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FM-TV RADIO COMMUNICATION

THE JOURNAL OF

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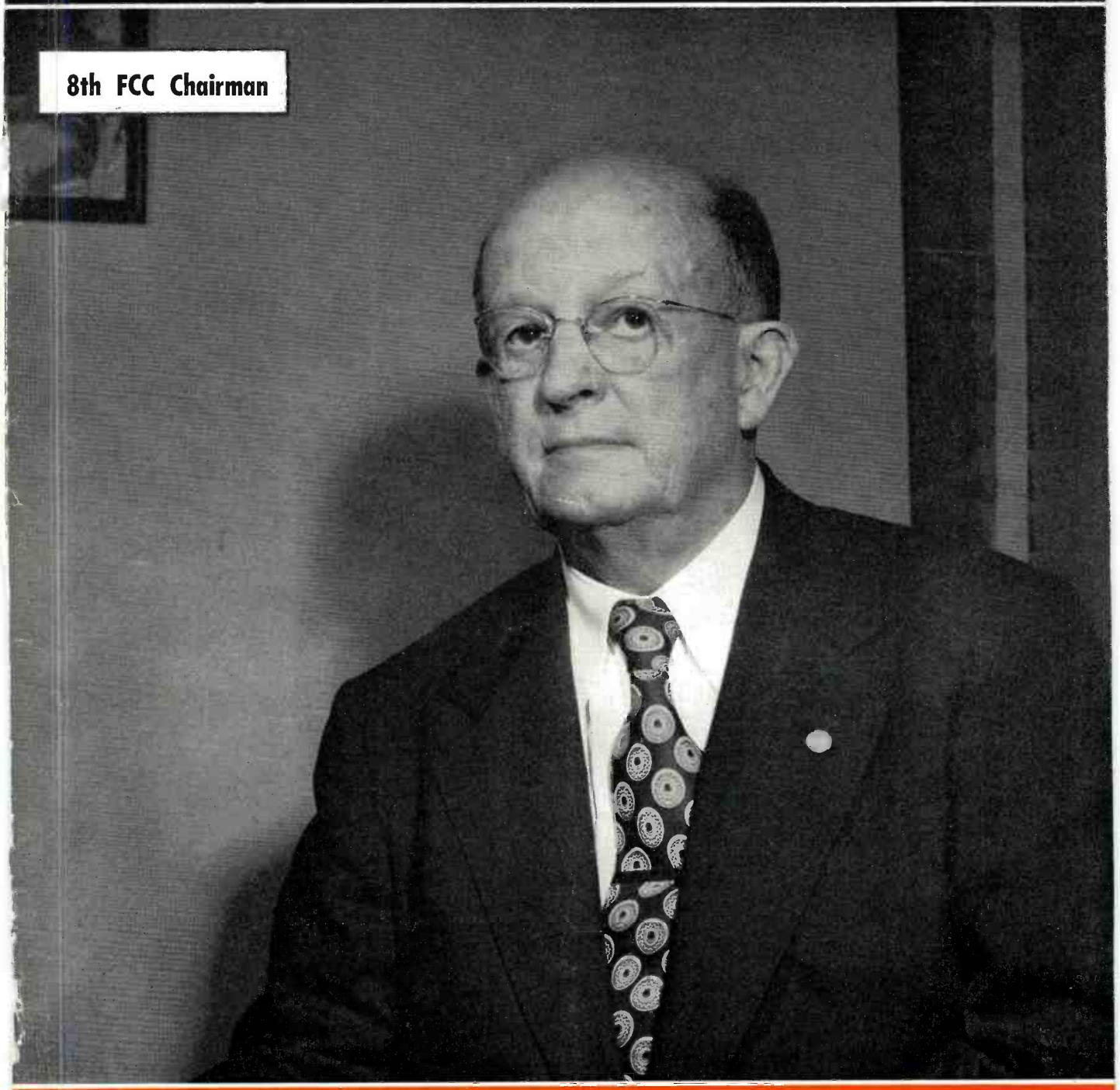

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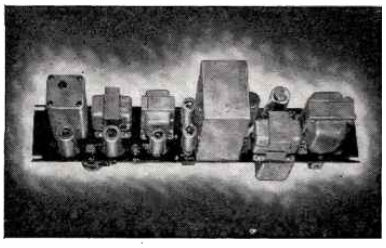

The Hammarlund Standard Duplex Signalling Unit consists of a tone generator and receiver designed to operate over wire lines, telephone or power line carrier, and radio or microwave communications circuits for signalling, dialing, slow speed telemetering, supervisory controls or other information. Transmitters and receivers are available for 33 frequency channels between 2000 and 6000 cps. This equipment is being used by military and governmental agencies, pipeline and power companies, railroads and other groups requiring remote on-off switching, continuous indication of operating conditions, and automatic detection of wire line or power source failures along their systems.

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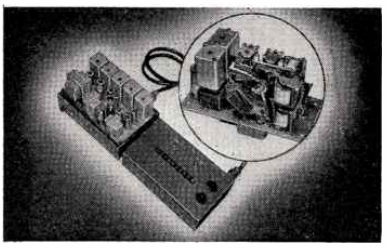

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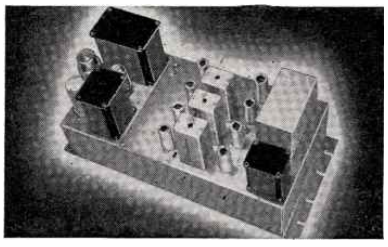

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FM-TV RADIO COMMUNICATION
TELE-VISION ENGINEERING

Formerly *FM* MAGAZINE and *FM* RADIO-ELECTRONICS
Now incorporating TELEVISION ENGINEERING Magazine

VOL. 12 SEPTEMBER, 1952 NO. 9

INDUSTRY NEWS

BROADCASTING

AUDIO

COMMUNICATION

SPECIAL DEPARTMENTS

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CPA AUDIT

CIRCULATION AUDITED BY
HENRY R. SYKES
CERTIFIED PUBLIC ACCOUNTANT
SYKES, GIDDINGS & JOHNSON
PITTSFIELD, MASSACHUSETTS

July is the low month of the year in home set production, but more than usual significance attaches to the drop in AM radios. According to RTMA figures, it was the second lowest month since the end of the war. Moreover, the average monthly production in 1952 is running below any year in that period except 1949. It will be remembered that that was the year when, just prior to the freeze, people expected television to take over.

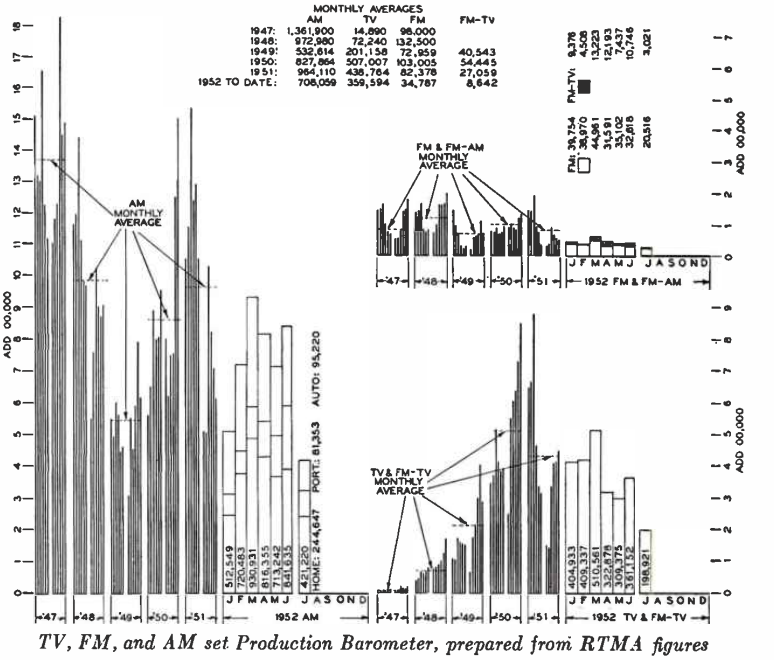
Some observers believe that the poor quality of so many current radio programs, and the competition of phonograph records are definitely cutting into the demand for audio receivers. Few radio executives seem to realize it, but there are over 200 record companies in the USA. Companies producing LP records, as listed in the Schwann Catalog, now number 144.

In the past, broadcasters and set manufacturers have taken little interest in each other's activities, and the broadcasters have been so impressed with the ease of making money from what they transmit that they have paid little attention to the character of what their listeners receive.

Newspapers and magazines have an advantage over broadcasters in that their editorial contents is not produced by their advertisers. Consequently, if the editorial pages attract readers, they can hold their circulation and deliver it to *all* advertisers whether their copy is good or poor.

But in broadcasting, the advertisers prepare and deliver *both* the "editorial material" and the advertising. Listening habits being what they have become, if the program on one station is boring, listeners tune to another or switch off their sets entirely. In either case, the first station has 1) lost circulation for *all* its sponsors and perhaps those of the other stations in the same area as well, 2) it has hurt the manufacturers of receiving sets, and 3) quite possibly it has encouraged still more people to turn to phonograph records for that commodity which is in increasing demand today: musical entertainment.

When radio was a novelty, both broadcasters and manufacturers benefited. They continued to benefit as sponsors, restrained by strict standards of good taste in program material, took over the expense of providing radio entertainment. But now the bars are down to sponsors, broadcasters are cutting their rates, set manufacturers are losing business, and record sales are increasing.



TV, FM, and AM set Production Barometer, prepared from RTMA figures

THIS MONTH'S COVER

Paul A. Walker, whose picture appears on this month's cover, is the 8th Chairman of the FCC. He was appointed in 1934, when the FCC succeeded the Federal Radio Commission. He was made Chairman last February 28th, following Wayne Coy's resignation. His present term expires on June 30, 1953. Behind Mr. Walker's quiet manner is an amazing vigor that has carried him through the arduous labor involved in winding up the TV freeze, and launching the expansion of national television service. His particular forte is common carrier matters.

SPOT NEWS NOTES

ITEMS AND COMMENTS, PERSONAL AND OTHERWISE, ABOUT PEOPLE AND COMPANIES CONCERNED WITH RADIO COMMUNICATION

Great Barrington 1300:

That is the new telephone number for RADIO COMMUNICATION and HIGH-FIDELITY Magazines. To accommodate the increasing number of long-distance calls coming into the Publishing House, the Southern New England Telephone Company has installed special central office equipment to provide us with incoming lines having consecutive numbers. Since consecutive numbers were not available, extra facilities were added to eliminate busy reports on incoming calls. Please make a note of the new number. It is Great Barrington, Mass. 1300.

TV Hearings:

In accordance with the FCC's order of priorities, first hearings will be held on pending applications from Denver, Colo., Canton, Ohio, Portland, Ore., and Waterbury, Conn. Said Commissioner Bartley: "Denver, having received 3 grants, stands to end up with possibly 6 grants before we can schedule hearings looking toward a second grant for St. Louis, a city twice the size of Denver, or 8 other single-station cities larger than Denver. I believe it would be more in line with our responsibilities if we employed our extremely limited resources on the basis of the facts existing at the time examiners become available."

Causes of Component Failures:

Leon Podolsky, manager of field engineering at Sprague Electric, reviewing major causes of failures: "1) Use of components under conditions for which they were not designed and are not suited. 2) Failure of designer to anticipate and test for overload and emergency conditions of temperature, voltage, current, and mechanical stress. 3) Lack of adequate component parts specifications and inspection, and the corollary failure to test components. 4) Exaggerated performance claims for parts which have not been tested adequately, and which have been zealously oversold to unsuspecting and inexperienced equipment engineers, often working under harassing demands for less space and weight. 5) Excessive price consciousness, when reliability is the real criterion of value. 6) Lack of adequate interchange of information between the equipment designer and the components manufacturer at early stages of the design."

FM and TV Problem:

Complaint from Television Engineers & Company, Linden, N. J.: "How can the public be expected to believe the dealer who insists that the buyer needs an outdoor antenna installation when the manufacturers themselves imply that there is no need for one, and advertise that receivers can function perfectly anywhere with built-in antennas?" Since both FM and TV are all-or-nothing services we've wondered, too, why manufacturers jeopardize good will by encouraging people to expect perfect reception on VHF and UHF without adequate signal pickup.

New Material for Magnets:

According to the National Production Authority, a new magnetic material called Bismanol is under development by the Naval Ordinance Research Laboratory. If and when the material becomes available, it will result in a considerable saving of cobalt and nickel, for which bismuth, manganese, and powdered iron are substituted. A full report on Bismanol is available to radio equipment manufacturers on application to the NORL.

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SPOT NEWS NOTES

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FM Transitcasting:

It's obvious that there's some kind of private skullduggery behind the substantial amount of money and legal effort that has been expended in opposition to transitcasting. The source of this support has not been disclosed publicly, but it's obvious that it has not come from the public. Most recently, in opposing the FCC's renewal of WWDC-FM's license, the Transit Riders Association (number of members not known) asserts that "transitcasting operation is not 'broadcasting' but point-to-point communication in that it is designed for specific transit riders." As any one can determine by tuning in on WWDC-FM, the real quality of entertainment provided by this station is of a substantially higher level than the programs of certain Washington AM stations. Further, it must be "broadcasting" in the truest sense, since reception is available to every FM set owner. Thus it cannot, under any interpretation, be point-to-point communication.

We were surprised that Commissioner Webster, in his dissenting opinion, used the expression "beep operation" repeatedly. It is only reasonable to expect such an experienced and respected engineer to be more meticulous in the matter of terminology. The word "beep", although not defined in the Merriam-Webster Unabridged Dictionary, is used commonly enough to indicate any kind of a small noise. The original idea of "beep service" was a system of broadcasting accompanied by objectionable noises which would be removed by a device supplied to listeners who subscribed to the service. That type of service was rejected, and quite rightly, long ago. To refer to transitcasting or functional music broadcasting as "beep services" is to imply that audible control signals are transmitted. That is not true. But the use of this term, particularly by the Commission, has served to mislead the public and to create misunderstanding and prejudice against the special FM services.

New TV Grants:

New CP's for TV stations are added each month to the cumulative list published in this Magazine. Therefore, the list includes all grants issued since the end of the freeze.

Society of Music Enthusiasts:

Interest in high-quality reproduction from FM, records, and tape has developed to the point where plans have

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SPOT NEWS NOTES

(Continued from page 8)

been set up to form a nation-wide Society of Music Enthusiasts. Primary purpose is to organize local listening-and-discussion groups, and to provide records, tapes, and demonstrations for such meetings. Educators, dealers, and manufacturers are taking an active part in this project. Management of the Society will be in the hands of a planning committee, working with regional representatives elected by the local chapters. Complete details of the organization will be published in the November issue of HIGH-FIDELITY Magazine. Meanwhile, preliminary information can be obtained from Charles Fowler, Great Barrington, Mass.

Robert B. Moon:

Resigned as manager of Government sales at General Instrument to become general sales manager at Hammarlund Manufacturing Company. Previously, he was with Bendix Radio for 14 years where, as assistant sales manager, he was responsible for all commercial sales activities.

TV Revenue and Profit:

Figures released by the FCC show that operating losses of TV stations, amounting to $25.3 million in '49 and $9.2 million in '50, shifted to $41.6 million profit before taxes in '51. TV revenues for the three years were $34.3, $105.9, and $235.7 million respectively. Of 106 stations covered in the FCC report, 92 showed a profit. Of the 14 which came out in the red, 8 were in New York City or Los Angeles. Only one of the 40 stations in single-station markets reported a loss.

Wisconsin FM Network:

Wisconsin is the first to have state-wide coverage from an educational system. It is comprised of FM stations WHA-FM Madison, WHAD Delafield, WHKW Chilton, WHRM Rib Mountain, WHCW Colfax, WHLA West Salem, WHHI Highland, WHSA Brule, and AM stations WHA Madison, and WLBL Auburndale.

Those Audio Demonstrations:

Letter from John Cashman, president of Radio Craftsman: "Usually I can see eye to eye with you, but in your June issue you made the statement that all manufacturers who demonstrate high-fidelity equipment do so at very high volume level. In our rooms at the New York and Chicago Audio Fairs we, for one, were operating at ordinary room level. I have always instructed our

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SPOT NEWS NOTES

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people to demonstrate our equipment as it should be heard in average homes." We are sure that this exception will be noted gratefully by visitors at Radio Craftsmen demonstrations, and by adjacent exhibitors.

Telephone Handsets:

Various types of handsets, hangers, and cords suitable for radio communication use, are detailed in a bulletin issued by Connecticut Telephone & Electric Corporation, Meriden, Conn.

Dr. Oliver E. Buckley:

After 38 years of service with the Bell System, Dr. Buckley, who started in the research branch of Western Electric and rose to the board chairmanship of Bell Laboratories, retired last month. During his career, he made many contributions to the advancement of scientific knowledge. The accomplishment that probably gave him the greatest personal satisfaction was the completion of the Murray Hill Laboratories, planned and built under his direction.

KC2XAK Bridgeport:

The UHF TV station operated by RCA and NBC was closed down on August 23, after two and one-half years of operation for research and development purposes. The equipment will be moved to Portland, Ore., where it will be operated by Empire Coil. Service is scheduled to start there by Election Day.

Carrier Telephone Equipment:

Now manufactured by 12 companies. These are: Communication Development, Communications Equipment Engineering, Federal, Harmon Electronics, Kellogg, Lenkurt, Lynch Carrier, Motorola, Radio Engineering Products, Railway Communications, Southern Electric & Transmission, and Union Switch & Signal Company.

A Very Bad Situation:

It's beginning to look as if President Truman is using FCC Chairman Walker and Commissioner Hennock to front for someone who has sold him an idea for making some dubious use of educational TV. It might be such an organization as the CIO-PAC, for example. The pressure must be tremendous, because the FCC is breaking its own Rules to speed the issuance of CP's. This was pointed out by NARTB in a petition for reconsidering a grant to the Kansas State College. Commission Rules provide that no license shall be issued unless the financial responsibility of the applicant is proved.

(Continued on page 11)

PATTERN FOR TV PROFIT

PART 4 — INTRODUCTION TO TRANSMITTING SYSTEMS — FCC REQUIREMENTS — DISCUSSION ON TRANSMITTER AND AMPLIFIER CHARACTERISTICS

By Roy F. Allison, *in collaboration with* A. B. Chamberlain, Rodney D. Chipp, Raymond F. Guy, Thomas E. Howard, *and* Frank L. Marx*

INTRODUCTION

ON April 14, 1952, the FCC issued its Sixth Report and Order, ending the freeze on new TV station construction which had been in effect since September 30, 1948. This provided 2,051 channel assignments in 1,275 communities throughout the Country and, at the same time, fixed maximum and minimum operating powers for all stations.

