be flat within 1 db from 20 to 20,000 cycles at 3 db below the rated power.

For best results, it is recommended that the duplex speaker be used with the A-323 amplifier or its equivalent. This amplifier has been designed expressly for operation with this loudspeaker along with its associated networks. The use of a conventional amplifier may result in poor overall quality since amplifier distortion is readily reproduced by the loudspeaker. Experience has shown that users have thought there was something wrong with the duplex speaker only to find out later that the cause was due to distortion in the amplifier, radio set or phonograph pickup.



In its multiplicity of wiring problems the many new and precious features of Surco Spiralon Keyed Insulation, with the widest range of identification in all sizes and lengths, is proving invaluable to Farnsworth Television & Radio Corp. of Fort Wayne, Ind. The ease with which this new insulated wire can be used in small compact areas or in large or intricate installations found instantaneous favor with this famous concern which is taking full advantage of Spiralon's diverse uses.

Spiralon is non-inflammable, non-fogging, non-corrosive, yet flexible and tough; and highly resistant to oils, dilute acids and alkalies to prove ideal for wiring under any and all conditions. Identification stripes are easily seen even on diameters as small as .025. The absence of all pigment fully preserves every electrical property, increases insulating resistance and allows for greater voltage.

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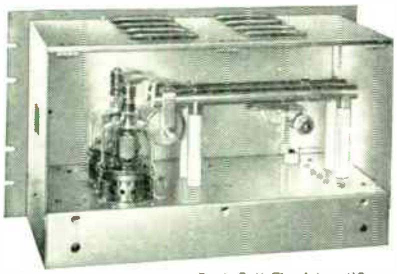

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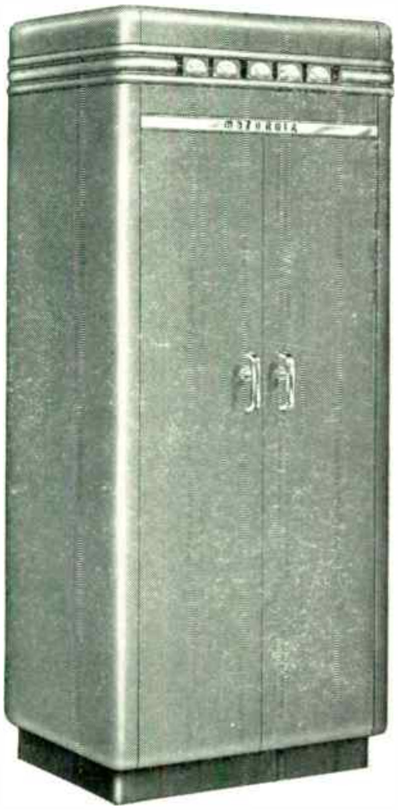

Motorola RADAR RESEARCH

Makes This Advance Possible!

When the F. C. C. established the 152-162 mc. band for emergency communications, Motorola engineers were more than ready to design a new line of equipment for these frequencies. Motorola superiority had been established to the point where, during the past five years, *80% of all Police equipment installed was MOTOROLA.* The experience of Motorola engineers had been augmented by five years of manufacturing equipment for the armed forces. Most important of all was the experience gained through the design and manufacture of RADAR equipment.

Motorola's extensive RADAR development and productive activity is reflected in the new line of 152-162 mc. equipment. The use of cavities, lines and microwave techniques provide exceptional performance and trouble-free service in the new bands.

The new 152-162 mc. equipment has been field-tested and proved before being released. Recently, field tests were conducted at the Motorola factory before a group of APCO members. The tests included comparison of 250-watts 162 mc. and 30-40 mc. equipment using a 150-ft. tower for antenna support. The Central Station power was reduced to 15 watts. Two cars using 15-watt transmitters were cruised over a radius of 20 miles including areas like the loop, lower level of Wacker Drive and Lake Shore Drive with tall buildings between the cars and Central Station, in addition to the normal territory encountered in a large city. Solid 2-way coverage with marvelous fidelity and very high signal-to-noise ratio was reported. Comparison with 30-40 mc. over the same area showed marked superiority of 162 mc.

Motorola proudly announces its 152-162 mc. equipment with the Model FSTRU-250-BR 250-watt Central Station Transmitter-Receiver unit.

Check These Advantages of the Motorola FSTRU-250-BR:

1—Maximum Stability.
2—Power Output Rating for Continuous Operation.
3—Radar-type Cavity Tuning and Control Circuits.
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5—Adequate Safety Factor.
6—Simple in Design and Adjustment.
7—Forced Draft Ventilation from Internal Blower.

Additional features of the Motorola 152-162 mc. Mobile Equipment:

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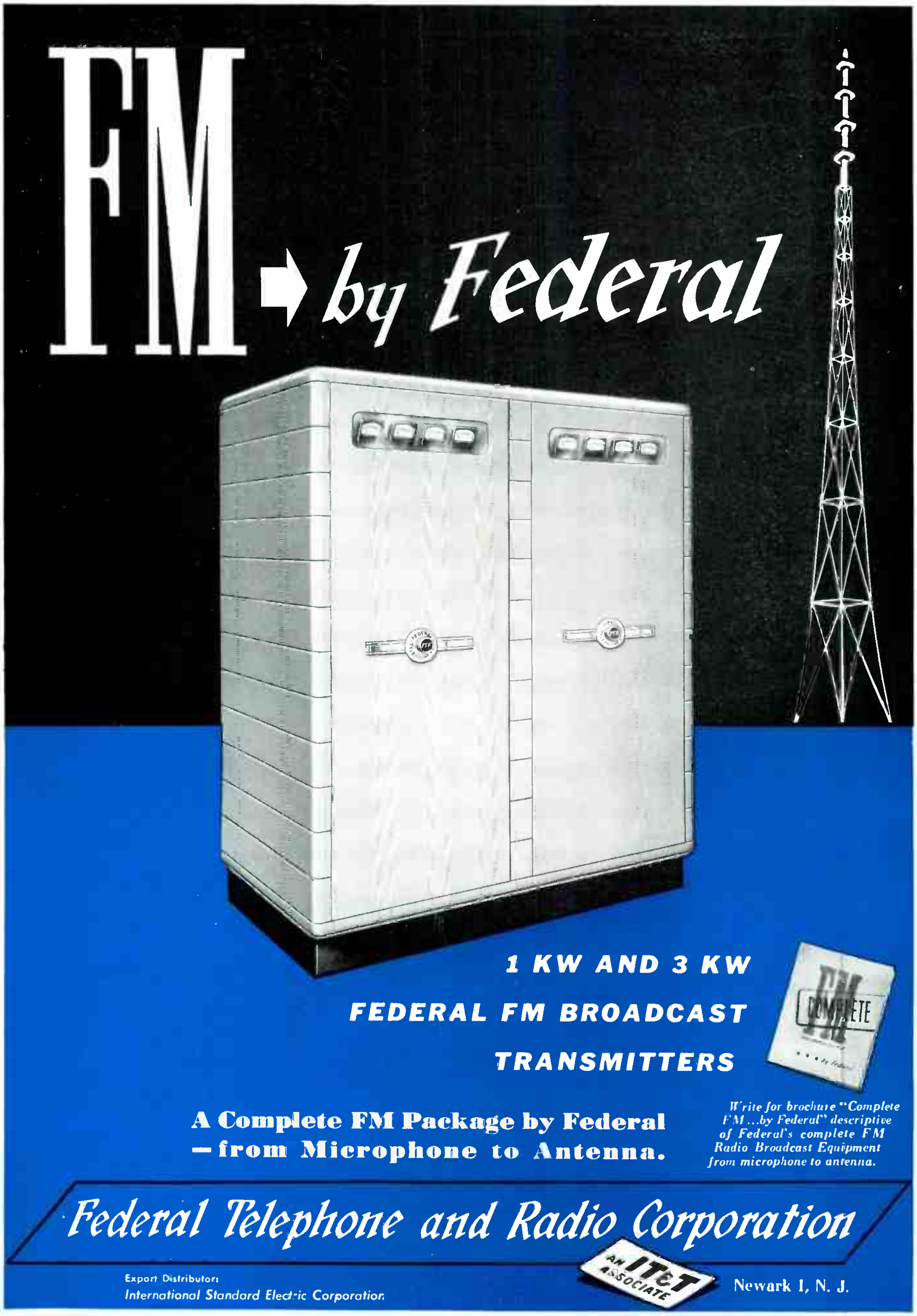
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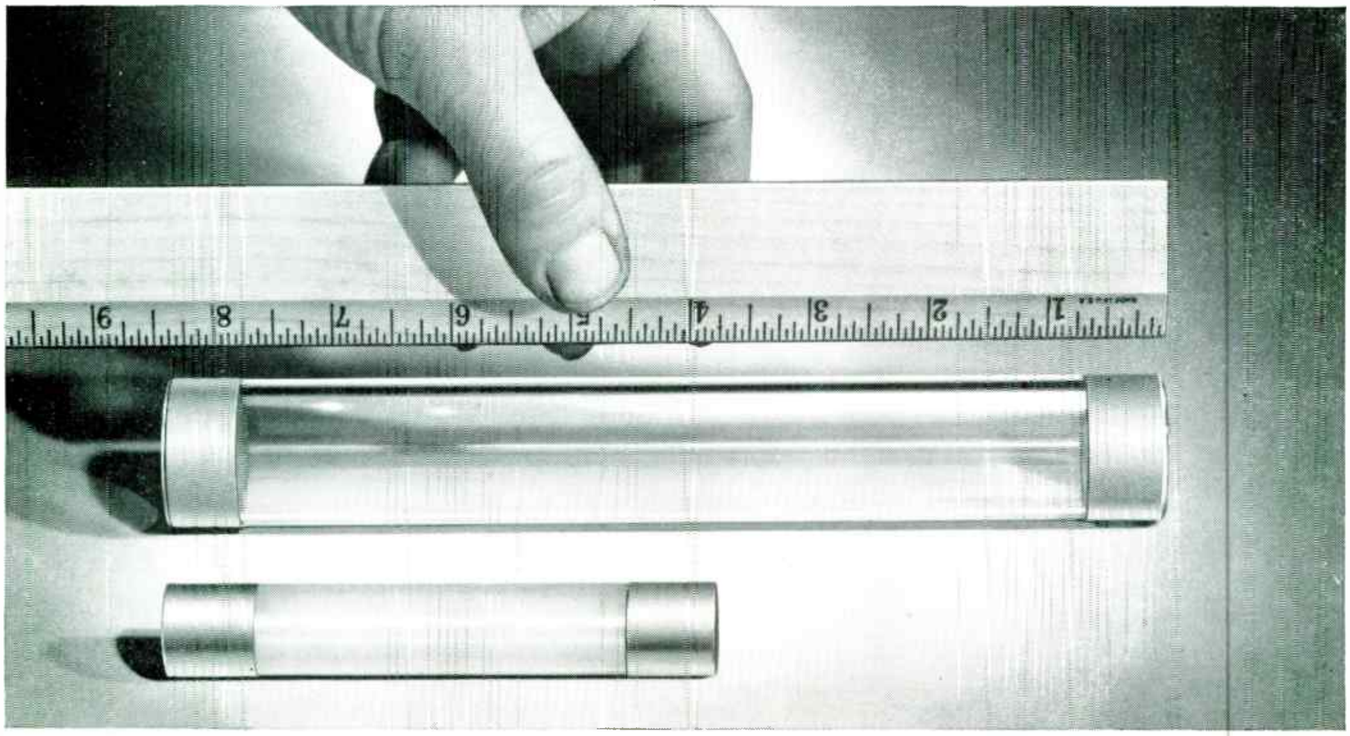