Two restrictions were made regarding minimum operating power, both of which must be satisfied. The first requirement is that the following minimum median field intensities, in db above 1 microvolt per meter, must be provided over the entire principal community to be served by the station:

MINIMUM MEDIAN FIELD INTENSITY
Channels 2 to 6: 74 db (5,000 uv./meter)
Channels 7 to 13: 77 db (7,070 uv./meter)
Channels 14 to 83: 80 db (10,000 uv./meter)

The second requirement, regarding actual minimum ERP, is set up according to the population of the community served, as follows:

POPULATION	MINIMUM ERP
1 million or more	50 kw. at 500 ft.
250,000 to 1 million	10 kw. at 500 ft.
50,000 to 250,000	2 kw. at 500 ft.
Less than 50,000	1 kw. at 300 ft.

Of course, the antenna heights shown are not intended to represent minimum heights or even recommended heights, but serve to relate power and height. The minimum permissible ERP's for other antenna heights are given in Fig. 1.

Ordinarily, if the second requirement is met, the first will be satisfied also. But this may not be true in cases where geographical shapes of principal communities are peculiar, and population distributions are abnormal; where natural or man-made obstructions produce propagation shadows of appreciable size; or where the station site is far removed from the city.

No distinctions according to population served are made in the maximum power limitations, since assignments were made in all cases with equal separations in each zone.[1] Maximum permissible ERP's are given below:

MAXIMUM ERP
Channels 2 to 6: 100 kw.
Channels 7 to 13: 316 kw.
Channels 14 to 83: 1,000 kw.

However, definite restrictions were placed on the antenna heights at which these powers can be used. In zones 2 and 3, the powers indicated can be employed with antenna heights up to 2,000 ft. in all bands. In zone 1, the powers indicated can be employed in the UHF band at antenna heights up to 2,000 ft., and in the VHF band up to 1,000 ft. For antenna heights greater than these, see Fig. 2.

Since very wide limits are provided in these Rules, especially for stations in the smaller population groups, the owner has the opportunity to decide for himself the combination of transmitter, antenna, and tower that will provide the most practical service to the particular community and surrounding area in which his station is located, and will result in the maximum number of profit dollars. Combinations of these components are available now for maximum power in the lower VHF band, and should be available within several months for the high VHF channels. Maximum power for UHF is not, at the moment, attainable commercially, but certainly will be within 2 to 3 years.

Factors Determining ERP:

The television transmitter itself is only one of the components in the transmitting system which determine the effective radiated power. A TV transmitter is actually *two* separate and distinct

*Collaborators are, respectively: Chief Engineer, CBS Television, New York; Director of Engineering, DuMont Television Network, New York; Manager, Radio and Allocations Engineering, NBC, New York; Chief Engineer, WPIX, New York; and Vice President in charge of Engineering, ABC, New York.

[1] For a more detailed presentation of the FCC's Sixth Report and Order, including an explanation of the propagation zones, see "FCC Plan for Nationwide TV," Radio Communication Magazine for May, 1952.

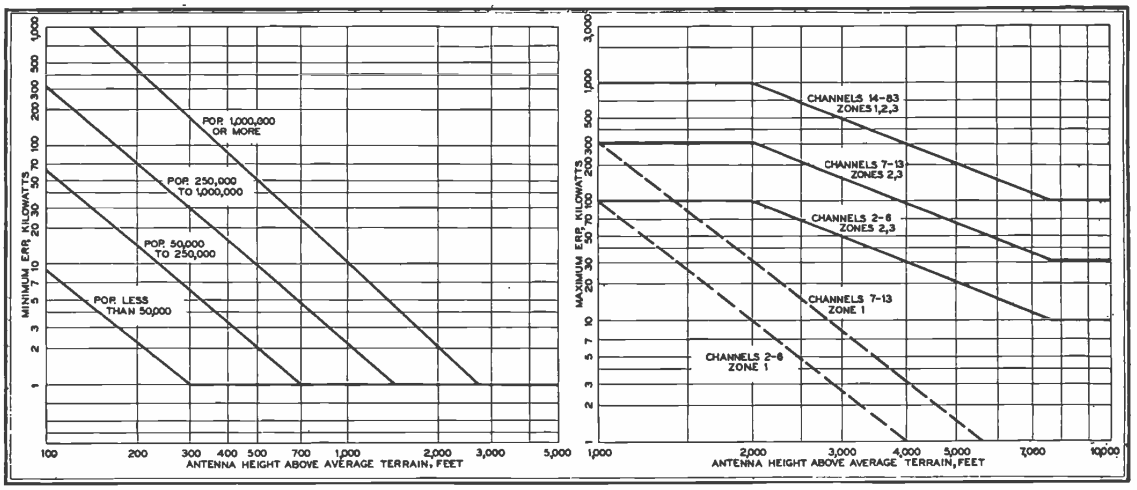


FIG. 1, LEFT: MINIMUM EFFECTIVE RADIATED POWER ACCORDING TO ANTENNA HEIGHT WHICH WILL BE PERMITTED IN COMMUNITIES OF VARIOUS SIZES
FIG. 2, RIGHT: MAXIMUM ERP PERMITTED VARIES ACCORDING TO ZONE, CHANNEL, AND ANTENNA HEIGHT, BUT NOT THE COMMUNITY POPULATION

transmitters, as shown in Fig. 3, consisting of an FM section for the sound or aural part of the broadcast, and an AM section for the picture or visual part. These two signals are usually combined

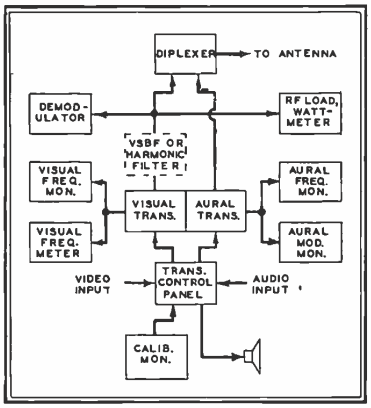


FIG. 3. TRANSMITTER WITH ASSOCIATED UNITS

in a diplexer so that they can be fed to the same antenna. Either a *bridge* diplexer or a *slot* diplexer may be employed; each attenuates the signals to some degree. The transmission line which carries the combined signals from the diplexer to the antenna absorbs some of the power also, the amount of attenuation depending on the type and diameter of the line, and the length of the run.

Thus, the power actually reaching the antenna may be considerably less than that generated by the transmitter. Television antennas, however, are without exception characterized by a property termed *power gain*. Strictly speaking, an antenna cannot radiate more power than is fed to it. But it can be made to concentrate the radiated power into a very small vertical angle, by reinforcing the radiation in one vertical direction and cancelling it in all others. In one vertical direction, therefore, which is ordinarily zero degrees from the horizon, the radiated power may be many times that which would be obtained if a simple dipole antenna were fed the same amount of power. Thus, the power is concentrated in the direction where it is useful, and is not wasted in directions above the horizon. This beam-narrowing effect is increased as the number of sections (or bays) of the antenna is increased. The ratio of power radiated in the maximum-power direction to that radiated by a half-wave dipole in the same direction, with equal power input, is called the power gain of the antenna. Power gains from 2 to more than 27 are typical of TV transmitting antennas.

The effective radiated power (ERP) of a station, then, is the transmitter output (visual or aural) minus the losses in the diplexer and transmission line, (which usually averages from 15 to 25%), multiplied by the gain of the antenna. Since aural power is ordinarily less than visual power (FCC Rules permit a ratio of 2 to 1), a station has two ERP figures. Where a single figure is given and is not identified, it is assumed to be peak visual power.

TRANSMITTERS

Television transmitters of most manufacturers are contained in a number of rack cabinets, sometimes called *cubicles*, matched in style and appearance and ordinarily of the same size. The aural and visual sections are usually isolated completely.

The cabinets, which vary in exact dimensions according to the manufacturer but average about 7 ft. high by 2½ ft. wide by 2½ ft.. deep, are installed side-by-side or in a U arrangement. Occasionally they are arranged in an L configuration or are divided into two rows. There may be from 2 to 12 such cabinets, depending on power rating, in addition to exterior accessories such as filters, plate transformers, control racks, a diplexer, the cooling equipment, and power supplies.

Those transmitters of minimum power, 500-watt VHF and 100-watt UHF, are composed of 2 or 3 cabinets. One cabinet contains the aural transmitter. The visual transmitter takes up either one or two cabinets, depending on the make. Transmitters of higher power, of course, take more space.

Manufacturers have followed the practice of designing transmitters so that low-power units can be used as drivers for amplifiers of higher power. This building-block design method serves to prevent obsolescence of low-power equipment. A station can begin operation with low power and a relatively small initial investment in transmitting equipment, and can increase power simply by adding suitable amplifiers. The original antenna, transmission line, and diplexer should, of course, be capable of handling the final projected power planned for if the planned increase is not so great as to make this provision impractical.

Transmitters are supplied with control panels, suitable for rack or console mounting, or control consoles. These control panels are usually provided with switching and fading facilities for four or more audio inputs and two or more video inputs, gain controls, waveform controls, power supply controls, and basic indicating devices. Fig. 4 shows a typical control panel of this sort, supplied by General Electric for its 5-kw. transmitter. For the very simplest types of operation, this panel can be used for all the station switching. However, it should be remembered that this unit is intended only for transmitter feed and control, and cannot be expected to replace a master control. It isn't wise to employ the transmitter control panel for master-control operations where there are more than two sources of program material to be handled.

In the light of these facts, the need for a transmitter control console, in addition to the master control, may be questioned. It should be understood that a transmitter control console is not absolutely necessary. A simple control panel can be rack-mounted along with the monitoring equipment, in the minimum installation. However, there are many good reasons why a central control position increases the efficiency of control. If a console is provided, all the transmitter operating controls, meter read-

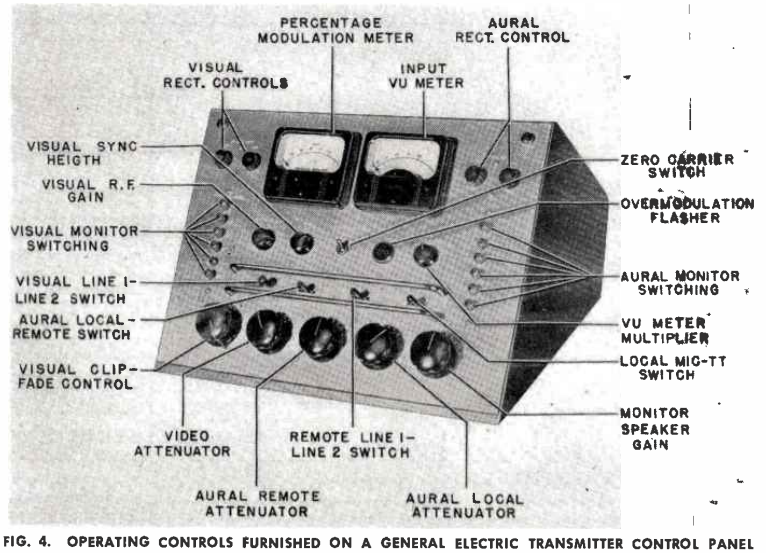
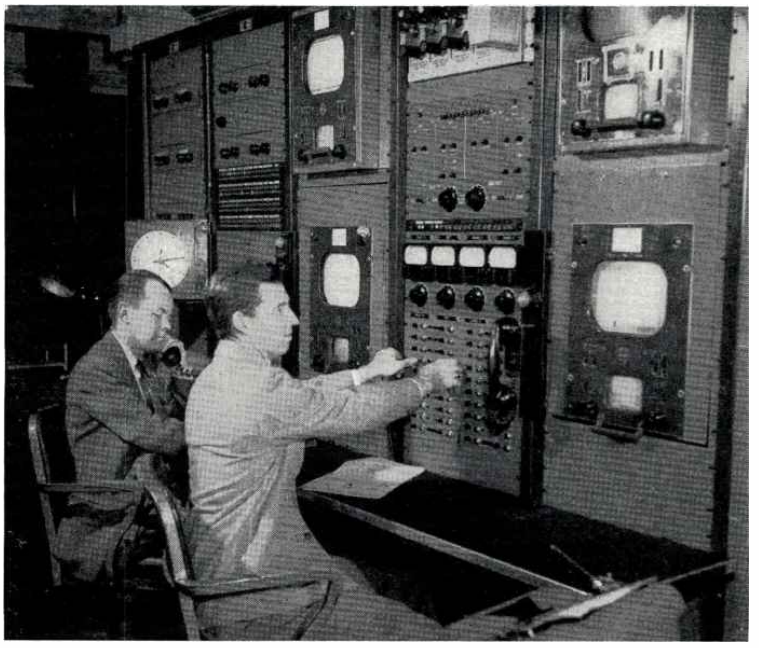


FIG. 4. OPERATING CONTROLS FURNISHED ON A GENERAL ELECTRIC TRANSMITTER CONTROL PANEL



RCA CONTROL AND MONITORING EQUIPMENT USED AT ABC'S MASTER CONTROL IN NEW YORK CITY

ings, and tally lights can be located (or duplicated) at one point. A picture monitor can be mounted in the console also. This can be switched to any of a number of points throughout the transmitting system, from the control panel itself to the output of the transmitter. A similar audio monitor is provided as well.

In more elaborate installation, a second picture monitor provides a constant check on the output of the transmitter. Still another fixed monitor may be employed for the input. These picture monitors are ordinarily of the highest quality, and have associated with them oscilloscopes for checking waveforms and significant voltage levels.

The indicating scales for the frequency and modulation monitors are usually duplicated at the transmitter control position also. Finally, intercommunication facilities with the rest of the station or with master control may be located here. Centralization of all these functions can pay dividends in consistently superior signal quality, more complete and accurate logs, and faster diagnosis and repair of breakdowns. It may, furthermore, permit a reduction in the number of operating personnel.

Video transmitters are designed according to one of two general methods, one utilizing high or mid-level modulation of the carrier; the other, low-level modulation.

Where high or mid-level modulation is employed, the intermediate power-amplifier stages can be operated Class C, and are relatively easy to adjust for proper tuning. Only the amplifier stages, if any, which follow the modulated stage need be linear. Fewer intermediate stages are required for this type of transmitter. However, little attenuation of the lower sidebands can be obtained and an external vestigial sideband filter must be used. Also, more modulating power is needed.

In the other type of transmitter, modulation of the carrier is accomplished at a low power level, and little modulating power is required. Succeeding linear amplifier stages are tuned so that the lower sidebands are attenuated to a considerable degree. Only a simple, self-contained notching filter is needed to provide the necessary extra attenuation at the sound-carrier frequency. The disadvantages of this design are that more intermediate linear stages are required for equivalent power output, and they require much more careful tuning than Class C stages.

High-power amplifiers, designed to be driven by transmitters of lower power, must be composed of linear stages. When the low-power unit concerned is designed for operation with a vestigial sideband filter, a new filter may or may not be required also, depending on individual circumstances.

Cooling Systems:

Heat is generated by any equipment using vacuum tubes. Where many tubes are used in a relatively small space, and where large amounts of power are generated by tubes, heat dissipation becomes a severe and expensive problem. Especially for transmitters of higher powers, the equipment required for cooling purposes takes up a good deal of space, and this equipment should be considered in the initial planning stages of the station.

The smallest transmitters have built-in air cooling systems which may be sufficient if the transmitting room itself is air-conditioned or has forced ventilation. Transmitters of 1 kw. and over, however, should be provided with forced-air exhaust systems. Such systems should have provisions for exhausting the heated air directly out of doors, with dampers such that part of the air can be recirculated. It is possible also to use the air for space-heating purposes in the winter.

Air should be filtered as it enters the building and also as it enters the individual racks. The same low-pressure exhaust system can be used for cooling the miscellaneous equipment racks as well as the transmitter racks, providing the capacity of the system is great enough. Capacity requirements vary, and are specified by the manufacturers for each transmitter. Low-pressure systems, in which the air is drawn through the entire cabinets from bottom to top, are known as cubicle cooling systems.

Most transmitters of medium and high power require, in addition to a cubicle cooling system, an individual cooling system for the final amplifier tubes. These are called anode cooling systems. They are usually high-pressure forced-air exhaust systems, and operate only in the immediate vicinity of the power tubes. Fig. 5 is a diagram of an air duct layout recommended for a 5-kw. high-channel transmitter. The anode and cubicle cooling systems have individual feed ducts and blowers, but utilize the

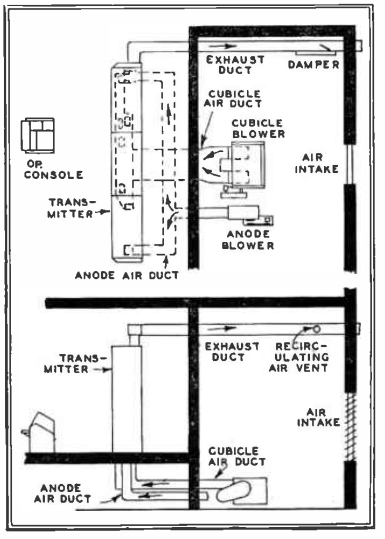


FIG. 5. HOW A 5-KW. TRANSMITTER IS COOLED

same exhaust duct. Transmitter ventilation equipment must be custom-built to fit each case. Cost of this equipment for a 5-kw. transmitter may run to $4,000 or higher.

Some old VHF transmitters, new VHF transmitters and amplifiers of very high power (25 to 50 kw.), as well as high-power UHF transmitters, employ water-cooled final amplifier tubes. These, of course, require complete plumbing systems and rather bulky water coolers. However, air-cooled versions of some presently water-cooled tubes are being developed, and it is expected that they will be used rather than the water-cooled versions as soon as they become available.

Present FCC Rules state that carrier center frequencies must be held to within ± 1 kc. of the assigned frequencies. This close tolerance is necessary for successful operation of the offset-carrier system, wherein adjacent stations assigned the same channel have carriers offset from one another by 10 or 20 kc. to reduce mutual interference. In order to maintain this tolerance and to satisfy FCC Rules, continuous indications of aural and visual frequency must be provided. Both visual and aural modulation, while not tied into the frequency tolerance problem, must be monitored also. Aural modulation monitors are conventional FM units. Visual modulation monitors are usually special types of waveform monitors.

Many transmitter manufacturers make visual waveform and modulation monitors. Some also manufacture visual frequency meters and aural frequency and modulation monitors. Others, however, supply these units as manufactured by one of the well-known companies which specialize in this sort of equipment. Cost is from $3,000 to $4,000 for visual frequency monitors and aural frequency and modulation monitors, with UHF equipment slightly more. Visual modulation monitoring equipment may cost up to $4,500 more.

Other input, control, and miscellaneous equipment may cost from $5,000 to $10,000.