THESE GLASS TUBES HAVE A RULE AGAINST LETTING THE OUTSIDE IN!

THE point is—they're metallized at each end with the famous Corning process that makes a permanent bond between the glass and metal. This means these tubes for resistors, capacitors, etc. can be soldered into place to form a permanent hermetic seal. No dust, moisture, or corrosive atmosphere can get in.

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If metallized glass can improve your product through hermetic seals or faster assembly, Corning can help you. Look at the Corning Electronic Products below. If something like these are what you have been looking for, write, wire or phone The Electronic Sales Department, F -1, Technical Products Division, Corning Glass Works, Corning, New York. We'll have an engineer at your doorstep in nothing flat ready to help you work out your problem.

NOTE—*The metallized Tubes and Bushings, Headers and Coil Forms below are all made by the famous Corning Metallizing Process. Can be soldered into place to form true and permanent hermetic seals. Impervious to dust, moisture and corrosion.*

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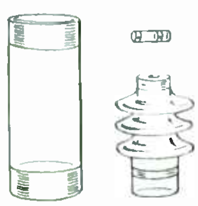
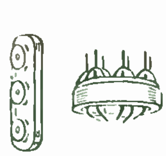


Metallized Bushings. *Tubes in 10 standard sizes, 5/16" x 25/32" to 1" x 4 7/32" in mass production for immediate shipment.*



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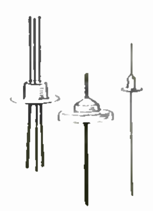

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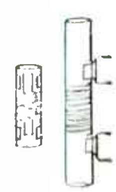

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Note the many superior Amphenol features of these antennas . . . high strength, lightweight seamless tubular aluminum elements—durable molded bakelite insulator — rugged steel mast and cadmium plated fittings. These factors, coupled with *Amphenol engineering* and precision workmanship, result in long life, durability and top performance.

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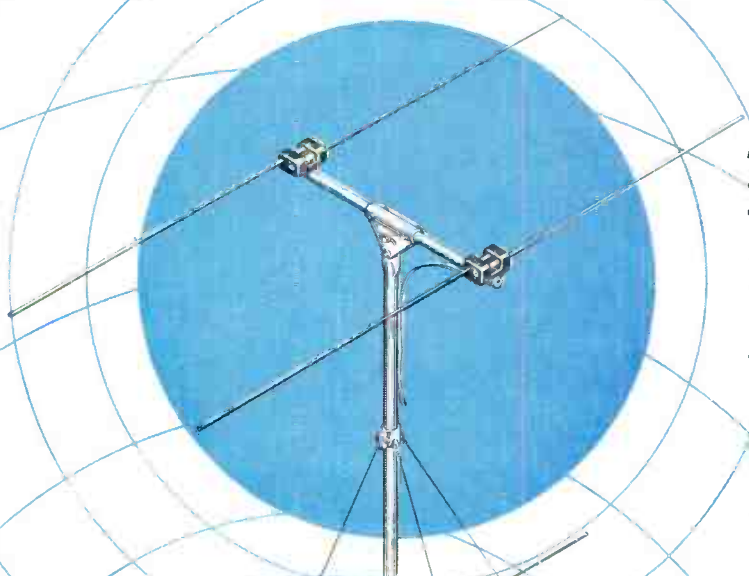

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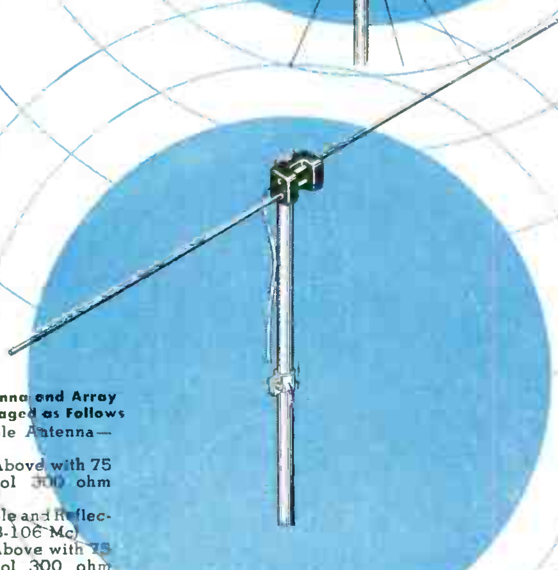

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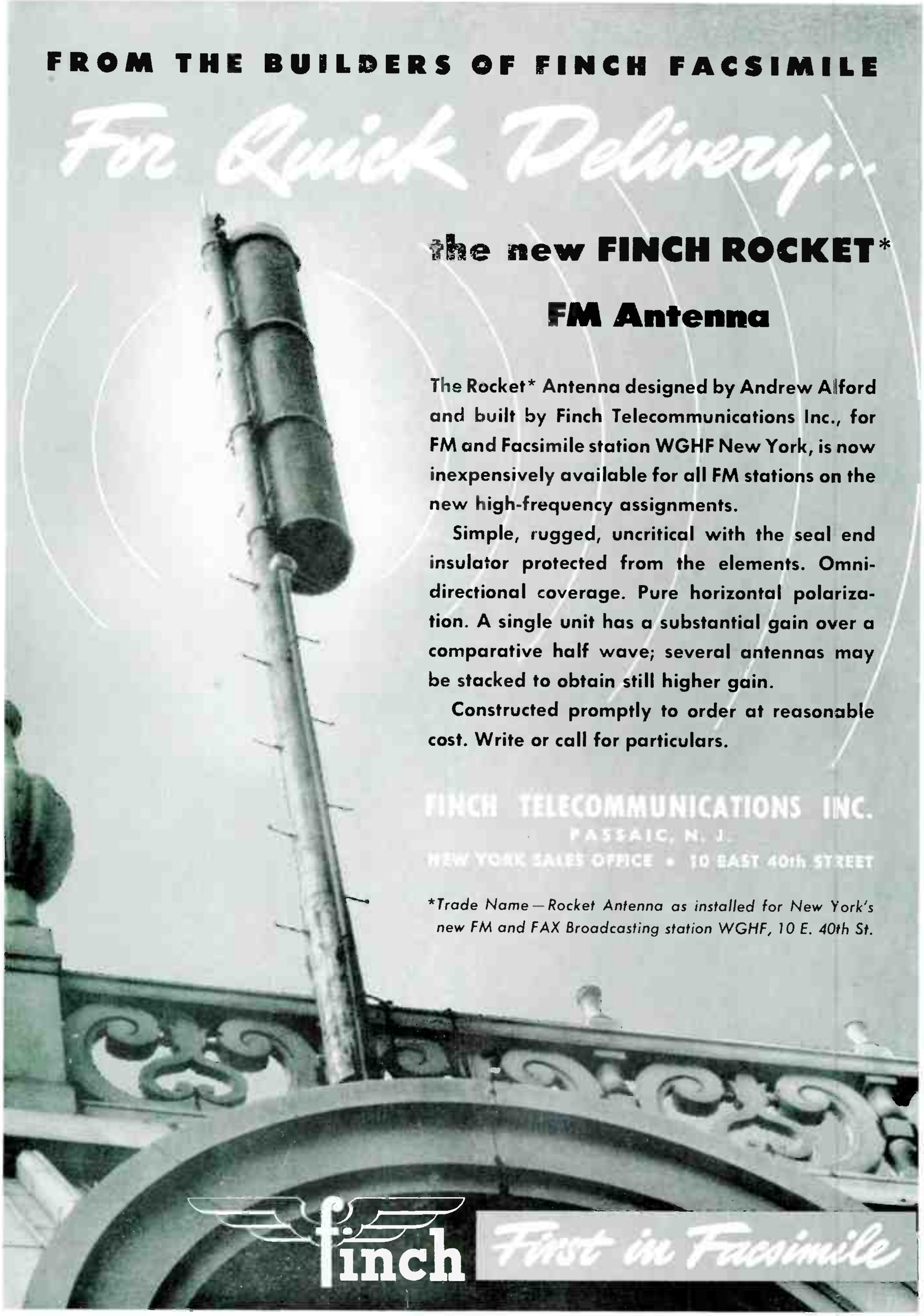
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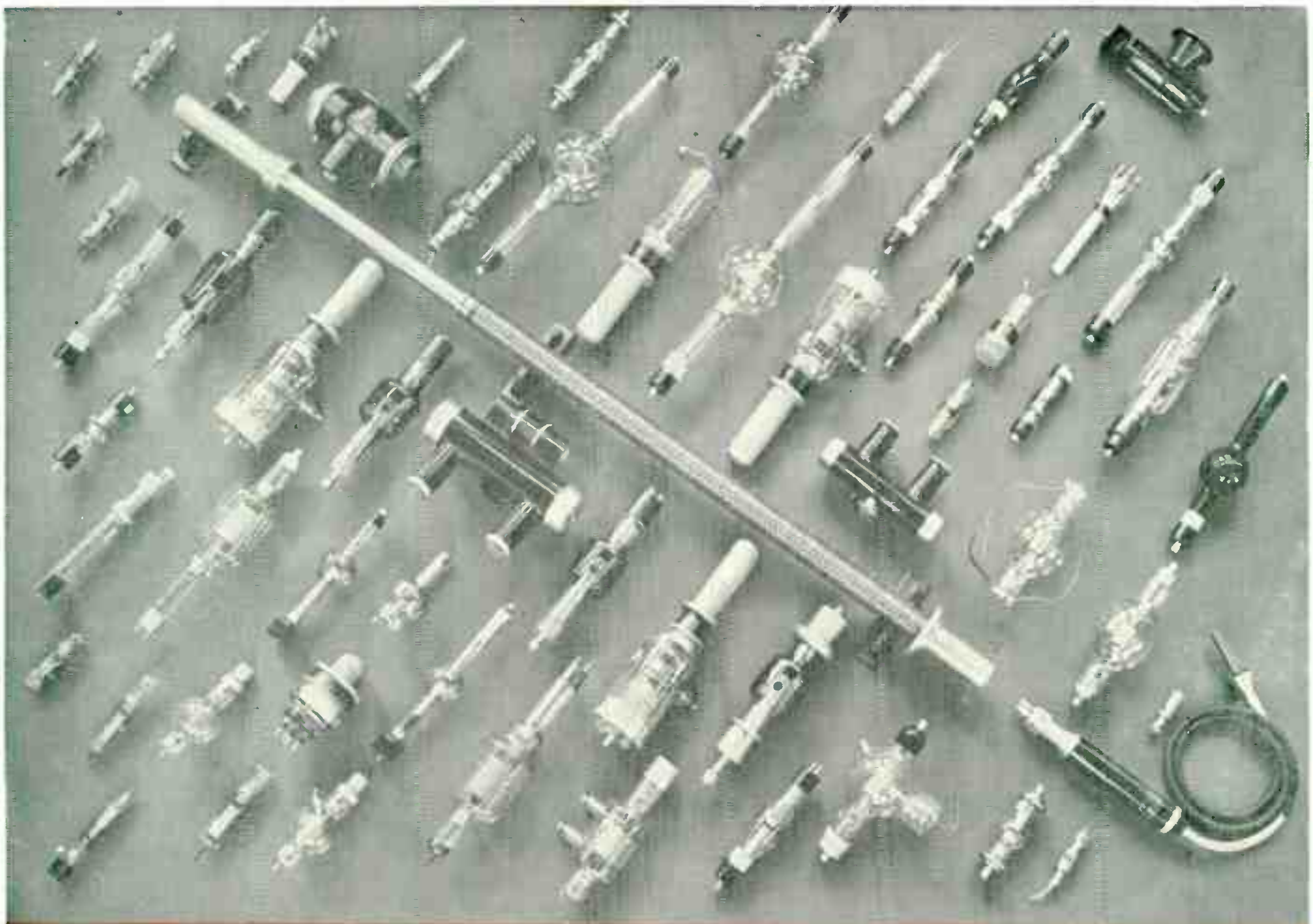