Transmitters of various manufacturers, in production now or definitely scheduled, are listed below:

PEAK VISUAL POWER	CHANNELS OR BAND	DIMENSIONS, INCHES	ANODE COOLING SYSTEM	MANUFACTURER
100 w.	UHF		Air	GE
100 w.	UHF		Air	Standard
500 w.	2-13	107 by 87 by 27	Air	DuMont
500 w.	2-13	89 by 78 by 35	Air	Gates
500 w.	2-13	56 by 84 by 31	Air	RCA
500 w.	2-13	94 by 83 by 39	Air	Standard
500 w.	UHF			Gates
1 kw.	2-13	100 by 83 by 30	Air	Federal
1 kw.	UHF	71 by 87 by 27	Air	DuMont
1 kw.	UHF	103 by 84 by 33	Air	RCA
1.5 kw.	UHF	100 by 83 by 30	Air	Federal
2 kw.	2-13	106 by 84 by 31	Air	RCA
2.5 kw.	UHF			Gates
5 kw.	2-13	178 by 87 by 27	Air	DuMont
5 kw.	2-6	195 by 83 by 30	Air	Federal
5 kw.	2-13	174 by 78 by 35	Air	Gates
5 kw.	2-13	180 by 84 by 34	Air	GE
5 kw.	2-13	178 by 83 by 39	Air	Standard
5 kw.	UHF	213 by 87 by 27	Water	DuMont
5 kw.	UHF			Gates
5 kw.	UHF		Water	GE
5 kw.	UHF	182 by 84 by 33	Water	RCA
5 kw.	UHF			Standard
7.5 kw.	7-13	195 by 83 by 30	Air	Federal
10 kw.	2-13	192 by 84 by 33	Air	RCA
10 kw.	2-13	262 by 83 by 39	Air	Standard
10 kw.	UHF	222 by 84 by 33	Water	RCA
12 kw.	UHF		Water	GE
20 kw.	7-13		Air	GE
20 kw.	7-13	324 by 84 by 33	Air	RCA
20 kw.	2-13	346 by 83 by 39	Air	Standard
25 kw.	2-6	249 by 87 by 27	Water	DuMont
25 kw.	2-13	293 by 83 by 30	Air	Federal
25 kw.	2-6	324 by 84 by 33	Air	RCA
35 kw.	2-6	252 by 84 by 34	Water	GE
50 kw.	7-13	320 by 87 by 27	Water	DuMont
50 kw.	7-13			GE
50 kw.	2-13	380 by 84 by 33	Air	RCA
50 kw.	UHF	320 by 87 by 27	Water	DuMont
60 kw.	UHF		Water	GE

CONTROL EQUIPMENT AT KSL-TV, SALT LAKE CITY, MANUFACTURED BY DUMONT LABORATORIES, INC.

Average costs of the equipment listed above are given in the following table. It should be understood that these figures are representative of prices quoted at the time of publication, and are subject to change. Most of the transmitters listed in the lower power brackets, and a few high-power VHF equipments, can be delivered within a few months of ordering. VHF transmitters of the highest power, however, will probably be available for delivery in a year to two years and the high-power UHF transmitters within 2 to 3 years.

TYPICAL TRANSMITTER COSTS

POWER	CHANNELS 2-6	CHANNELS 7-13	UHF
100 w.			$35,000
500 w.	$30,000	$35,000	
1 kw.	35,000	35,000	52,000
2 kw.	44,000	49,000	
5 kw.	65,000	69,000	75,000
10 kw.	81,000	86,000	134,000
12 kw.			135,000
20 kw.	138,000	143,000	
25 kw.	145,000	150,000	
35 kw.	145,000		
50 kw.	208,000	215,000	250,000

Linear amplifiers, designed for conversion of low-power equipment to high-power operation, are listed in the table following:

PEAK VISUAL POWER	CHANNELS OR BAND	ANODE COOLING SYSTEM	MANUFACTURER
5 kw.	2-13	Air	DuMont
5 kw.	2-6	Air	Federal
5 kw.	2-13	Air	Gates
5 kw.	2-13	Air	Standard
5 kw.	UHF	Water	DuMont
7.5 kw.	7-13	Air	Federal
10 kw.	2-13	Air	Standard
10 kw.	UHF	Air	RCA
20 kw	7-13	Air	GE
20 kw	7-13	Air	RCA
20 kw.	2-13	Air	Standard
25 kw.	2-13	Air	Federal
25 kw.	2-6	Water	DuMont
25 kw.	2-6	Air	RCA
35 kw.	2-6	Water	GE
50 kw.	7-13	Water	DuMont
50 kw.	7-13	Water	GE
50 kw.	2-13	Air	RCA

The delivery schedules for these amplifiers correspond to those for transmitters of the same power. Prices will be somewhat less, as shown in the following table:

TYPICAL AMPLIFIER COSTS

POWER	CHANNELS 2-6	CHANNELS 7-13	UHF
5 kw.	$35,000	$35,000	$30,000
10 kw.	50,000	53,000	80,000
20 kw.	68,000	70,000	
25 kw.	72,000	77,000	
35 kw.	80,000		
50 kw.	110,000	110,000	

In the lists of transmitters and amplifiers from various manufacturers, blank or unfilled spaces indicate that such information was not available at the time of publication. In the price lists, blank spaces indicate either that no equipment of such power is presently

(Concluded on page 36)

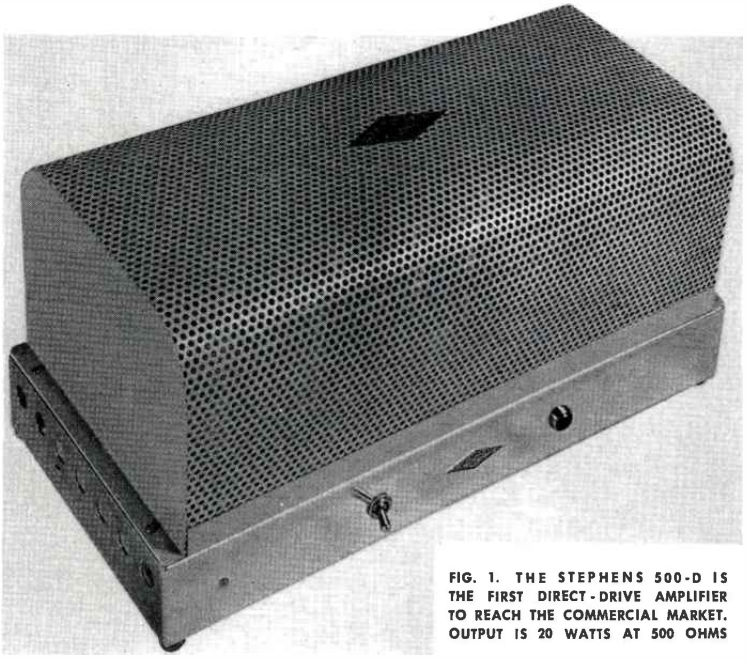


FIG. 1. THE STEPHENS 500-D IS THE FIRST DIRECT-DRIVE AMPLIFIER TO REACH THE COMMERCIAL MARKET. OUTPUT IS 20 WATTS AT 500 OHMS

Audio Notes

DESCRIPTIONS AND DISCUSSIONS OF NEW AUDIO EQUIPMENT FOR COMMERCIAL AND PRIVATE USE

It cannot be denied that the elimination of an output transformer from an audio amplifier has certain basic, inherent advantages much to be desired. For that reason, the 500-D direct-drive amplifier, manufactured by Stephens Manufacturing Corp., in Culver City, California, has been responsible for a great deal of discussion since it made its appearance at the 1951 Audio Fair in New York. Most of the discussion has been concerned with whether or not the problems which are caused by elimination of the output transformer have been or can be overcome completely and at an advantageous price. Certainly the 500D, shown in Fig. 1, has been favorably received as the first direct-drive amplifier available commercially.

Fig. 2 is the schematic diagram of the amplifier. A 12AU7 is used as a straight 2-stage voltage amplifier, RC-coupled to a 12AX7. Direct coupling is used from this stage to the triode-connected cathode-follower 6K6 driver. The 6K6 drives four 2A3's connected in an ingenious way so that the optimum terminating impedance is very close to 500 ohms. Thus, a 500-ohm speaker or speaker system can be fed directly through a large capacitor. The company has developed a line of 500-ohm speakers for use with the amplifier.

Two feedback loops are provided. The loop from the output to the cathode of the first stage gives 8 db, while that from the output to the 12AX7 cathode gives 25 db. Positive and negative selenium rectifier circuits operate from a single high-voltage AC winding. Outputs are +520 volts for the 2A3's, which consist

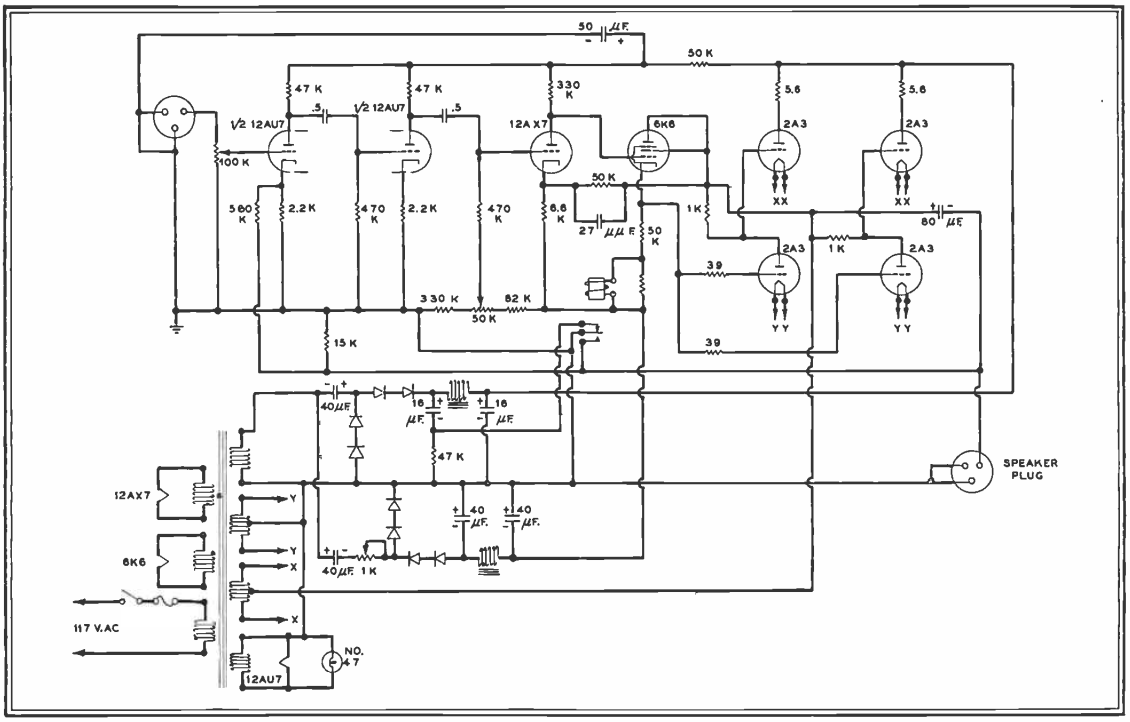


FIG. 2. SCHEMATIC OF THE 500-D DIRECT-DRIVE AMPLIFIER. NOTE COMPLEXITY OF POWER SUPPLY, NECESSARY TO PROVIDE FOR DC-COUPLED STAGES

FIG. 3. THIS BROADCAST AMPLIFIER CAN BE EMPLOYED FOR REMOTE OR STUDIO APPLICATIONS

of 2 pairs in series so far as B+ is concerned, and −440 volts used as B− for the DC-coupled stages.

Specifications are very impressive. At 20 watts output, the following performance is claimed:

Frequency response, ±¼ db, 20 to 70,000 cycles.

Total distortion, .5%

Hum and noise, down 90 db

Voltage gain, 47 db

Apparent output impedance, 5 ohms at 1,000 cycles, 100 ohms at 20 cycles

Phase shift, less than 15° at 20 cycles

Versatile Broadcast Amplifier:

General Electric's model BA-6-B portable broadcast amplifier, Fig. 3, is designed for studio as well as remote applications. A built-in AC power supply is provided, as well as circuits for battery operation.

The new unit contains 4 preamplifiers and a master mixer, all employing low-noise miniature tubes. For setting reference levels, a 400-cycle oscillator is included. High and low-level plug-in headphone connections and a cue amplifier gain control facilitate operation in noisy locations.

The output transformer has an isolated monitor winding, permitting program feed to a PA system or other external amplifier. Weight, including the batteries, is only 35 lbs.

Dual-Impedance Speaker:

Fig. 4 shows two new speakers introduced recently by University Loudspeakers, Inc., 80 South Kensico Avenue, White Plains, N. Y. On the left is a 15-in. woofer, designated C-15W, which has a dual-impedance voice coil. Either 4 to 8 ohms or 10 to 16 ohms can be obtained simply by selection of the proper terminals on the speaker chassis. Whichever impedance range is selected, the entire voice coil is employed, so that maximum efficiency is retained. This is a very bright idea, for it facilitates experimentation and permits the installation of the speaker in almost any multiple-speaker system.

The Cobreflex horn shown on the right is a wide-angle projecter which can be used in 2-way or 3-way high-fidelity systems or as a paging speaker, depending on the driver unit employed. Dispersion is said to be exceptionally uniform over a range of 120° by 60°. The horn itself is of die-cast aluminum, and can be mounted easily by means of an adjustable U-bracket.

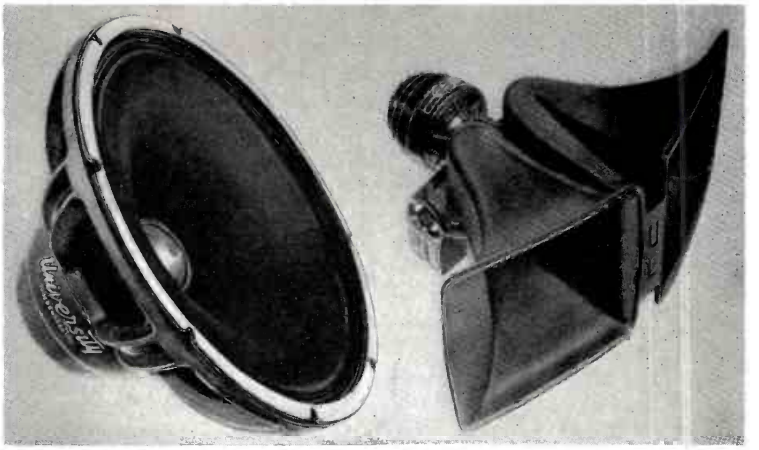


FIG. 4, LEFT: DUAL-IMPEDANCE 15-IN. WOOFER. RIGHT: HORN SPEAKER FOR PAGING OR HI-FI USES

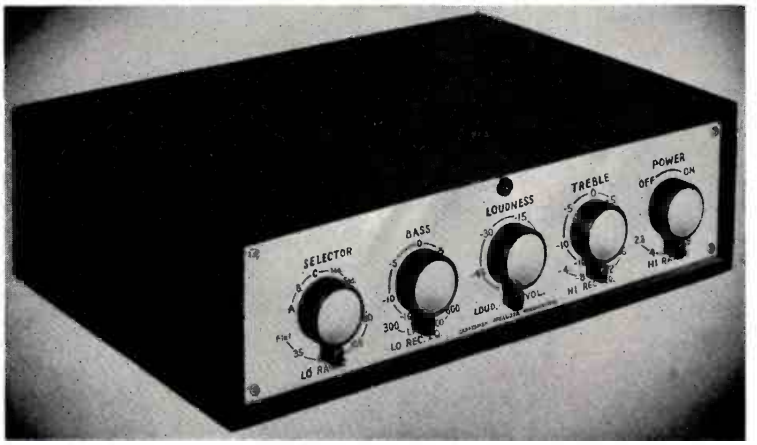


FIG. 5. NEW RADIO CRAFTSMEN PREAMPLIFIER-EQUALIZER HAS EXTREME VERSATILITY OF CONTROL

Multi-Control Preamp:

Model C300 equalizer-preamplifier, Fig. 5, is easily one of the most versatile to appear on the market. It is made by Radio Craftsmen, Inc., 4401 North Ravenswood Avenue, Chicago 40, Illinois. For record equalization, there are controls for five turnover frequencies and five treble rolloff curves, adjustable individually. Two other controls provide sharp cutoffs at five low frequencies for suppression of hum or rumble, and at five high frequencies for scratch reduc-

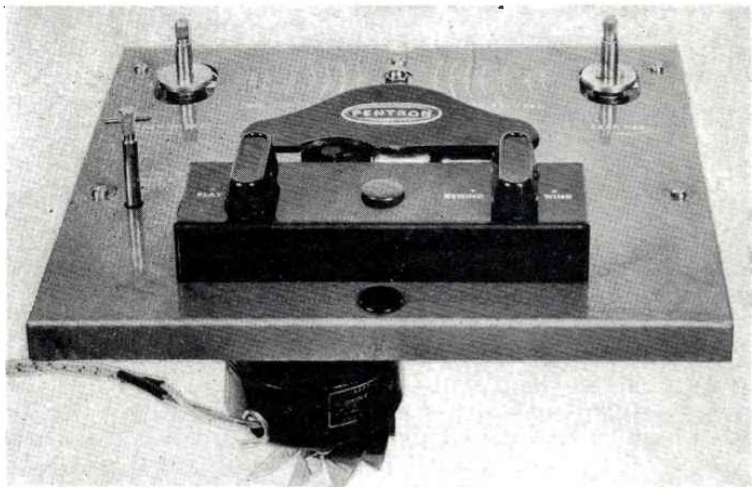


FIG. 6. TAPE TRANSPORT MECHANISM HAS 3¾ & 7½ IPS. SPEEDS, ALSO FAST FORWARD AND REWIND

tion. A selector switch is furnished for five inputs. Bass and treble controls are continuously variable, and produce either boost or droop. Finally, the output level control can be operated either as a straight volume control or as a compensating loudness control.

The all-triode circuit has a cathode-follower output, so that a long lead to the amplifier can be employed without danger of hum pickup or high-frequency attenuation. Although the power supply is self-contained, it is well shielded and the tube filaments are operated with DC. The tubes themselves are on a shock-mounted sub-chassis.

Tape Transport Unit:

Described as being of professional quality, the tape transport mechanism shown in Fig. 6 can be used for high-fidelity custom installations or PA systems. This unit, made by Pentron Corporation at 221 East Cullerton Avenue, Chicago, Illinois, can be operated at either 3¾ or 7½ ips. Speed can be selected by push-buttons, with a fast forward and rewind speed. Playing time is 2 hours at 3¾ ips. with a 7-in. reel, the maximum size.