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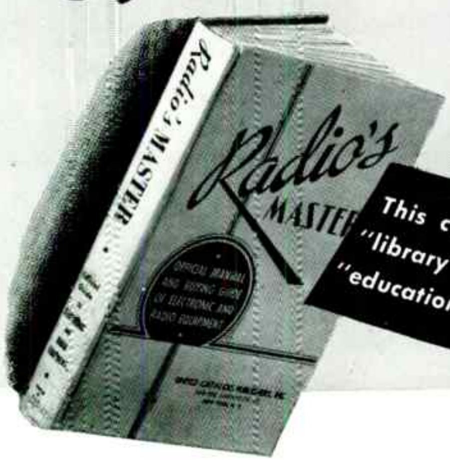

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WHAT'S NEW THIS MONTH

(CONTINUED FROM PAGE 4)

any part of it, is made available for FM broadcasting in addition to the band 88 to 108 megacycles.

Licensees of FM or television stations, manufacturers of FM equipment, and other interested persons may participate in said hearing. Persons desiring to participate should file an appearance with the Commission no later than January 14, 1946, stating the name or names of the witnesses who will appear, the subject matter concerning which they will testify, and the length of time they will need for their testimony.

(*Signed*) T. J. SLOWIE
Secretary

Commenting on the FCC's action, Comdr. McDonald said: "The order is based on newly developed, factual data which were not before the Commission in its FM hearings of the past year. Nor were these data before the Commission in June, 1945, when it issued the decision placing FM in the 100-mc. band.

"As there had been little broadcasting experience in the 100-mc. band, the FCC, in May, 1945, requested Zenith Radio Corporation to coöperate with the Commission by making extensive comparative tests of the 50- and 100-mc. bands in the midwest, for comparison with similar eastern tests being conducted simultaneously by the Commission between New York and Andalusia, Pa. This we did at an elaborate testing and calibrating station which we set up at Deerfield, Ill. We made our test in conjunction with *The Milwaukee Journal's* transmitting station, on both the 50- and 100-mc. bands.

"The full and complete findings of these actual tests were not reported to the Federal Communications Commission until Friday, December 28, 1945.

"The findings indicate that FM transmitters operating in the 100-mc. band, while rendering good service to a limited area, will satisfactorily cover only 40% of the area which could be covered by a similar transmitter of identical power in the 50-mc. band. This means that the majority of the rural population of the United States would be deprived of static-free FM service if FM were confined exclusively to 100 mc.

"Favorable action on our petition will not only give FM service to rural areas, but will also preserve the large investment the public already has in receivers that function only in the 50-mc. band. It will also provide forty additional channels which can accommodate from 500 to 1,000 additional FM stations. The Commission already has more applications for FM stations than it has frequencies in the upper band.

"In congested area No. 1, extending from northern Massachusetts to Wash-

(CONTINUED ON PAGE 71)

WHAT'S NEW THIS MONTH

(CONTINUED FROM PAGE 70)

ington, D.C., there exist conflicting problems which do not prevail in the balance of the United States. Community television stations, having a radius of eight miles, may desire to operate in this geographical area although, so far as we know, there are at present no applications on file for such permits. Therefore, some exceptions in the No. 1 area, by which community television could be accommodated, may be necessary."

In our April, 1945 issue, we said of Chairman Porter: "FCC Chairman Paul A. Porter will be remembered as the man under whose administration the Commission arrived at the right — or wrong — answer on FM frequencies. The wisdom or error in the final decision will eventually be known to all, and there will be no way to cover up a mistake, if one is made now. We shall have to live with that decision, for better or worse, a long, long time. And because Chairman Porter knows this, it is certain that he will search the records diligently to find the truth."

When, on June 27, 1945, the final allocations for 42 to 108 mc. were announced, the Commission made three mistakes. These were: 1) limiting the service range of FM broadcasting to listeners in population centers, 2) limiting FM to single-market coverage, thereby putting FM at a competitive disadvantage with respect to AM stations selling multi-market coverage, and 3) limiting the number of stations within range of radio listeners to the extent that, in a great part of the United States, they will have service from fewer stations than there are networks, thus precluding the organization of new nets for the purpose of providing high-fidelity programs.

What the Commissioners failed to realize at that time was that scientific progress cannot serve public interest, convenience, and necessity with full effectiveness if it is beset by arbitrary and artificial limitations.

Chairman Porter is to be congratulated on his open-minded attitude in reconsidering the matter of lower-band FM. He took up the extremely difficult and delicate problem of FM allocations as unfinished business initiated by his predecessor, James Lawrence Fly. Few Government officials have been confronted with situations in which scientific testimony could be so effectively biased in the service of established interests. To make matters still more difficult, it was necessary for the FCC to reach a decision at a time when those who strove honestly to present the facts could not demonstrate their contentions, nor could the opposition be challenged to prove its statements.

Furthermore, as one of the engineering consultants remarked recently, "The FM group did not have a spellbinder like Paul

(CONCLUDED ON PAGE 72)

WHAT'S NEW THIS MONTH

(CONTINUED FROM PAGE 71)

Kesten. Engineers just don't know how to think and talk that way."

We cannot hazard a guess at this time as to the final outcome, but it seems certain that the right answer will be found without any extensive delay. At least we do believe that the network stations which seized upon the AFM edict as an excuse to close down their low-band FM transmitters are going into a wild scramble to get back on the air in order to keep their old frequencies.

2. In this issue, we have presented an analysis of the FCC's tentative allocation pattern for FM broadcasting which is being used as a basis for allocating Metropolitan and Rural channels.

The first part is the FCC list of frequencies for each city. In addition, we have broken down that list, in the second part, to show what cities are to share each channel.

The FCC's plan was worked out on the assumption of effective radiated power of 20 kw. and an antenna height of 500 ft. above average terrain. Separation of co-channel stations varies from that required by ground-wave interference, principally in eastern U.S., to separation required for freedom from tropospheric interference 1% of the time or less, principally in western areas.

We have not yet obtained any comment from outside propagation experts on this plan, but there will be such information in our report of the January 18th hearing, next month. The announcement carried the statement that: "The Commission wishes to emphasize that this allocation pattern is tentative only, that the channels listed for particular cities (and their areas) will not be followed in a hard and fast manner, and that departures will be made from the plan wherever it is found desirable or necessary to do so."

Milton B. Sleeper

(CONTINUED FROM PAGE 45)

telephone service on inter-city routes are extensions of plans announced previously for urban mobile service. Substantial progress has been made already in the program for establishing radiotelephone stations in several cities to provide communications to vehicles, including trucks, cars, and boats. To date, FCC approval has been obtained for experimental installations at Boston, Baltimore, Washington, New York, Newark, Philadelphia, Pittsburgh, Detroit, Atlanta, New Orleans, Cleveland, Cincinnati, Miami, Memphis, Chicago, Milwaukee, Green Bay, Indianapolis, St. Louis and Houston. Equipment is being manufactured, and it is expected that service will begin at some of the cities within a few months. Applications have been filed or are under preparation for stations in thirty-two other cities.

A GI'S REPORT ON FM

(CONTINUED FROM PAGE 21)

There were occasions when conditions called for top speed, and pin-point accuracy on the part of the guns had to be matched by perfect clarity on the part of the radios, for the speed of radio communication could be vitiated by garbled messages. A well-timed manoeuvre could be upset by delayed information, and a nicely-planned attack could collapse into a rout. I remember a day when our battalion flirted with disaster and was saved by the perfect functioning of our FM equipment.

One of the tricks used by the Army was to convert an ordinary Infantry battalion into a task force. A task force was a basic combat team, such as a battalion, to which artillery, tanks, and tank destroyers were temporarily attached. On this day we had planned an extremely delicate operation by which the battalion was to become a task force in the middle of a fight. An infantry company was to jump off into the attack and then, at the crucial moment, a platoon of tanks was to swing into action, trapping and crushing the enemy between the two forces.

There was one weak spot in the plan. The tanks were to enter our sector from an entirely different area of command, another division in fact, and only when they crossed an imaginary line were they to turn on their radios. Tanks do not ordinarily carry SCR-300's, so the sets were tied to their turrets, and operated from handsets on long extension cords in the interiors of the tanks.

Either the company started too soon or the tanks were delayed en route. Anyway, the attack didn't mesh. The Germans were stirred up by the Infantry and were getting set to give the GIs a bigger fight than they were prepared to handle. Whereupon the tanks rolled up to the imaginary line and, seeing the Germans, opened fire. Now a shell from a 76 mm. gun hits very hard on a target. In fact, it will go through a target. The tanks were shooting into the Germans all right; but they were also shooting through them, and the shells were landing in the middle of our Infantry company.

Result: the Infantry was pinned down by the fire from the tanks and could not do anything about it, while the tanks had knocked out their own Infantry support, and without Infantry support they are pretty helpless. To make matters worse, the company could not tell who was throwing the heavy stuff and called for information and help, plenty of both, and in a hurry. In turn, the tanks could not see the company and, hearing the frantic calls for help over the radios, got a little nervous themselves, because tankers do not like heavy stuff either.