Two heads are employed, one for record and playback, the other for AC erase. Either single-track or dual-track heads can be used, and are interchangeable.

Duplex Loudspeakers:

Altec-Lansing Corporation, 155 Sansome Street, San Francisco, has just introduced two new loudspeakers in the Duplex line. Exceptionally wide and smooth frequency response is claimed for both models. Model 601A, shown in Fig. 7, consists of 12-in. cone speaker driven by a 3-in. edge-wound aluminum voice-coil, and a separate high-frequency horn unit. Model 602A is identical, except that the cone is 15 ins. in size and a heavier magnet is used.

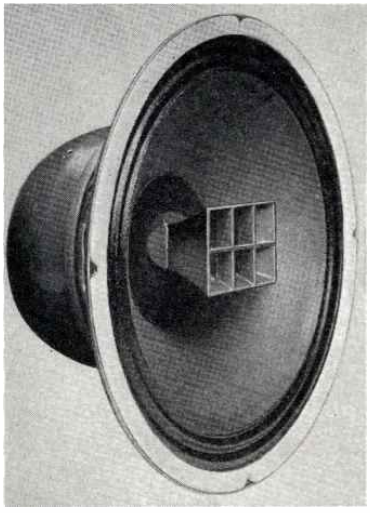


FIG. 7. ONE OF NEW ALTEC DUPLEX SPEAKERS

Both speakers employ external dividing networks which cross over at 3,000 cycles. Response from 30 to 3,000 cycles is specified for each cone when properly mounted, with somewhat better results below 50 cycles being obtained with the 602A. The high-frequency units mounted in the center of each cone consist of separate drivers and exponential multicellular horns. It is stated that these units provide smooth output from 3,000 to 22,000 cycles.

A 1.8-lb. magnet structure is employed for the low-frequency cone in the model 601A, while a 2.4-lb. magnet is used in the 602A. Cloth spiders are used for center suspension. Natural cone resonance for both models is below 50 cycles. A corner cabinet of the bass-reflex type, containing 8 cubic feet, has been designed especially for these speakers.

Power-handling capacity of each speaker is 20 watts.

McIntosh Preamp Change:

A new equalizer-preamplifier, model C-104, has been developed by McIntosh Laboratories, Binghamton, N. Y., to supersede the old model AE-2A. The two are similar except that the C-104 provides greater simplicity of control, and has an additional turnover frequency position for record compensation.

The new model is available as a chassis only or enclosed in a mahogany case, as in Fig. 8. While designed specifically to complement the McIntosh amplifier, it can be used for control of any sound system. Five input channels are furnished: one each for a low-level microphone, a low-level magnetic cartridge, a high-level magnetic cartridge, a TV audio input, and an FM-AM tuner input. Separate adjustable level controls for the tuners are available at the back of the unit. Continuously-variable controls adjust the bass ±20 db and the treble +15 to −20 db.

FIG. 8. McINTOSH C-104 PREAMP-EQUALIZER IS MORE VERSATILE THAN THE OLD MODEL AE-2A

Communication News

FOR THOSE WHO ARE CONCERNED WITH MOBILE, POINT-TO-POINT, & MICROWAVE RELAY SYSTEMS

This month we present the breakdown of applications for new communication facilities filed with the FCC during the 2nd quarter of 1952. The figures were taken from the lists of new applications, published each month in RADIO COMMUNICATION. Data for the 1st quarter appeared in the May issue, a few copies of which are still available.

Second Quarter Applications:

There was no significant change in the number of systems which filed applications, or the number of base and relay or control stations. Quite noticeable, however, was the total of 63 Speedmeters, and the increase of 1,600 mobile units. The 1,114 low-power units of .25 to 3 watts indicate the acceptance of such equipment for the communication services. Largest purchases were by telephone companies. The majority were rated at 3 watts, indicating operation from 115 volts AC.

Special industrial service was still the largest single market, up considerably over the first quarter, with taxis a fairly close second. Practically all taxi applications were for new systems, as were fire applications, which climbed into second place. Police and public utilities were filling in or replacing base transmitters and mobile units, for the most part.

Activity at 450 to 460 mc. still lagged. A noticable exception was the Independence Taxi Operators Association, Boston, which filed for 500 units to operate on 452.05. Here is the breakdown for the 2nd quarter:

Service	Systems	Base Trans.	Relay & Control	Mobile Trans.	L. P. Port.
POLICE	157	132	26	792	26
FIRE	66	68		820	30
FORESTRY	32	110		206	110
HIGHWAY	18	27	15	177	
SP. EMER.	90	87		301	2
PUB. UTI.	102	197	30	791	131
PIPELINE	63	235	44	503	34
FOR. PROD.	23	34	2	268	21
SP. IND.	219	318	10	2841	195
R. R.	17	33		75	20
TRANS. UT.	1	1		5	
AUTO EM.	15	15		106	
TRUCKS	36	44		582	
TAXIS	164	164		2436	
I. C. BUSES	1	4	9		
L. P. IND.	48				545
	1062	1469	136	9883	1114

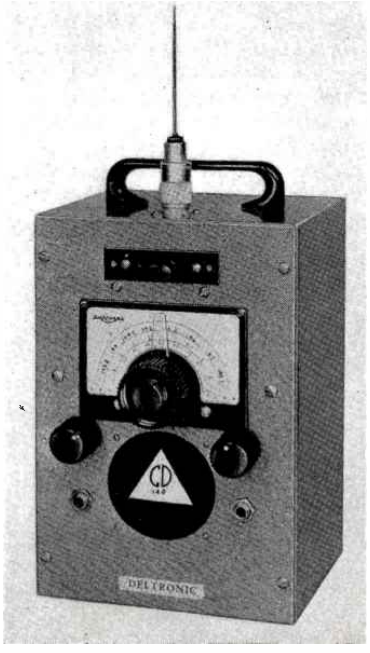
That Citizens Band:

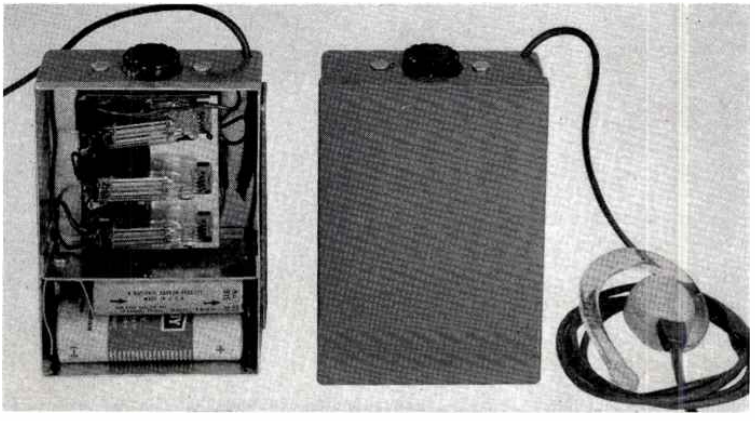
There is no particular significance to the state-of-total-vacuum which continues to prevail in the citizens radio band, but we do not hesitate to predict that at some time not far removed it will be necessary for the FCC to revise the present Rules applying to it. As matters stand now, the people to whom it could be most useful are not willing to move into a band set up as sort of public swimming pool, where the Rules permit anyone to splash around at will. Easing the requirements has not had the intended result of encouraging the use of the citizens band. The effect has been exactly the reverse, as might have been anticipated.

TWO-WAY RADIO CALL BOX AND SELECTIVE SIGNAL LIGHT FOR POLICE AND CIVIL DEFENSE

Radio Paging:

As indicated by this month's listing of applications for new communication facilities, there is currently quite a rush to file for radio paging transmitters. There seem to be divided opinions concerning the profit possibilities of this service. Some communication men are





LEFT: PORTABLE AM UNIT HAS NARROW BAND TUNING. RIGHT: BUDELMAN RADIO IS BUILDING THIS VEST-POCKET AM RECEIVER FOR RADIO PAGING

MUCH POLICE RADIO EQUIPMENT, NOW TECHNICALLY OBSOLETE, IS BEING REPLACED. HERE PAUL CHAMBERLAIN OF GE TURNS OVER A NEW 250-WATT TRANSMITTER TO UTICA CHIEF LEO MILLER

highly enthusiastic about it, holding that it will be no problem to sign up a large number of subscribers for this new type of service, particularly because of the relatively low rate at which it can be provided, and the low cost of operation.

On the other hand, there are those who believe that most applications being filed by established telephone-answering companies are just a hedge against competition that might develop if radio paging should turn out to be really profitable, which they doubt.

Listing New Applications:

Next month, the arrangement of the list of new applications will be changed, although the information will be the same. Purpose of the change is to present the information more clearly. Your comments on the new method, whether favorable or otherwise, will be appreciated.

Mobile Transmitter Ratings:

The following communication was received from Norman Helwig, manager of Kaar Engineering Company, Palo Alto: "This criticism is proof that we read your publication. In fact, we feel that it is the outstanding magazine in the mobile communication field. However, I would like to take exception to the statement that appears on pages 20 and 21 of your July 1952 issue. The following is a quotation from the paragraph with the heading, Transmitter Output Ratings:

" 'Since mobile units aren't made to deliver such high values of output power [100 watts] it appears that the listings are not correct.'

"This erroneous statement will prove very misleading to your readers because some of the applications noted for 100 watt mobile transmitters are applications specifying our FM-100X 30 to 50 mc. units. The FM-100X will definitely deliver 100 watts of RF power as measured on a Bird watt meter with a nominal input voltage of 6.3 volts DC. If you wish to make the measurements yourself, we will gladly furnish a transmitter.

"We feel that you should print a correction as your magazine has a wide circulation, and many prospective purchasers of the FM-100X transmitter may now question the rating of this model."

Mr. Helwig's letter explains in part what seem to be excessively high ratings for mobile transmitters, but it still leaves open to question ratings as high as 150 watts which appear from time to time in the applications file.

Hand-Carried Equipment:

An AM transmitter-receiver unit weighing only 7 lbs., designed for operation from 110 volts AC and 6 volts DC, has been brought out by the Deltronic Company, 9010 Bellanca Avenue, Los Angeles 45. The case measures 6½ by 6 by 9½ ins. The standard model, illustrated here, can be tuned over a range of 143.8 to 148.1 mc. Other frequency ranges can be supplied as required.

Radio Call Box:

During the past 20 years, various plans have been proposed and rejected for radio-operated fire alarm systems. Most serious objections were that they lacked the feature of fail-safe operation provided by closed-circuit, wire-connected systems, and that they would become inoperative in case of electric power line interruptions. While those objections may not have been met entirely, it looks as if the day of the radio-operated fire alarm system has been advanced con-

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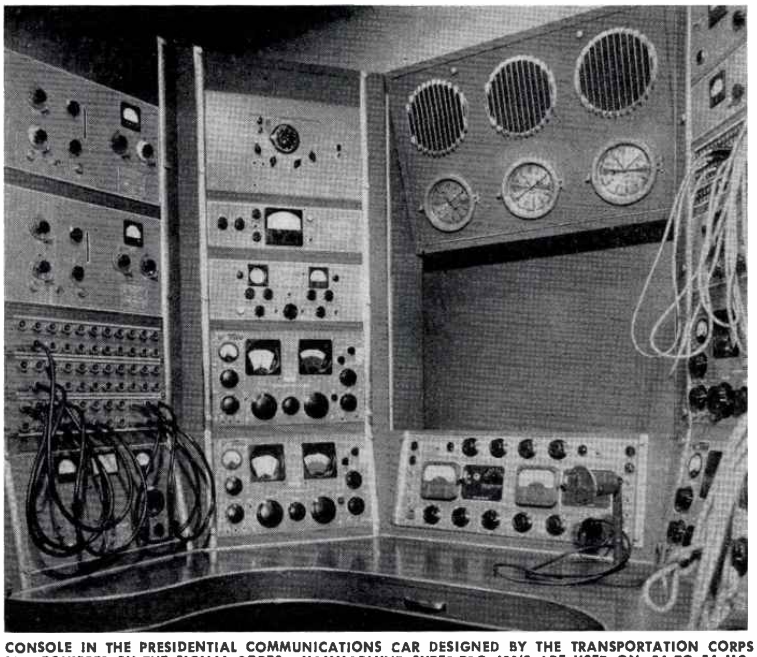


CONSOLE IN THE PRESIDENTIAL COMMUNICATIONS CAR DESIGNED BY THE TRANSPORTATION CORPS AND EQUIPPED BY THE SIGNAL CORPS. HAMMARLUND SUPER-PRO 600'S ARE USED ON .54 TO 54 MC.

Narrow-Band Operation at 40 Mc.

A COMPLETE REPORT ON 25 TO 50-MC. SPLIT-CHANNEL PERFORMANCE AND THE PROBLEMS OF CHANGEOVER — *By* JERRY S. STOVER AND T. J. McMULLIN*

This report covers recent developments and tests connected with the operation of mobile radio equipments with 20-kc. channel spacing in the 25 to 50-mc. band, rather than the 40-kc. channel spacing now being used.

THERE has been considerable discussion recently, at various conferences and in the literature, regarding the feasibility and desirability of so-called narrow-band or split-channel operation in the 25 to 50-mc. mobile radio band.

Two-way radio, first used primarily in the police and emergency services, is now finding wide application in industry. Thousands of transmitters have been installed and are operating in such varied industries as petroleum and power production and distribution, lumbering, taxicabs, and ranching, among others. Because of the tremendous demand for frequency assignments, particularly in certain areas of the Country where industries employing radio are highly concentrated, it is quite often necessary that several companies share one radio frequency channel. Although this is now being done, with excellent cooperation among the various users, the point is being approached where additional sharing of channels can result in a general decrease in operational efficiency.

The available radio spectrum is limited, particularly at those frequencies used for mobile communication. Some means must be found, therefore, to obtain more channels within this limited spectrum. At the General Mobile Hearings held by the FCC in 1947, it was suggested by C. A. Priest of the General Electric Company that equipment performance and operational techniques had improved sufficiently so that it might be advisable to inaugurate 2-way systems using a total emitted bandwidth of only 20 kc., rather than the 40 kc. then being used. On this basis, more systems could eventually be assigned frequencies within a given block of spectrum space.

Early Experiments:

Experimental work carried out in 1948 and early 1949 indicated that 20-kc. bandwidth operation was feasible. On April 22, 1949, a complete 20-kc. base and mobile system was demonstrated by G. E. at Syracuse, for representatives of the FCC. This test demonstrated two very important facts:

1) The difference between signal-to-noise ratios of the 20 and 40-kc. systems is so small (less than 3 db) that, in order to detect it, it was necessary to install both equipments in one automobile, using the same antenna and the same loudspeaker. A sketch of the test setup used to demonstrate this is shown in Fig. 1. It might be expected that, because of the narrower bandwidth, the ultimate range of the 20-kc. system would be slightly greater than that of the 40-kc. system. However, from a practical standpoint, the ultimate ranges were found to be the same.

2) More important, the test showed that not only could operation be carried out *in the same service area* with 40-kc. channel spacing without interference, but that operation was possible with 20-kc. adjacent-channel spacing provided that reasonable precautions were observed in the locations of the 20-kc. stations.

Extensive field experience with several hundred units for the past three years

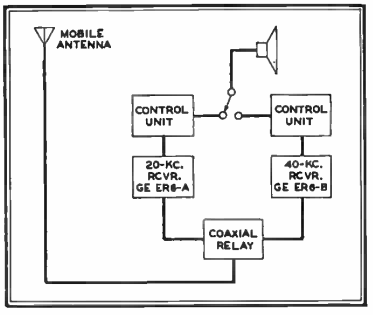


FIG. 1. EQUIPMENT FOR THE COMPARISON TESTS

has confirmed these test results. In the presence of certain types of noise, the 20-kc. receivers actually give quieter performance than the 40-kc. units.

During the same period several companies, using equipment five or six years old, have found it necessary to modernize their systems by installing more selective receivers at certain locations where 40-kc. adjacent-channel interference was received. Rather than merely installing more selective wide-band (40-kc.) equipment, many of these companies, recognizing the possibility of future channel-splitting, installed narrow-band (20-kc.) receivers. It was found that wide and narrow-band units could be mixed in the same system without significant change in the operation insofar as range or noise was concerned. The complete elimination of off-channel interference usually resulted in a marked operational improvement. In most instances, the deviation of all transmitters in the system was reduced to approximately ±10 kc., a compromise value[1] that did not seriously affect the signal-to-noise ratios of either the old wide-band receivers or the new narrow-band units.

Maintenance:

Field operation has demonstrated very clearly also that no special maintenance techniques are required for operation with narrower bandwidths. However, this is not surprising when it is considered that there are thousands of units in operation in the 150-mc. band on a 60-kc. channel width which, percentage-wise, is equivalent to a 20-kc. bandwidth at 50 mc.

It is believed that the factor of maintenance is probably the most important in the successful development of 20-kc. operation. Certainly it would not be feasible to adopt a 20-kc. system if such a system required increased maintenance and highly-skilled maintenance techniques. For this reason, the maintenance records of 20-kc. systems were observed carefully and found to be no different from systems employing greater bandwidths. Much of the credit for this low maintenance factor should go to crystal design engineers, for developing and producing stable and economical crystals which do not require elaborate and expensive temperature-control systems.

Later Test Results:

Because operation with 20-kc. channel spacing had previously been conducted under test conditions, it was deemed desirable to obtain data over a greater period of time. In May, 1952, the Midstates Oil Corporation, operating with narrow-band equipment on a frequency of 48.74 mc. in northern Louisiana, obtained Special Temporary Authority from FCC to shift to a frequency of 48.72 mc. Remaining on 48.74 mc. was the Louisiana system of the Transcontinental Gas Pipe Line Company, also using narrow-band equipment. Operating only 20 kc. lower in frequency, on 48.70 mc., was the system of Interstate Petroleum Communications, using older wide-band equipment, some of which had re-

*Communications Engineering Company, 1630 North Industrial Blvd., Dallas, Texas.

[1]Standard deviation for wide-band equipment is ±15 kc., and for narrow-band equipment, ±6 kc.

ceivers with relatively broad selectivity. Even though certain of Interstate's operations were less than 30 miles from Midstates' operations, no interference has yet been reported to any of the three systems involved in this extended 20-kc. test.

The drilling and production operations of petroleum companies are often concentrated in a limited geographical area. For this reason, the petroleum radio service probably felt the pinch of limited frequencies more quickly than any of the other services, with the possible exception of the taxicabs service. In an effort to obtain relief from this situation, the National Petroleum Radio Frequency Coordinating Association appointed a Special Engineering Committee to test the feasibility of 20-kc. operation. Tests conducted by this Committee in the fall of 1951, with the cooperation of four manufacturers of radio equipment, demonstrated two important facts: 1) There is no significant difference between the operating range of wide-band and narrow-band equipment, and 2) commercial equipment is available in the 25 to 50-mc. band that will give satisfactory operation with 20-kc. channel spacings.