The battalion CO, on a hill overlooking the whole scene, watched his beautiful

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A GI'S REPORT ON FM

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plan being wrecked by bad timing, misunderstanding, and overly-effective fire. Disregarding code words and in the plainest Army language, unfit for this publication, he straightened out the tanks and got the Infantry on its feet. In the confusion, more Germans escaped than should have. However, we carried the day, although it was not a famous victory.

In retrospect, that battle has its comic aspects, although it was not funny at the time. It might have been a tragedy but for the SCR-300's on the tanks. Strapped on in an all-too-haywire fashion, they were rattled around as no laboratory shake-table ever shook a radio set. But they worked!

The way our task force could manoeuvre under "radio control" was a thing of beauty to behold. There was a day when there were nineteen SCR-300's in our net, as compared with the usual five or six. They were carried on operators' backs, mounted on jeeps, tanks, and tank destroyers, and every set worked so perfectly that the attack was good enough to warrant the high praise of being called a *school solution*. A school solution means that everything went exactly according to plan, as if the affair were a sham battle carefully rehearsed for the movies.

In connection with what I have said about the clarity of FM reception, both as to speech quality and freedom from interference, I want to emphasize this point: Potential combat radiomen were selected from those who showed a natural aptitude for handling code on CW. The men so gifted were given two hundred to four hundred hours of code practice and then sent forth to battle. But under battle conditions all transmissions were by voice. Therefore the air was filled with a great variety of accents and inflections which created some startling effects.

For a while, our regimental net was identified by the names of trees, as Birch, Maple, and Pine. It always got a laugh when one voice called: "Boich to Boich One, ovah!" When Boich was talking to an operator distinguished for his pure Georgia drawl, if reception had been garbled with AM static and inter-station interference, the result would have been chaos. Almost all of our messages were of immediate importance, concerning the location of our own troops, disposition of the enemy, the kind and location of weapons he was using, requests for food and ammunition or medical aid, and orders giving times and routes of advance. If reception hadn't been clear, mistakes would have been made, and time lost. Time is the scarcest commodity in battle. It is the one thing which is not expendable. FM saved lives and won battles because it speeded our communications, and enabled us to move more quickly than the

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A GI'S REPORT ON FM

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Germans, who had to depend on AM.

This is a long letter, but I want you to understand that I know about FM from experience, and not from reading it off a slip-stick.

Now, back home at my AM broadcast receiver, and with time to catch up on my reading, it makes me plenty sore to find that the FCC has been listening to engineers who claim to be experts on FM broadcasting because they've studied sunspots or charts of reception in Hawaii.

If the Commissioners had been with me, they'd know how well thousands of FM stations can work on 42 to 50 mc., for all our FM sets operated between 40 and 48 mc. I don't mean to discredit the radio engineers. After all, they gave us our radio equipment, and they can well be proud of their work. But to get home and find the whole FM broadcast setup in a mess because some fancy-pants experts said it couldn't do a good job below 80 mc. — Well, Mister, it slays me.

And here's the payoff: The best NBC reception on my set is from WBAL, Baltimore, but WEAF, New York, garbles the signals most of the time, and sometimes over-rides WBAL. Well, when I was visiting a friend in New York City recently, he tuned in WEAF. The reception wasn't clear, though, and my friend said, "No, that station isn't very good. I get interferences from WBAL, in Baltimore!"

Maybe now that they have made some changes in the engineering department at the FCC, the Commissioners will settle for making FM only 99% pure. As far as I'm concerned, they can keep the 44 100% if they'll only get some FM sets on the market, and more transmitters on the air.

AM FOR CLEAR CHANNELS ONLY

Keep an eye on forthcoming proposals to limit AM broadcast stations to clear channel operation. Such a plan is due to appear before long, and it will explain some of the moves already made by the networks and AFM. This thinking was explained in *FM* AND TELEVISION for August, 1945. Operators of 50-kw. AM stations hope that the single market coverage plan for FM will be continued, so that they can sell multi-market AM coverage. AM will be at a disadvantage in audio quality if FM stations can get high-fidelity network programs. Hence the nets are anticipating this by going on record with the FCC as to public preference for low-fidelity reproduction. On the other hand, FM gives program material and commercials an effectiveness through the impact of realism that AM cannot deliver. Sooner or later, advertising agencies will investigate the relative merits of high-fidelity FM vs low-fidelity AM, and the outcome will be quite a jolt for the standard-bearers of inferior quality.

Which one is yours?

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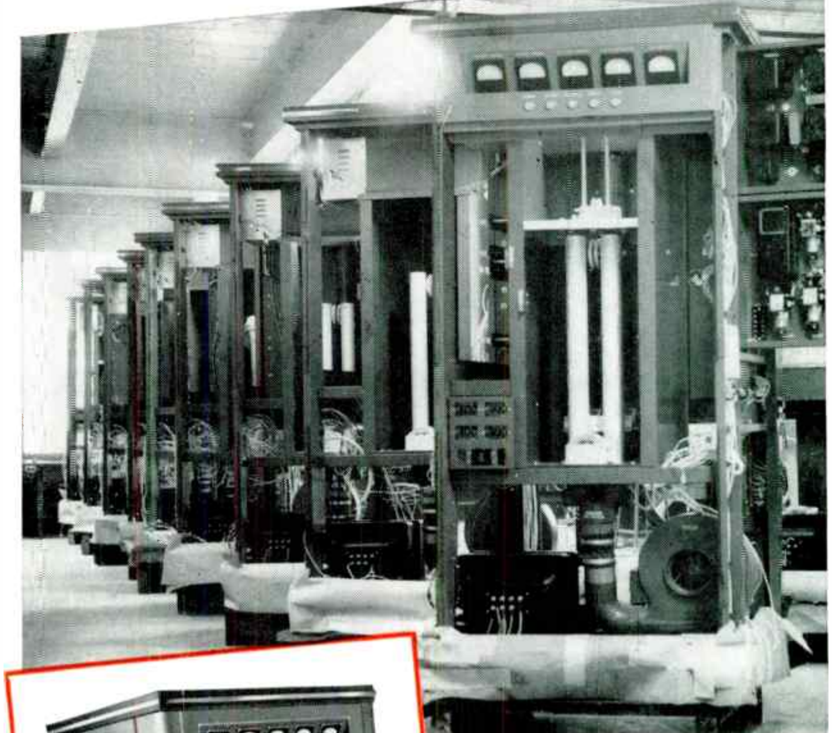

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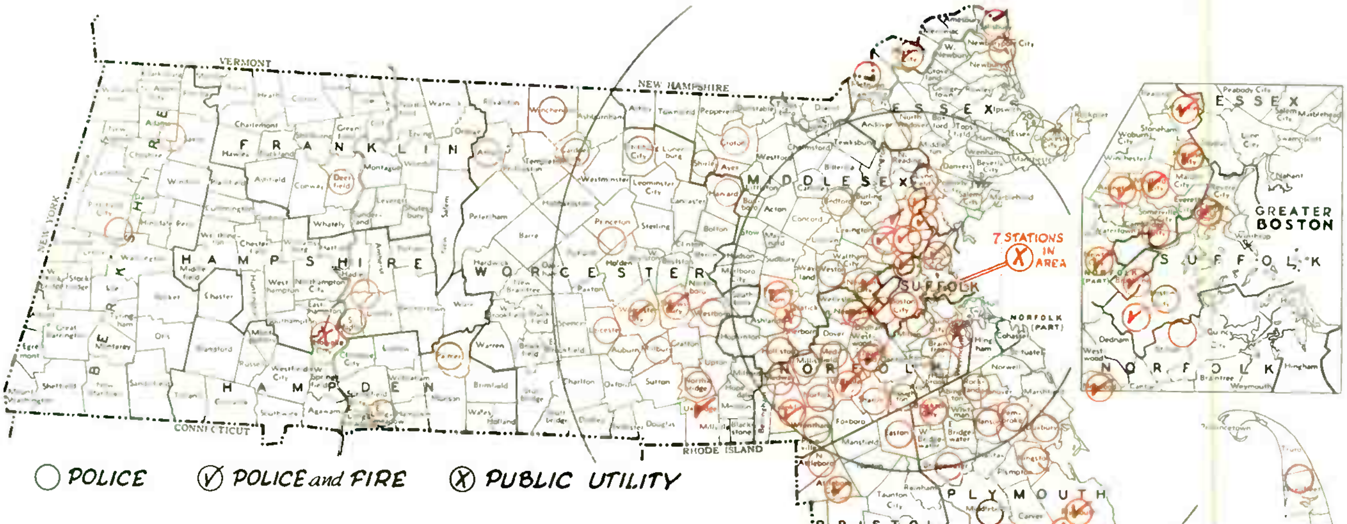

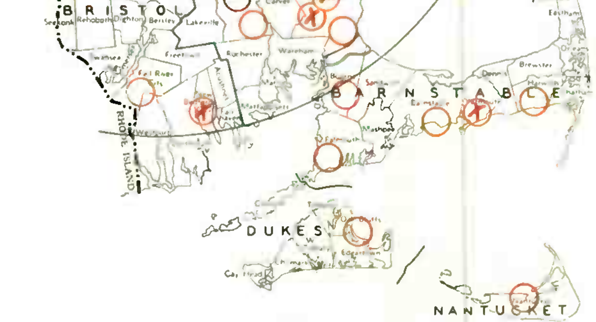

Like New York and Pittsburgh metropolitan areas, Link emergency radio equipment is PREFERRED in the Boston, Massachusetts, area *TOO.*

Police, Fire, Public Utility and other emergency services throughout the Country depend on Link equipment 24 hours daily; thus the installations indicated on this map verify that in Massachusetts too — their confidence in Link trouble free operation is well founded.

PARTIAL LIST of LINK RADIO USERS IN THIS AREA

Police Departments

Massachusetts State Police
Metropolitan District Commission
Arlington
Athol
Attleboro
Bedford
Boston
Bridgewater
Brockton
Brookline
Cambridge
Chelsea
Deerfield
Duxbury
East Longmeadow
Framingham
Franklin
Fitchburg
Gardner
Gloucester
Groton
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Haverhill
Harvard
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Kingston
Lynnfield
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Melrose
Methuen
Middleborough
Millbury
Mills
Needham
Newburyport
Newton
North Attleboro
Northbridge
North Easton
Norwood
Norfolk
Pembroke
Plymouth
Rockland
Salisbury
Shrewsbury
Shirley
Stoughton
South Hadley
Wakefield
Walpole
Winchendon
Worcester
Wrentham
Westboro
Weston

Fire Departments

Mass. Dept. of Conservation
Arlington
Attleboro
Brockton
Brookline
Cambridge
Chelsea
Framingham
Franklin
Haverhill
Medford
Melrose
Needham
Newton
Norwood
Palmer
Plymouth
Shrewsbury
Wakefield
Walpole
Worcester
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