In addition to field tests performed by various organizations, considerable laboratory work has been done to analyze the problem of adjacent-channel operation.[2] Using the results obtained from tests and empirical data available from laboratory work, it is possible to summarize the range of interference that may result under various conditions of operation, when using 20-kc. channel spacing. For comparison, the range of interference for co-channel operation is shown in the accompanying Tables also.

Interference tests are conducted using a desired signal and an undesired signal which is 20 kc. off frequency from the desired signal. To represent actual operating conditions, the transmitter on the desired frequency is moved out from the desired-frequency receiver (connected initially to a mobile antenna), to a point at which the received signal is so weak that the location represents the ultimate range of the system. The desired signal is held sufficiently weak at all times so that the receiver is quieting 15 to 20 db. The undesired transmitter, 20 kc. off frequency, is then put in operation with voice modulation. It is moved in toward the desired receiver until the interference begins to ride in on the weak desired signal. The tests are made for different interfering transmitter powers and antenna heights.

The desired-signal receiver is then connected to a station antenna, and the desired-signal transmitter is moved out farther, to reduce the signal strength once again to a very low level. The tests are then repeated for various interfering transmitter powers and antenna heights.

Due to many factors such as terrain and transmitter noise levels, the figures shown in the accompanying Tables will, of course, vary. However, because mobile units normally have quite wide deployment, frequency allocation plans are usually made up on an area basis, rather than on a specific location basis. In other words, a variation in the exact location by 3 or 4 miles will not affect materially any specific frequency allocation plan. In perhaps only a few cases, therefore, will an error of even several miles in the interference range seriously affect an allocation plan.

A factor which influences greatly the amount of interference experienced, and the distance the interference will be received, is the selectivity characteristic of the receiver. For that reason, in order to apply generally the summaries presented herein, the interference is shown in Table 1 for two different types of receivers:

1) Receiver A represents the narrow-band type of receiver, available since 1951, having a selectivity of better than 100 db at ±20 kc.

2) Receiver B represents an average modern wide-band receiver, generally installed in 1949, having a selectivity of 100 db at ±40 kc.

In addition, Table 2 summarizes the interference that a narrow-band system might expect to receive from a wide-band transmitter with a deviation of ±15 kc., operating 20 kc. away, and swinging into part of the narrow-band receiver's passband.

Conclusions:

These results, even though approximate, show that 20-kc. operation points the

(Continued on page 33)

[2]See "Equipment Performance Specs," by H. H. Davids, RADIO COMMUNICATION, September 1951, page 21.

TABLE 1

DISTANCE IN MILES THAT INTERFERENCE CAN BE DETECTED WHEN DESIRED SIGNAL IS AT MINIMUM USUABLE VALUE, GIVING 15 TO 20 DB QUIETING. DESIRED-SIGNAL SOURCE IS THEREFORE AT MAXIMUM SYSTEM RANGE.

RECEIVING AND TRANSMITTING CONDITIONS	STATIONS ON SAME FREQUENCY (CO-CHANNEL)	STATIONS 20 KC. APART RECEIVER A	STATIONS 20 KC. APART RECEIVER B
RECEIVER OF DESIRED SIGNAL CONNECTED TO MOBILE ANTENNA, RECEIVING MINIMUM USABLE VALUE OF DESIRED SIGNAL. 50-WATT INTERFERING TRANSMITTER, SWINGING ±6 KC., WITH 200-FT. ANTENNA HT.	40	5	28
RECEIVER OF DESIRED SIGNAL CONNECTED TO MOBILE ANTENNA, RECEIVING MINIMUM USABLE VALUE OF DESIRED SIGNAL. 250-WATT INTERFERING TRANSMITTER, SWINGING ±6 KC., WITH 200-FT. ANTENNA HT.	50	8	38
RECEIVER OF DESIRED SIGNAL CONNECTED TO 200-FT. ANTENNA. DESIRED-SIGNAL SOURCE MOVED OUT TO MAINTAIN MINIMUM USABLE DESIRED SIGNAL. 50-WATT INTERFERING TRANSMITTER, SWINGING ±6 KC., WITH 200-FT. ANTENNA HT.	65	13	55
RECEIVER OF DESIRED SIGNAL CONNECTED TO 200-FT. ANTENNA. DESIRED-SIGNAL SOURCE MOVED OUT TO MAINTAIN MINIMUM USABLE DESIRED SIGNAL. 250-WATT INTERFERING TRANSMITTER, SWINGING ±6 KC., WITH 200-FT. ANTENNA HT.	75	20	68

TABLE 2

DISTANCE IN MILES THAT INTERFERENCE CAN BE DETECTED WHEN DESIRED SIGNAL IS AT MINIMUM USUABLE VALUE, GIVING 15 TO 20 DB QUIETING. DESIRED-SIGNAL SOURCE IS THEREFORE AT MAXIMUM SYSTEM RANGE.

RECEIVING AND TRANSMITTING CONDITIONS	STATIONS ON SAME FREQUENCY (CO-CHANNEL)	STATIONS 20 KC. APART RECEIVER A
RECEIVER OF DESIRED SIGNAL CONNECTED TO MOBILE ANTENNA, RECEIVING MINIMUM USABLE VALUE OF DESIRED SIGNAL. 50-WATT INTERFERING TRANSMITTER, SWINGING ±15 KC., WITH 200-FT. ANTENNA HT.	40	18
RECEIVER OF DESIRED SIGNAL CONNECTED TO MOBILE ANTENNA, RECEIVING MINIMUM USABLE VALUE OF DESIRED SIGNAL. 250-WATT INTERFERING TRANSMITTER, SWINGING ±15 KC., WITH 200-FT. ANTENNA HT.	50	25
RECEIVER OF DESIRED SIGNAL CONNECTED TO 200-FT. ANTENNA. DESIRED-SIGNAL SOURCE MOVED OUT TO MAINTAIN MINIMUM USABLE DESIRED SIGNAL. 50-WATT INTERFERING TRANSMITTER, SWINGING ±15 KC., WITH 200-FT. ANTENNA HT.	65	40
RECEIVER OF DESIRED SIGNAL CONNECTED TO 200-FT. ANTENNA. DESIRED-SIGNAL SOURCE MOVED OUT TO MAINTAIN MINIMUM USABLE DESIRED SIGNAL. 250-WATT INTERFERING TRANSMITTER, SWINGING ±15 KC., WITH 200-FT. ANTENNA HT.	75	51

Equipment For Telemetering Systems

PART 3—DESCRIPTIONS OF EQUIPMENT MADE BY MANNING-MAXWELL-MOORE, MELPAR INC., BROWN, MOTOROLA, RAYMOND ROSEN, AND STANCIL-HOFFMAN

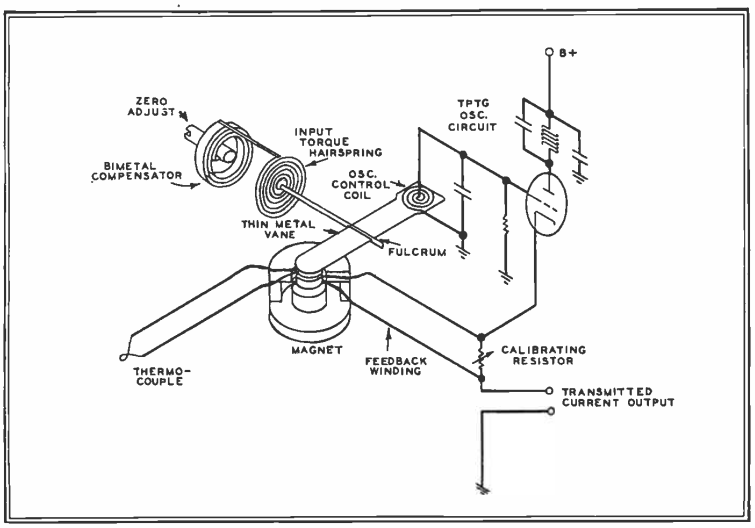


FIG. 18. HOW THE MICROSEN BALANCE OPERATES. A MICROSEN TEMPERATURE TRANSMITTER IS SHOWN

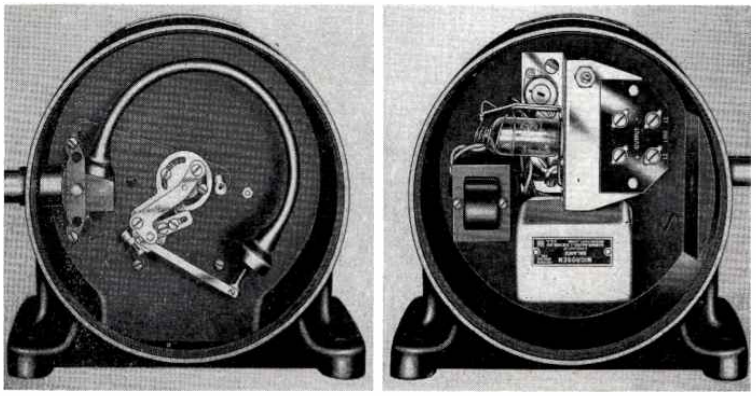
MANNING, MAXWELL, & MOORE, INC. *Stratford, Connecticut.* This company makes the Microsen Balance, a general-purpose transducer for producing a DC electrical output proportional to a mechanical input, for transforming an electrical input to a corresponding mechanical motion, and for stable DC amplification of weak electrical signals. Telemeter receivers and various automatic valve-positioning devices are available also.

The transmitters are designed for measurement of pressure, temperature, flow, and liquid level. A Microsen transmitter for temperature measurement is shown semi-schematically in Fig. 18. It can be seen that the device operates on a force-balance basis. Essentially, it is a Kelvin balance modified for automatic operation.

A thermocouple, with a DC output, is connected to a winding on an electromagnet which exerts force on one end of a thin metal vane acting as a pivoted beam. At an intermediate point on this beam, a rod attached to a hairspring acts as a fulcrum. The other end of the hairspring, in the case of the temperature transmitter, is coupled to a bimetal temperature compensating coil with a zero-adjustment screw.

The two forces acting on the beam determine its proximity at the other end to a coil in the grid circuit of a tuned-plate tuned-grid oscillator. Thus, the two forces determine the resonant frequency of the grid tank circuit. As the grid circuit resonant frequency is varied in relation to that of the plate circuit, the plate current varies accordingly. Where the transmitter is used with wire lines, the rectified plate current is also the line current. However, the transmitter can be terminated in any resistance up to 3,000 ohms for use with other intermediate means of signal transfer.

Part of the line current is fed back to a second winding on the electromagnet, producing a force in opposition to that developed by the input winding. This self-balancing action provides a linear DC output in relation to the input. The circuit is adjusted so that the maximum output current is 5 milliamperes, and the minimum is .5 milliamperes. For strictly mechanical inputs, such as for pressure, flow, liquid level, and position indications, the input is coupled to the beam via the hairspring, and only the feedback winding is utilized on the electromagnet. Figs. 19 and 20 show the mechanical and electrical sections of a Microsen pressure transmitter.



FIGS. 19 AND 20. FRONT AND REAR VIEWS OF COMPLETE MICROSEN PRESSURE TRANSMITTER UNIT

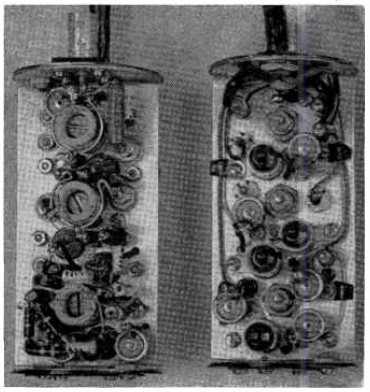


FIG. 21. MELPAR 3-WATT 220 MC. TRANSMITTER

MELPAR, INC., *452 Swan Avenue, Alexandria, Virginia.* Operating in the range from 215 to 230 mc., the FM/FM telemetering systems made by Melpar were developed originally for use by the armed forces in transmitting data from aircraft and guided missiles. Model MP-1077, described here, has been declassified recently and made available for commercial applications.

This equipment consists of an RF transmitter, up to 8 subcarrier oscillator chassis, a master chassis containing terminal connections and unit interwiring,

and a bias regulator if the equipment is to be battery-operated. Where a constant-voltage power supply is available, the bias regulator is not required, since the 30-volt bias for the subcarrier oscillator multivibrators can then be obtained from a voltage divider.

The RF transmitter, shown in Fig. 21, is only 2 ins. in diameter and 4 ins. long. Four 5703 subminiature triodes perform the functions of oscillator, modulator, doubler, and power amplifier stages. About 2.5 watts RF output is provided with a plate supply of 135 volts, or 3.5 watts with a plate supply of 180 volts. Drift does not exceed 500 kc. over the temperature range from –20° to +60°C., and maximum modulation deviation is ±125 kc. with less than 2% distortion.

Fig. 22 shows a complete 6-channel assembly partially dismantled. A bias regulater unit is in the foreground, in front of the case, and the RF transmitter chassis is in back of this unit, and slightly to the right. Four subcarrier oscillator chassis are removed from the case.

The individual subcarrier units are 8½ by 5 by 1 in. overall. One subminiature and two miniature tubes are employed in a positive-bias multivibrator and bridge circuit. The pickup, whether of the strain-gauge or potentiometer type, is driven by the multivibrator. The amplified unbalance output of the gauge is returned to the multivibrator as a bias voltage. Therefore, the amplitude of the quantity being measured determines the operating frequency of the multivibrator.

Standard center frequencies for the sub-carrier channels are 1,700, 2,300, 3,000, 3,900, 5,400, 7,350, 10,500, and 14,500 cycles. Maximum deviation is 7½% of center frequency at 5% distortion. Output voltage is .5 volts rms.

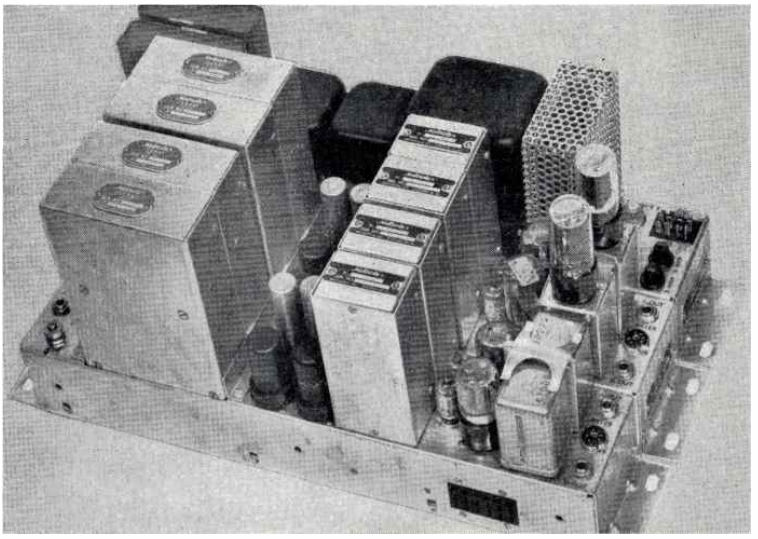


FIG. 23. TWO MOTOROLA 2-CHANNEL TONE RECEIVERS AND THE ASSOCIATED POWER-SUPPLY CHASSIS

MINNEAPOLIS-HONEYWELL REGULATOR COMPANY, BROWN INSTRUMENTS DIVISION, *Wayne and Windrim Avenues, Philadelphia 44, Pennsylvania.* The main output of this company in the electrical telemetering field is in the form of chart indicator-recorders, of both the strip and rotary types.

For electrical telemetering of liquid-level and flow, transducers and recording mechanisms are provided for inductance-bridge measurements. These systems require 3-wire line connections. Transducers for conductivity and pH measurements are provided with appropriate transmitters and recorders for 2-wire systems. 60-cycle choppers can be supplied.

Brown *ElectroniK* recorders are used extensively with telemetering equipment of other manufacturers. They are potentiometer-type high-speed units, adaptable to totalizing measurements as well as single quantities.

MOTOROLA, INC., COMMUNICATIONS AND ELECTRONICS DIVISION, *4545 W. Augusta Boulevard, Chicago 51, Illinois.* The audio-frequency channelizing equipment supplied by Motorola can handle telegraph, teleprinter, telemeter, and various sub-audio and DC signals for transmission over land lines, radio links, power line carrier and microwave systems, or any other system capable of carrying voice frequencies. Telemetering signals of the impulse-rate or impulse-duration type, as well as sub-audio sine waves, can be accommodated.

Since frequency modulation is employed to superimpose the intelligence on the individual carriers, the equipment can be operated in circuits having up to 30 db attenuation, with no loss in accuracy. Two types of modulation are employed for various amplications. For impulse-type signals, frequency-shift keying is utilized, each impulse shifting the carrier frequency by 60 cycles. Other signals are handled with straight frequency modulation.

Channels are spaced 150 cycles apart, with center frequencies from 525 to 3,075 cycles. Thus, a total of 18 signaling channels can be provided without interaction well within the normal single-channel voice-frequency range of communication equipment. By using additional filters, it is possible also to multiplex several signaling channels with a restricted voice channel on one normal voice channel.

Iso-Kay plastic-encased band-pass filters bridge the transmitter outputs and receiver inputs to a 600-ohm line imped-

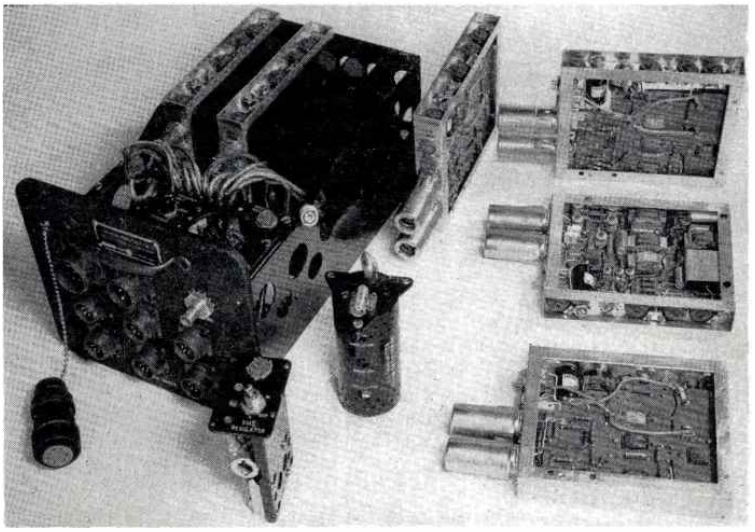


FIG. 22. A SIX-CHANNEL TELEMETER TRANSMITTING SYSTEM, COMPLETE EXCEPT FOR POWER SUPPLY

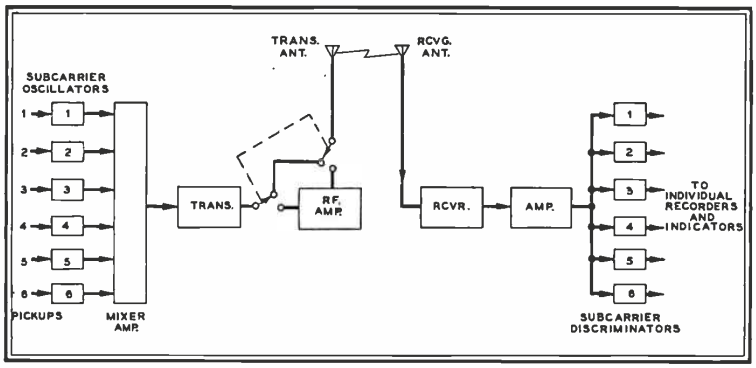


FIG. 25. BASIC 6-CHANNEL 220-MC. FM/FM TELEMETERING SYSTEM DEVELOPED BY RAYMOND ROSEN

ance and, at the same time, serve to eliminate unwanted sidebands and carrier harmonies. Each chassis contains two independent transmitters or receivers. Plug-in sub-chassis units permit changes in the operating frequency or type of operation. Fig. 23 shows two 2-channel receiver chassis, one of each type, and a power supply chassis. The transmitter chassis are very similar in appearance to the receivers. All chassis are of the same size, suitable for mounting in 19-in. open racks or rack cabinets. Fig. 24 is a view of a terminal-station cabinet with receiving equipment for 24 telemetering channels, including power supplies.

RAYMOND ROSEN ENGINEERING PRODUCTS, INC., *32nd and Walnut Streets, Philadelphia 4, Pa.* This company has developed a versatile FM/-FM telemetering system, operating at 215 to 230 mc., which can be expanded from the basic 6-channel system to one providing virtually any number of channels up to 58.

In the basic system, diagrammed in Fig. 25, six telemeter pickups are used to frequency-modulate six subcarrier oscillators with continuously varying information. The pickups may be of any of the three available types: strain-gauge, potentiometer, or variable reactance. The oscillator outputs are mixed and amplified, and used to frequency-modulate the RF transmitter. An output of 3 watts is provided, which is ample for line-of-sight operation under normal conditions. However, an auxiliary 30-watt RF amplifier is available if desired. Maximum RF deviation is ±125 kc.

The receiver output consists of the mixed audio subcarriers. This signal is applied to an audio amplifier, which feeds the six subcarrier discriminators. These separate the individual subcarriers and demodulate them, providing voltage outputs proportional to the original quantities measured. Each output signal can be fed to a panel meter, a servo-indicator, or pen, tape, or galvanometer recorder. A panoramic adaptor can be provided as optional equipment.

Overall accuracy of this system is claimed to be within ±2%, and cross-channel interference less than .5% of that amount. Any 6 of 23 channels from 400 to 70,000 cycles can be utilized. Frequency response ranges from 6 cycles for the 400-cycle channel to 2,100 cycles for the 70 kc. channel with ±15% deviation.

Twenty-six additional channels can be obtained by commutation of one of the six basic channels. In the 32-channel system, 27 pickups of either the potentiometer or strain-gauge type are sampled by a mechanical commutator at the rate of 5 samples per pickup per sec. The sampled information is fed in sequence to the subcarrier oscillator having the highest center frequency. Each commutated channel, or sub-channel, has a frequency response of 1 cycle per sec. Increased frequency response can be obtained by cross-strapping the commutator segments, so that a particular pickup is sampled more than once each revolution. This decreases the total number of sub-channels available, of course.

At the receiving end, the outputs of the first five channels are exactly the same as before. The recorded output of the commutated channel is a series of pulses, however, as shown in Fig. 26. Each pulse corresponds to one sample of the quantity being measured on that particular subchannel. In other words, the amplitude of pulse A1 is proportional to the amplitude of the quantity being measured by the pickup feeding contact A of the commutator at the instant the rotat-

(Concluded on page 32)

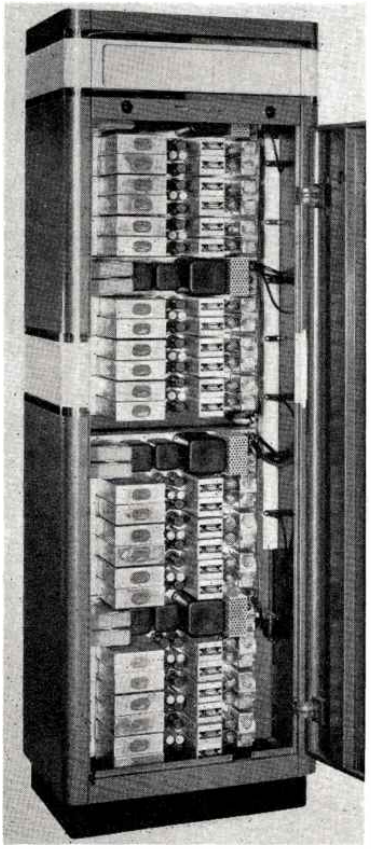


FIG. 24. TONE RECEIVERS FOR 24 TM CHANNELS

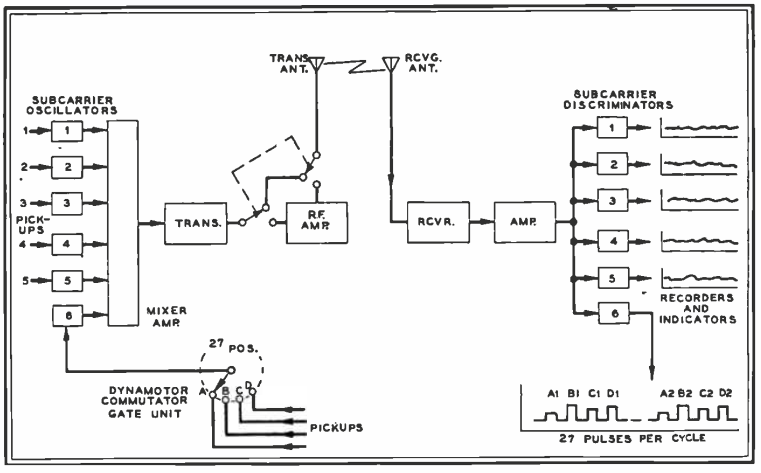


FIG. 26. EXTENSION OF SYSTEM TO PROVIDE 32 CHANNELS BY COMMUTATING ONE BASIC CHANNEL

A Versatile Phase-Comparison

Carrier-Current Relaying System

IMPROVEMENTS IN THIS PHASE-COMPARISON PROTECTIVE RELAYING SYSTEM PROVIDE BROADER APPLICATION FIELD — *By* N. O. RICE AND J. S. SMITH*

SINCE its introduction approximately six years ago, phase-comparison protective relaying has come into wide use. As conceived originally, its field of application was to be limited to medium-length, 2-terminal overhead lines. Operating experience has been so satisfactory that requests have been made for extending its field of application to longer lines, to 3-terminal lines, and to certain cables. Also, its inherent immunity to the effects of mutual inductance makes its use advantageous for ground-fault protection, even though it may not be applicable for phase-fault protection. In such cases, there was a need to combine the virtues of phase and directional-comparison relaying.

Modifications have now been made to phase-comparison relaying equipment that will provide the desired expansions in its field of application. Also, advantage has been taken of past experience and of later design techniques to make other improvements in the basic equipment, still retaining the desirable features of the earlier equipment.[1]

Details of Modifications:

Modifications employed in the new equipment result in the following improvements:

1) Positive operation is assured on transmission lines with attentuations up to 35 db. This permits operation over longer lines and over certain types of cables.

2) Through increased receiver selectivity and reduced transmitter harmonics, more carrier-current channels can now be obtained in the available frequency spectrum.

3) Provisions are incorporated in the equipment for its combined use with directional-comparison equipment. This is for application on medium and long lines where directional-comparison relaying can be used to advantage for phase relaying, but because of mutual inductance with parallel lines, phase-comparison relaying will be required for ground faults.

4) Two adjustable levels of fault detection can be used to compensate for a possible 2-to-1 ratio of fault current magnitudes between the ends of a 3-ended line, making the equipment applicable to some 3-ended lines.

5) Higher speeds of operation are obtained at lower values of fault current than with the superseded equipment. An operating time of less than 2.5 cycles at 60-cycle frequency is obtained at just above the pickup current threshold. The operating time averages less than 2 cycles at a value of fault current four times the pickup current.

6) The equipment is designed for use with vacuum tubes which are either pretested to eliminate early failures or are of a long-life type. However, the equipment will operate unimpaired with standard receiving-type tubes.

7) Minimum relay pickup current is independent of the load imposed by the carrier-current transmitter on the power amplifier of the relay equipment.

8) The carrier equipment is available in two operating frequency ranges, covering a wider range of channel frequencies than before.

9) A phase shifter is incorporated to compensate for the time of propagation between terminals of long transmission lines.

10) The carrier set is so arranged that it can be converted for directional-comparison operation simply by exchanging a small sub-panel on the front of the equipment.

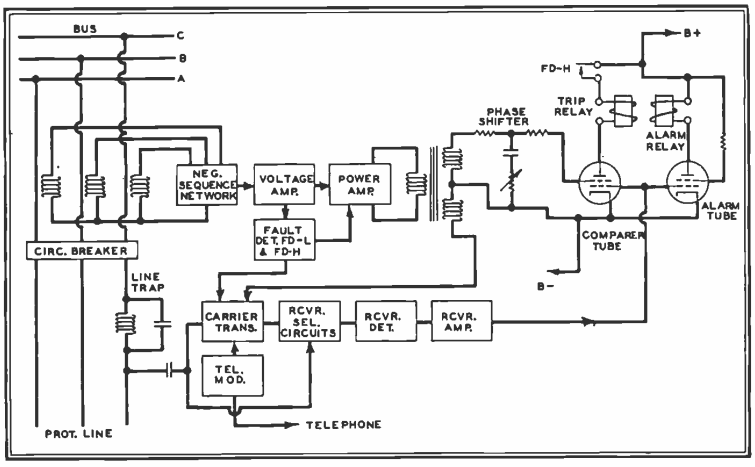


FIG. 1. PHASE-COMPARISON PROTECTIVE RELAYING EQUIPMENT FOR ONE POWER-LINE TERMINAL

Operating Principles:

Phase-comparison carrier-current relaying consists basically of comparison, by means of a carrier-current channel, of the phase angles of the line currents entering and leaving a protected line section. Currents from the secondaries of current transformers at each terminal of the protected line are fed into a fault detector which, if the current is of fault magnitude, turns on the phase-comparison circuits. This, in turn, transmits a signal over the carrier-current system by means of which a comparison is made of the phase angles of the currents at all terminals. The phase relationship of the currents at the ends of the transmission line determines whether or not the circuit breakers are tripped.

Phase comparison is accomplished by a vacuum-tube stage called the comparer, shown in Fig. 1. A voltage obtained from the local line currents is applied to the screen grid. The received voltage, obtained via the carrier channel from the line currents of the remote end, is applied to the control grid. When the local voltage swings the screen grid positive, the tube conducts and causes tripping of the circuit-breaker, unless it is blocked by the presence of a received negative signal on the control grid at the same time. For external faults, the phase relation of the line currents at the two ends is such that, as the local voltage of one end swings the screen grid

*General Electric Company, Philadelphia, Pa., and General Electric Company, Syracuse, N. Y., respectively. This paper was given at the 1952 Winter General Meeting of the AIEE.

[1] "Phase-Comparison Carrier-Current Relaying," by A. J. McConnel, T. A. Cramer, and H. T. Seeley, *AIEE Transactions*, Vol. 64, 1945, Pages 825 to 833.

positive, the received voltage from the other end drives the control grid negative, preventing tripping. In the case of internal faults, the phase of the line current at one terminal reverses, causing the control grid of the comparer tube to be driven negative by the received signal when the screen grid is swung negative by the local signal. On the next half cycle, the screen grid is swung positive and no carrier signal is received to drive the control grid negative. Plate current flows in the comparer tube, and the relay trips.

For a fault fed from one end only, the relay at that end trips its breaker, but no tripping will occur at the remote terminal. As with all carrier-pilot relaying equipment, if carrier current is being transmitted for auxiliary purposes from a terminal having no infeed, tripping cannot occur at any end.

Relay Equipment:

A complete phase-comparison carrier-current relay terminal consists of carrier-current and relay equipment. Carrier-current equipment is composed of a transmitter, receiver, voice modulator, and test equipment. Relay equipment consists of a network unit, a breaker trip unit, and test equipment.

The network and tripping units can be broken down further into the following basic components, connected schematically as shown in Fig. 1: A negative-phase-sequence network, a voltage amplifier, fault detectors, a power amplifier, phase shifter, comparer, and signal alarm. The negative-sequence network, power amplifier, comparer, and signal alarm are substantially the same as in superseded equipment.

Negative-phase-sequence network. This network converts the three-phase current into a single-phase voltage. Greater sensitivity during single-phase-to-ground faults can be obtained, if necessary, by adding zero-phase-sequence current to the network. Operation on three-phase faults is obtained by adding a positive-phase-sequence component to the network, by the operation of three-phase-overcurrent units. The use of negative-sequence or negative-plus-zero-sequence currents permits operation in the load area on all but three-phase faults.

Voltage amplifier. This element is new, and it accounts for several of the improvements noted previously. Output from the negative-phase-sequence network is fed to a wave-forming, push-pull voltage amplifier. Here, the small sinusoidal signals are amplified and formed into square waves. Output signals from the amplifier are large enough to drive the following power amplifier stage to saturation at minimum fault current levels. Thus, the relay operates at full carrier power for all magnitudes of fault current above the pickup level.

Fault detectors. The square-wave output of the voltage amplifier is fed to an isolated full-wave rectifier, whose DC output is used to operate the fault detectors. This method of fault-detector operation gives high-speed relay operation at fault currents just above pickup level. The low-set fault detector, FD-L, determines the magnitude of current at which the transmitter will be modulated and send a blocking signal to the opposite end to prevent tripping.

The high-set fault detector, FD-H, determines the fault-current magnitude necessary to initiate phase comparison

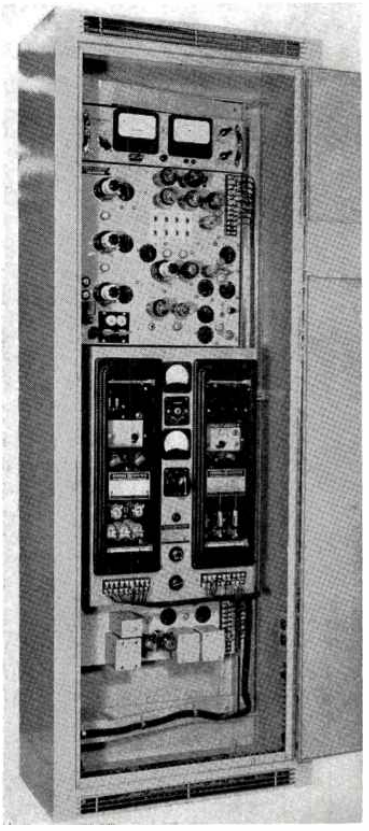


FIG. 2. CABINET HOLDS RELAY, CARRIER UNITS

and permit tripping. Both FD-L and FD-H are continuously adjustable over a wide range to compensate for the possible two-to-one ratio of fault current magnitudes between the ends of a three-ended line and to meet various line conditions. Normally, FD-H is set 50% above FD-L to give a 50% safety-margin between the blocking and tripping function of the relay. Grid limiting is used to obtain a .004-sec. delay of FD-H behind FD-L. This ensures that regardless of fault-current magnitude, the blocking signal will arrive from the remote end before phase comparison can begin.

A normally closed contact on FD-L is used to cut off the power amplifier until FD-L picks up. This prevents carrier transmission, and interference with auxiliary functions of the relaying equipment, until a predetermined fault magnitude occurs. Operation of the power-amplifier in this manner makes for a long tube life, dependent almost entirely on that of the heater.

Power amplifier. The output from the voltage amplifier in the network unit, substantially a square wave, is used to drive the power amplifier of the tripping unit. Normally, the power amplifier is cut off by means of a contact on FD-L. As soon as FD-L picks up, the power amplifier is turned on and driven to saturation, insuring maximum carrier output for blocking purposes. The power amplifier, through a transformer, provides a square-wave signal to the screen of the carrier-current transmitter. From another winding on this same transformer, the power amplifier provides a signal to the comparer-tube screen grid 180° out of phase with that furnished the transmitter.

Phase shifter. A simple, adjustable phase-shift network of the resistance-capacitance type, Fig. 1, delays the power-amplifier signal to the comparer-tube screen grid behind the signal applied to the transmitter. This time-delay compensates for the time of carrier-current propagation between terminals of long transmission lines.

Comparer tube and trip relay. The comparer tube is the heart of the phase-comparison relay. All other elements either determine when phase comparison occurs, or transform the line currents into quantities suitable for operating or restraining the trip relay via the comparer tube. Operation of the comparer and trip relay have been explained previously.

Test equipment. No important changes have been made in the DC test equipment. A major improvement, however, has been made in the AC test equipment. Rather than simulating fault-current magnitude above the tripping value, it is now possible to test the response of either the blocking or the tripping units simply by turning a test switch. Also, a test switch position is provided to take the equipment out of service without the danger of tripping should the load over the protected line be above the tripping level.

Carrier-Current Equipment:

Carrier-current equipment used for phase-comparison relaying is, in many respects, similar to that used with directional-comparison relaying. This similarity has facilitated the design of a

(Continued on page 30)

TELEMETERING UNITS

(Continued from page 26)

ing contact was connected to contact A during one revolution. Twenty-seven pulses later this connection is made again, so that pulse A2 represents the amplitude of this same quantity 1/5 sec. later in time.

Where all the commutated information is fed to one recorder, as in Fig. 26, it is necessary to count the individual pulses to pick out the required information for any one channel. This is known as manual data separation, and it is tedious work at best. Ordinarily, one of the subchannels is fed a fixed reference pulse to provide easy identification of the various information pulses.

In order to facilitate the separation of commutated data, electronic means were developed to separate the pulses in the sequence in which they were sampled, and to record the information from each commutated pickup separately. Automatic data separation is provided by a pulse selector and commutator analyzers, which select every twenty-seventh pulse, integrate it, and feed it to an individual recorder.

The system can be extended to 58 channels by utilizing two basic channels for commutating purposes.

STANCIL - HOFFMAN CORPORATION, *1016 N. Highland Avenue, Hollywood 38, California.* Magnetic tape recorders and reproducers for telemetered data are supplied by Stancil-Hoffman. These are single-channel, wide-range units, with frequency response flat from 40 to 30,000 cycles, ±1 db. Fig. 27 shows the tape transport mechanism of the R4-30 and, just above it, the amplifier assembly. Plug-in recording and playback amplifiers are in the center section. A mixer can be provided, as shown at the bottom of the amplifier assembly, or two individual preamplifiers for recording. The equipment is portable, and can be operated either horizontally or vertically.

Timing accuracy is ±1 sec. per half hour. Playing time is 33 mins. maximum at the standard tape speed of 30 ins. per sec. Flutter and wow are said to be less than .09% rms. Maximum harmonic distortion is claimed to be 1% at full normal level, and signal-to-noise ratio at least 60 db, measured by the NAB standard method. Controls are interlocked electrically to prevent inadvertent erasure. Complete braking is provided, so that it is virtually impossible to damage the tape by any means while it is on the transport mechanism.

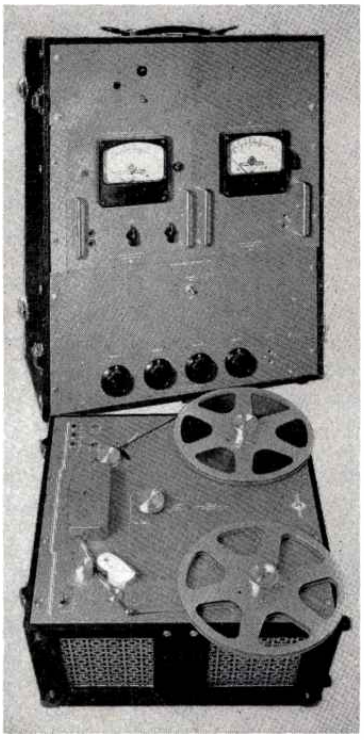


FIG. 23. STANCIL-HOFFMAN TM DATA RECORDER

RELAYING SYSTEM

(Continued from page 30)

readily applicable to three-terminal lines than the superseded units, a word of caution is in order. When applied to three-terminal lines, any phase-comparison relaying equipment must necessarily be less sensitive than when applied to two-terminal lines, sometimes only half as sensitive. Also, its application may be precluded because of phase-angle differences resulting from different X/R ratios of the several zero-phase-sequence paths, or because of different ratios of negative to zero-phase-sequence currents flowing through the three terminals. Each application must be judged separately.

FIELD SERVICE NOTES

Every radio system, at the time of installation or in the course of operation, presents special problems which must be solved by communication engineers or maintenance men.

In response to many requests, we shall provide a new department, under the title of Field Service Notes, where such experiences can be exchanged. If you have met and solved a problem, of installation, operation, or maintenance, or if you are seeking help with a difficulty you haven't been able to lick, write a letter about it, include pencil diagrams if necessary, and send it to Field Service Notes, RADIO COMMUNICATION, The Publishing House, Great Barrington, Mass.

To encourage this exchange of ideas and information, payment of $5.00 to $10.00 will be made for each letter published. Be sure to give your complete name and address.

COMMUNICATION NEWS

(Continued from page 21)

siderably by Motorola's introduction of the police radio call box illustrated here.

This call box comprises a Handie-Talkie unit equipped with dry cells but operated normally from AC, together with a selective calling device and a signal light. When the police radio dispatcher wants to talk to a particular patrolman, he transmits a selective signal over the regular radio transmitter. At the box selected, a tuned circuit responds by closing a relay which, in turn, switches on a light above the box. When the patrolman sees the light, he unlocks the box and calls headquarters over the Handie-Talkie. If he is given an assignment that requires communication with headquarters, he can remove the Handie-Talkie, carry it off with him, and replace it later.

Two-Way Radio in Hawaii:

The FCC has authorized the use of TV channels 5 and 6 (76 to 88 mc.) and the lower half of the FM band for inter-island common carrier radio communication. Success of multiplexed FM radiotelephone installations already in use there indicates that this is the practical answer to the growing demand for telephone service between the islands. Remaining TV and FM channels are adequate for such services in the Territory.

Hand-Carried Units:

Sale of low-power, hand-carried transmitter-receiver units is climbing to substantial proportions, as indicated by the summary of 2nd quarter applications published in this issue. Biggest single order so far will be place by the State of California, which recently asked for bids on 1,000 of these units. Largest previous orders have come from the telephone companies.

Use of 450 Megacycles:

In the course of a conversation with Jeremiah Courtney at Washington, we mentioned the fact that we had been looking for some real activity on 450 to 460 mc., yet very few applications had been filed in that band. Mr. Courtney offered three reasons: 1) The interruption of Link Radio's production of 450-mc. equipment, 2) the fact that Motorola has only started to deliver such equipment, and 3) the lack of detailed reports on operating experience. However, initial information will be available shortly, and those who have been following up the performance of 450-mc. installations are highly enthusiastic about operation on the new band.

NARROW-BAND UNITS

(Continued from page 23)

way toward increasing the number of systems in a particular area without increasing the interference as much as would be the case should extensive co-channel operation be adopted. For example, even with the older receivers, the area of interference to mobile units 20 kc. off frequency from a 50-watt transmitter with a 200-ft. tower is less than one-half (2,450 square miles) the area of interference that would result if the two systems were on the same channel (5,000 square miles) and furthermore, by the installation of narrow-band receivers, this interference area can be reduced to less than 100 square miles.

These summaries show also that to obtain maximum utilization of the spectrum space, even with 20-kc. spacing, it will be necessary for present wide-band users to reduce transmitter deviations to minimize interference to adjacent 20-kc. systems.

Because there is a great amount of 40-kc. equipment in operation, any changeover to a 20-kc. spacing should be carried out in such a manner as to avoid causing severe interference to the 40-kc. equipments. At the same time, however, the demand for frequencies in certain radio services may leave no alternative except 20-kc. spacing. The frequency coordinating committees of the various services have done outstanding jobs in coordinating present channel assignments and are familiar with the assignments in their particular areas. Therefore it is believed that, should the FCC permit closer channel-spacings, the changeover can be accomplished by the local coordinating groups with a minimum of confusion and interference to existing users.

It is understandable that any company presently obtaining satisfactory communication service with equipment even 4 or 5 years old would be reluctant to convert any or all of the equipment in order to facilitate split-channel operations. But an examination of the overall problem by the user would, no doubt, show that such split-channel operation might be considered the lesser of two evils. Where as co-channel interference might cover distances of 50 to 100 miles, the interference from an adjacent 20-kc. channel with only ±6 kc. swing might affect only two or three units of the existing system in the same immediate area. Furthermore, this interference could be eliminated by installing receivers only at those points, as it has been demonstrated clearly that wide and narrow-band receivers can be mixed without detrimental effects. The existing system might also find it necessary to re-

(Concluded on page 37)

FCC Television Grants

RADIO COMMUNICATION Magazine, in line with its policy of providing complete information on matters of interest to the industry, is presenting each month data on television station CP's, channel changes, and power increases granted by the FCC. Actions listed below are for the period from July 11 to August 15, 1952.

Information given for CP grants consists of the city, channel number, visual and aural ERP's, estimated cost of construction, and principal owner or owners. If grantee controls audio broadcast station, call letters are given in parentheses. For existing TV stations granted channel changes or power increases, information given consists of cities, call letters, old and new channels, and old and new visual ERP's. Grants are listed alphabetically by states. A star preceding a channel number indicates that the authorization is for a non-commercial educational station.

CONSTRUCTION PERMITS GRANTED

	CH.	KW.	COST
Mobile, Ala.	48	22.5-12	$152,200
Pursley Broadcasting Service (WKAB)			
Denver, Colo.	2	56-28	$364,500
Eugene P. O'Fallon, Inc. (KFEL)			
Denver, Colo.	9	240-120	$394,000
Colorado Television Corp. (KVOD)			
Denver, Colo.	26	105-52	$347,000
Empire Coil Company			
Bridgeport, Conn.	43	81-46	$223,900
Sthn. Conn. & Long Island TV Co (WICC)			
Bridgeport, Conn.	49	99-60	$223,600
Harry L. Liftig			
New Britain, Conn.	30	180-90	$323,800
New Britain Bcstg. Co. (WKNB)			
Ft. Lauderdale, Fla.	17	18.5-10.4	$336,400
Gerico Investment Co. (WBRD)			
Ft. Lauderdale, Fla.	23	100-56	$311,000
Gore Publishing Co. (WFTL)			
Manhattan, Kans.	*8	52-26	$362,600
Kansas State College			
Ashland, Ky.	59	250-130	$311,000
Polan Industries			
Baton Rouge, La.	28	225-115	$278,300
Modern Bcstg. Co. (WAFB)			
Holyoke, Mass.	55	65-35	$180,000
Hampden-Hampshire Corp (WHYN)			
New Bedford, Mass.	28	200-100	$396,000
E. Anthony & Sons (WNBH)			
Springfield, Mass.	61	115-58	$265,000
Springfield TV Bcstg. Corp.			
Flint, Mich.	28	17.5-8.7	$189,400
Trans-American TV Corp.			
Albany, N. Y.	*17	205-110	$251,000
Univ. of State of New York			
Binghamton, N. Y.	*46	200-105	$251,500
Univ. of State of New York			
Buffalo, N. Y.	*23	205-105	$251,500
Univ. of State of New York			
New York, N. Y.	*25	204-110	$251,500
Univ. of State of New York			
Rochester, N. Y.	*21	205-105	$251,500
Univ. of State of New York			
Youngstown, Ohio	27	200-100	$353,000
WBKN Broadcasting Corp.			
Youngstown, Ohio	73	175-89	$972,000
Vindicator Printing Co. (WFMJ)			
Portland, Ore.	27	91-46	$347,000
Empire Coil Company			
Scranton, Pa.	22	290-150	$336,300
Scranton Bcstrs., Inc. (WGBI)			
Scranton, Pa.	73	11-5.9	$138,000
Appalachian Company			
York, Pa.	49	96-54	$176,500
Helen Coal Company			
York, Pa.	43	170-86	$305,500
Susquehanna Bcstg. Co. (WSBA)			
Austin, Tex.	18	216-108	$405,500
Capital City TV Company			
Austin, Tex.	7	110-55	$341,000
Texas Bcstg. Company (KTBC)			
El Paso, Tex.	4	56-28	$253,000
Roderick Bcstg. Co. (KROD)			
El Paso, Tex.	9	64-32	$201,000
Tri-State Bcstg. Co. (KTSM)			
Spokane, Wash.	6	100-50	$331,900
KHQ, Inc.			
Spokane, Wash.	4	100-55	$377,000
KXLY and Bing Crosby			
Honolulu, Hawaii, T.H.	9	35-17.5	$345,000
Hawaiian Bcstg. System, Ltd. (KGMB)			
San Juan, P. Rico	2	100-50	$463,355
El Mundo Bcstg. Corp. (WKAQ)			

AUTHORIZED CHANNEL CHANGES AND POWER INCREASES

	CALL	CH.	KW.
Brmgham, Ala.	WBRC-TV	4 to 6	14 to 100
Atlanta, Ga.	WLTV(TV)	8 to 11	24 to 316
Louisville, Ky.	WAVE-TV	5 to 3	7 to 100
Gd. Rapids, Mich.	WOOD-TV	7 to 8	20 to 316
Rochester, N. Y.	WHAM-TV	6 to 5	17 to 100
Syracuse, N. Y.	WSYR-TV	5 to 3	23 to 100
Cincinnati, Ohio	WCPO-TV	7 to 9	24 to 316
Cincinnati, Ohio	WKRC-TV	11 to 12	25 to 316
Cleveland, Ohio	WNBK-TV	4 to 3	15 to 87
Cleveland, Ohio	WXEL-TV	9 to 8	7.5 to 316
Dayton, Ohio	WHIO-TV	13 to 7	24 to 200
Johnstown, Pa.	WJAC-TV	13 to 6	6.5 to 70
Pittsburgh, Pa.	WDTV(TV)	3 to 2	17 to 100
Providence, R. I.	WJAR-TV	11 to 10	30 to 316
Norfolk, Va.	WTAR-TV	4 to 3	24 to 100
Huntington, W. Va.	WSAZ-TV	5 to 3	17 to 84
Milwaukee, Wisc.	WTMJ-TV	3 to 4	1 to 100

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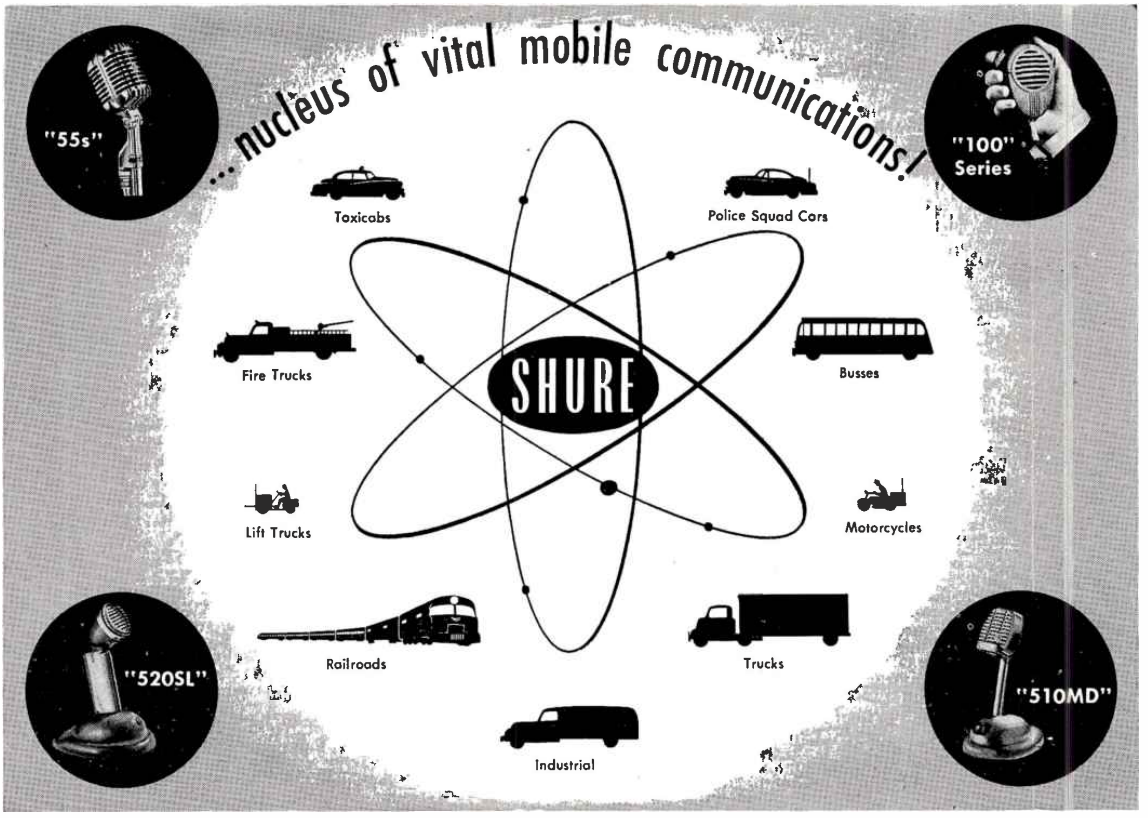


PATTERN FOR TV PROFIT

(Continued from page 16)

contemplated for the frequency band involved, or that information was not available.

There is a trend toward the provision of standby transmitters for emergency use. As the card rate of a station increases, even short-time outages become extremely expensive. Many stations now have night card rates of well over $1,000 per hour, some over $8,000 per hour. It can be seen that a serious breakdown for such a station would be very costly, and that a low-power standby transmitter might very well pay for itself in a short time.

Next month, antennas and transmission lines will be discussed.

New FCC Applications

This list includes applications for mobile, point-to-point, control, and relay communication facilities filed with the FCC from July 21 to August 15, 1952

This listing, provided as a regular monthly feature, is made possible by the cooperation of the Federal Communications Commission. Each listing shows the name and address of the applicant. If the transmitter is to be located in a different city, the name of the city appears on the second, indented line. The number and type of facilities are shown, with the operating power, frequencies, and the make of equipment for which applications have been filed. These may, of course, be changed before licenses are issued. Explanation of the code letters used in this listing appears below.

WEEKLY REPORTS

For the benefit of those who want to receive this data in advance, RADIO COMMUNICATION can furnish weekly reports. Requests for information on this service, and questions concerning these listings should be addressed to the Registry Editor.

CODE LETTERS

The following letters indicate the type of facilities for which applications have been filed. Unless indicated otherwise, FM operation is to be employed:

a AM operation	q Control station
b Base station	r Repeater or relay
m Mobile unit	s Fixed
mm Marine Mobile	t Temporary
p Portable unit	u Operational
	w Watts

Make of equipment is indicated by one of these letters:

AA Aircraft Radio	M Motorola
A Hallicrafters	N Gen. Railway Signal
B Belmont-Raytheon	NN Ntl. Aero. Corp.
BB Northern Radio	O Farnsworth
C Comco	P Philco
D Doolittle	Q Collins
E W. Coast Electronics	R RCA
F Federal Tel. & Radio	S Railway R. & S.
G General Electric	SS Sonar
H Harvey	T Bendix
J Comm. Equipment	U Western Electric
K Kear	W Westinghouse
L Link	WW Wilcox
Y Budleman	X Miscellaneous

AERONAUTICAL & FIXED

Alaska Aeronautics & Communications Comm Box 121 Juneau Alaska
East Point Alaska 1b 50w 2.474, 2.512, 5.622, 5.652 X
Port Graham Alaska 1b 30w 2.632, 2.986, 3.190, 3.202, 3.265, 5.622, 5.652 H
Tyonke Alaska 1b 15w 7 channels as above X
Nikolski Alaska 1b 15w 7 channels as above X
Perryville Alaska 1b 20w 7 channels as above A
Akutan Alaska 1b 75w 7 channels as above A

Belkofski Alaska 1b 30w 7 channels as above R
Trans-Pacific Air Lines Ltd Box 2133 Honolulu TH 1m 50w 129.1, 129.3 WW

Morrison Knudsen Co Box 320 Anchorage Alaska 1s 100w 2.986, 3.190, 5.137, 5.167, 5.622, 5.652 NN
Aeronautical Radio Inc 1523 L St NW Washington DC 1m 100w 1.134, 1.136, 1.233, 1.342, 1.505, 1.631, 1.663, 1.836, 2.976, 3.127, 3.432, 3.485, 4.742, 5.577, 5.612, 6.557, 8.220, 8.523, 8.700, 8.841 Q
Fork Mountain Va 2b 50w 131.9 L
Queens County Airport N Y 1b 250w 131.9 WW
Watertown N Y 1b 9.9w 129.7 T
Yreka Calif 1b 10w 130.7 X
Fork Mountain Va 2us .15w 6.705 M
Poplar Heights Va 1us .15w 6.585 M
Cordova Airlines Inc Cordova Alaska
Gulkana Alaska 1b 250w 2.922, 5.622, 5.652 X
Howard Chester Hayes Box 856 Juneau Alaska 1s 15w 2.474, 2.632, 2.512, 3.190, 5.622, 5.652 —

AIRDROME CONTROL

Robert L Tanner Port Lavaca Tex 1b 15w .278 G

FLIGHT TEST

Bell Aircraft Corp Helicopter Div Box 482 Fort Worth Tex 20m 15w 123.10 X

FLYING SCHOOL

Gibbons Aircraft Inc Rte 2 Box 368 Tyler Tex 2m 4w 123.1 NN

AERO MOBILE UTILITY

Northwest Precote Inc 7343 E Marginal Way Seattle Wash 1m 9w 121.9 T
City Phila Int'l Airport Philadelphia 42 Pa 10m 5w 121.9 C
City of Omaha Municipal Airport Omaha Neb 10m 4w 121.9 C

AIRDROME ADVISORY

Walter E Nix Marietta Ga 1b 4w 122.8 NN
Marshall Flying Serv Marshall Minn 1b 4w 122.8 NN
Shelton Flying Serv Cairo Ill 1b 4w 122.8 NN
Robert L Tanner Jr Port Lavaca Tex 1b 10w 122.8 T
Clarence M Miller Valentine Neb 1b -w 122.8 NN
Aeronautical Radio Inc 1523 L St NW Washington DC Raleigh County Airport W Va 1b 100w .266 X
Springfield Airport Auth Capitol Airport Springfield Ill 1m 4w 122.80 NN
City of Mt Pleasant Mich 1b 2w 122.8 X
Benson Airport Rte 8 White Bear Lake Minn Bald Eagle Lake Community Minn 1b 10w 122.8 T
Cantrell Aero Serv Conway Ark 1b 15w 122.7, 122.8 X
Clarence F Sylvester Goshen Ind 1b 4w 122.8 NN

(Continued on page 38)

NARROW BAND UNITS

Continued from page 33)

duce the deviation of the wide-band transmitter slightly, in order to avoid swinging into the pass-band of the narrow-band system 20 kc. off its channel frequency. As has been pointed out, a compromise value of 8 to 12 kc. would have no noticeable effect on the operation of the existing system, and would materially reduce or eliminate any interference to the narrow-band system.

The procedure outlined above may possibly be an over-simplification of the problem, but it does point out a way of obtaining relief from the present congestion, provided that the FCC will agree to permitting frequency assignments between channels at the discretion of the individual Frequency Chairmen.

If this cannot be carried out, all users must expect more and more co-channel operation on the present frequencies. New users of radio cannot reasonably be denied facilities, and they must have frequencies upon which to operate. Unless new frequencies become available, it will be necessary to put more and more systems on the same channels in the same areas.

SPOT NEWS NOTES

(Continued from page 11)

ture and Television Engineers. This annual award is for technical contributions to the television art.

Film Shows Microwave Progress:

A 20-minute, 16-mm. color film with sound has been made by Federal Telephone & Radio Corporation to show how microwave communication is being used by various types of industries. The film is highly informative for those interested in microwave applications. It can be borrowed without charge by company officials or organizational groups, upon application to Crump Smith, 100 Kingsland Road, Clifton, N. J.

Dr. Harold S. Osborne:

Chief engineer of AT & T has retired after 42 years with the Bell System. He will be succeeded by H. I. Romnes, who has been director of the long lines department since 1950.

Reliability of Microwave Systems:

Report on the performance of Western Union's five 2-way microwave systems—two between New York and Philadelphia and one each connecting New York, Washington, and Pittsburgh as a triangle —shows outages in per cent of total time reduced from 2.17% in 1949 to 1.5% in 1951. In that period, klystron failures were cut from .25 to .13%.

NEW APPLICATIONS

(Continued from page 36)

Savery Lewis Stuckey Ruston La 1b 4w 122.8 NN
Delfor Bowman Wray Colo 1b 4w 122.8 NN
Alan M Seaife Ligonier Pa 1b 4w 122.8 NN
Flight Line Inc Lincoln Nebr 1b 3w 122.8 NN
Sarasota Manatee County Joint Airport Authority Sarasota Fla
Sarasota-Bradenton Airport Fla 1b -w 122.8 NN
Riverside Flight Academy Riverside Calif 1b 10w 122.8 X
Smith Flying Serv Forty-Fort Pa 1b 4w 122.8 NN
Cape Central Airways Cape Girardeau Mo 1b 4w 122.8 NN
Joseph H Bower Berwick Pa 1b 4w 122.8 NN

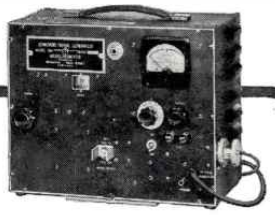
CIVIL AIR PATROL

CAP Ore Wing Int'l Airport Portland Ore Newberg Ore 1b 75w 2.374, 4.507, 4.585 X
CAP Ark Wing Adams Field Little Rock Ark Conway Ark 1b 75w 4.507, 4.585 A; 1b 50w 148.14 X; 1b 1w 5.500 X; 10 m 50w 148.14 X; 2m 50w 4.507, 4.585 R; 10m 1w 5.500 X
CAP Congressional Sqdn 4561 Cathedral av NW Washington D C Rockville Md 1b .8w 122.8 —
CAP Hdqtrs Kans Wing 434 Maple Wichita Kans Pratt Kans 1b 2.374, 4.507, 4.585 R; 1b 15w; 10m 15w 148.14 TX; 15m 15w 4.507, 4.585 X
CAP Louisville Sqdn 2 Louisville Ky 1b 75w; 1b 50w; 16m 50w; 2m 10w; 3m 25w; 3s 50w 4.325, 4.585 X
CAP Nevada Wing Fallon Nev 1b 75w 4.507, 4.585, 15w 148.14; 1w 5.500 T; 3m 45w 4.507, 4.585; 15w 148.14; 1w 5.500 T
CAP Mich Wing 84 S La Vista Blvd Battle Creek Mich Marshall Mich 1b 8.2w 148.14 X
CAP Ark Wing Paragould Ark 1s 75w 4.507, 4.585 X
CAP Texas Wing Dallas Tex 1b 40w; 24m 40w 2.374, 4.507, 4.585 X
CAP Cortland Sqdn Binghamton Grp NY Wing % Lt J H Knobel 32 Cayuga St Homer N Y Cortland N Y 3b 40w 2.374, 4.507, 4.585 U; 5m 6w 4.507, 5.500, 4.585 R; 1b 1w; 4m 1w 5.500 M
CAP Wausau Flight Wisc Wing Wausau Wisc 3b 10w; 1m 10w 148.1; 1b 1w; 4m 1w 5.500; 1b 75w 2.374, 4.507; 1m 75w 4.585 X

POLICE

City of Los Angeles Calif 1b 10w 954.4; 1b 10w 955.4; 1b 10w 959.4 R
Marshall County Sheriff Marysville Kans 1b 140w; 10m 85w 39.58 M
Town of Covington Va 6m 60w 39.5 M
Town of McCardless Pa Allison Park Pa 1m 120w 39.38 M
City of Rome N Y City Hall 10m 10w 155.01 M
Town of Harvard Mass 2m 30w 37.1 LM
Village of Merrionette Pk 11444 S Albany Chicago 43 Ill 2m 30w 155.19 M
Village of Rockton Ill 503 E Franklin 1b 20w; 2m 20w 155.25 M
City of Springfield Ill 601 Sangamon Ave 1b 150w 42.50 M
City of Oak Park Mich 13600 Oak Pk Blvd 1b 30w; 10m 30w 155.01 M
Archer County Sheriff Archer City Tex 3m 150w 42.90 G
Boro of Midland Pk N J 1b 120w; 3m 6w; 4m 2w 158.73 M
Delaware County Sheriff Manchester Ia 1b 120w 37.1 M
Hamphill County Sheriff Canadian Tex -m 150w 37.18 G
Twp of Troy 60 Walles Rd Birmingham Mich 1b 50w 155.37, 155.73 G
Boro of E Stroudsburg Pa 1b 120w; -m 120w 155.25 M
Vermillion County Sheriff New Port Ind 1b 80w; -m 80w 155.13, 155.37 G
Boone County Sheriff Lebanon Ind -m 80w 154.89, 155.13 G
State of Ark Box 1189 Little Rock Ark 1r 60w 155.79 M
Daniels County Sheriff Scobey Mont 1b 500w; 5m 75w; 2m 3w 39.82 M
City of Cornelius Ore 1b 60w 155.01 F
Town of Portsmouth R I 1m 60w 39.78 M
Fairfield County Sheriff Winnsboro S C 1b 120w; 15m 120w 45.54 M
Town of Belchertown Mass 2b 30w; 3m 30w 158.79 M
City of Alma Ga 1b 25w; 8m 25w 155.31 G
State of Kans 100 Van Buren Topeka Kans Mankato Kans 1b 120w 44.98; 1r 120w 75.98 G Linn Kans 1r 120w 75.98 G
City of Lebanon Ore 1b 120w; 10m 60w; 2m 2w 155.01 M
Village of Babylon N Y 1b 120w; 10m 60w 45.58 R
Orange County Sheriff Orlando Fla 1m .2w 2455 Speedmeter
Hamilton County Sheriff Aurora Neb 1b 60w; 5m 30w 39.90 M
Village of Greenfield Ohio 1b 140w; 4m 40w 39.58 M
Town of New Castle Chappaqua N Y 1b 120w; 13m 60w 39.1 M
Fillmore County Geneva Nebr 1b 60w; 5m 30w 39.9 M
Sheridan County Plentywood Mont

(Continued on page 41)



Measurements Corporation
MODEL 78

STANDARD SIGNAL GENERATORS

FREQUENCY RANGE: Choice of two bands; frequency ratio of each band 1.8 to 1 within range of 10 Mc. to 250 Mc. Special single band instruments also available up to 420 Mc.

OUTPUT VOLTAGE: Continuously variable from 1 to 100,000 microvolts.

MODULATION: AM, fixed at 30%.

POWER SUPPLY: 117 v., 50/60 cycles.

MEASUREMENTS CORPORATION
BOONTON NEW JERSEY

HARRISON HAS IT!

Brand New

STEEL TOWERS

20-30-40-50 Feet

Self-Supporting...Unguyed
Stronger . . . 3 Post Design

IN STOCK at SLASHED PRICES!

These sturdy, heavy gauge towers actually cost you less than "direct-from-factory" lightweight 4 post towers. You save $$$. . . but, you must act soon!

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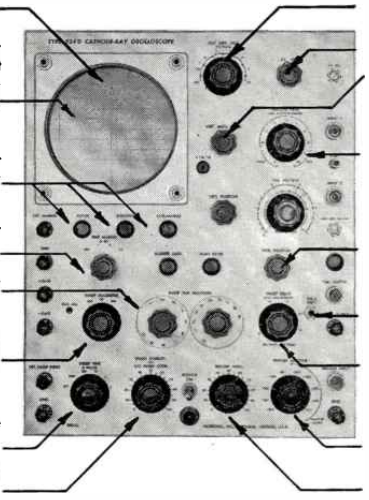
HARRISON RADIO CORP
225 GREENWICH STREET
NEW YORK 7, N.Y.

TV broadcasters!

HERE IS AN OSCILLOSCOPE WITH THE NECESSARY FEATURES FOR PROPER MAINTENANCE AND ADJUSTMENT OF TV TRANSMITTING AND STUDIO EQUIPMENT



The TEKTRONIX Type 524-D is a precision laboratory oscilloscope with many specialized television features. A completely new sweep magnifier expands the image to left and right of center, to either 3 times or 10 times normal width—***provides you with a minutely detailed display of sync and equalizing pulses.*** The variable sweep delay circuit provides a zero to 25 millisecond delay. Delayed sweeps, triggered by any line sync pulse throughout the picture, are available through the entire sweep range of 0.01 sec/cm to 0.1 μsec/cm. Field selector lets you switch from one field of the frame to the other at will.

Vertical Sensitivity
dc to 10 mc — 0.15 v/cm
2 cps to 10 mc — 0.015 v/cm

Transient Response
Risetime — 0.04 μsec

Signal Delay
0.25 μsec

Vertical Deflection
More than 6 cm undistorted

Sweep Range
0.01 sec/cm to 0.1 μsec/cm continuously variable, accurate within 5% of full scale

Internal Time Mark Generator
Modulates trace brightness, pips spaced 1 μsec, 0.1 μsec, 0.05 μsec, or 200 pips per television line

Regulation
All dc voltages electronically regulated

TEKTRONIX TYPE 524-D TELEVISION OSCILLOSCOPE
$1180 f.o.b. Portland, Oregon

TEKTRONIX, Inc.
P. O. Box 831J, Portland 7, Oregon **Cable: TEKTRONIX**

NEW APPLICATIONS

(Continued from page 38)

1b 80w; 5m 75w; 2m 3w 39.82 M
City of San Marcos Tex 1b 80w; 6m 30w 155.13 M
Boro of Moonachie N J 13 Broad st 1m 80w 37.1 L
City of Willamina Ore 1b 125w; 4m 54w; 4m 125w 39.18 G
City of Evansdale Ia 1b 21w; 2m 21w 155.25 M
Caln Twp Thorndale Pa 3m 105.6w 155.13 G
Cass County Plattsmouth Neb 1b 60w 39.90 M
Village of Annawan Ill 1m 30w 154.89 M
Village of Crete Ill 1b 30w; 4m 30w 155.19 M
Minn State Police 1279 Univ Av St Paul 4 Minn
Nr Rochester Minn 1b 30w 159.21 M
Nr Alma Wis 1b 30w 155.91 M; 1b -w -G
Town of Maiden N C 3m 20w 45.5 M
Nash County Nashville N C 1b 120w; 15m 60w; 6m 1w 39.42 M
Morton County Richfield Kans 1b 40w; 5m 80w 39.58 M
Elkhart Kans 1b 140w; 5m 80w 39.58 M
Rolla Kans 1b 40w; 5m 80w 39.58 M
Merced County Merced Calif 1q 60w 72.7 M
Mariposa Calif 1r 60w 75.5 M
Rapids Parish Alexandria La 5m 3w 39.5 M
Police Dept So Holland Ill 2m 27w 37.14 M
City of Hartwell Ga 5m 24.8w; 1b 24.8 156.03 R
City of Levelland Tex 3m 120w 37.18 M
N M State Police Box 919 Santa Fe N M
1p .2w 2455 speedmeter
City of Coquille Ore 1b 120w; 10m 60w; 2m 2w 155.01 M
Town of Merrimac Mass 1b 60w; 10m 30w 39.82 M
Ind State Police Stout Field Indianapolis Ind
South Bend Ind 1b 500w 42.42 M

FIRE

Roseland Fire Dept Santa Rosa Calif
1b 120w; 6m 20w 154.31 M
Simsbury Fire Dist Simsbury Conn 1b 60w; 12m 30w; 2m 1w 33.94 M
Berkey Fire Dept Berkey Ohio 3m 75w 33.74 G
Fire Dept 422 LaSalle Ottawa Ill
1b 30w; 6m 12w 154.19 M
Fire Dept 93 Belmont Av Jersey City N J
1b 120w 166.25 M
City of Winchester Va 1b 119w; 15m 59.5w 154.37 R
Boro of Latrobe Pa 1b 120w; 10m 120w 33.7 G
City of Springfield Ore 1b 120w; 2m 60w; 8m 30w; 2m 2w 154.43 M
Fire Headquarters Reno Nev 1b 500w; 6m 75w; 15m 28w; 4m 3w 46.06 M
Fire Headquarters Galena Kans 1b 60w; -m 60w 154.37 M
Town of Eliot Me 1b 30w; 5m 30w 154.19 L
Grays Lake Vol Fire Dept Grays Lake Ill
1b 120w; 1m 20w 154.31 M

FORESTRY

Washington Forest Fire Assn 949 Henry Bldg Seattle Wash 1m 10w 31.18, 31.34, 31.46 X
Ark Resources Dev Comm Little Rock Ark
1b 75w 31.58, 31.7, 31.82, 31.94 L
State of Calif Sacramento Calif 1b 30w 159.27, 159.33, 159.39, 159.45 R
Ala Dept of Conservation 607 Monroe St
Montgomery Ala
George County Miss 1b 30w 159.45 M
Clarke County Miss 1b 30w 159.45 M
Md Dept of Forests & Parks Annapolis Md
Nr Northeast Md 1b 75w 31.34 M
State Dept of Forestry Box 811 Waycross Ga
Evans Ga 1b 30w 159.39 M
State Div of Forestry Chillicothe Ohio
Nr Londonderry Ohio 1b 75w 31.34, 31.46 X
Nr Vernon Ohio 2b as above
Nr Taylorsville Ohio 1b as above
Nr Buena Vista Ohio 1b as above
Nr Friendship Ohio 2b as above
Nr Loudonville Ohio 1b as above
Nr Lecta Ohio 1b as above
Nr Linnville Ohio 1b as above
Ore State Dept of Forestry 2600 State St Salem Ore
Nr Klamath Falls Ore 1b 100w 30.94, 2.236 X; 1 usr 60w 159.39; 1 usq 60w 170.57 M

HIGHWAY MAINTENANCE

State of W Va Box 410 Buckhannon W Va
Mercer C Princeton W Va -r 120w 72.54 G

SPECIAL EMERGENCY

Clyde D Lyle Waukesa Wis
1b 60w; 1m 30w 47.66 M
Dr A L Blalock Sylvania Ga 1b 30w; 2m 30w 47.5 M
R C Schnelle Minster Ohio
1b 25w; 2m 25w 47.46 M
Drs W F Ellgen & L W Klein Ivanhoe Minn
1b 120w; -m 120w 159.75 M
Weedon Vet Clinic Main St Waxahachie Tex
1b 120w; -m 120w 47.50 M
Nash Cnty Bd of Education Nashville N C
-m 120w 47.62 M
F D Custer 2nd & Omar Oakland Md
-m 120w 47.62 M
Amer Ambulance & Oxygen Serv 1259 E North Av Baltimore Md 1b 120w; -m 60w 47.54 M
B J Thompson Rte 2 Sydney Ohio
1b 60w; -m 60w 47.46 M
W B Prendergast Stronghurst Ill
1b 60w; -m 30w 47.58 M
S W Underwood Box 464 Wapato Wash
Yakama County Wash -m 30w 47.46 M

Dr Cecil J Spears Enfield N C 1b 60w 47.66; 1m 30w 47.60 M
Lowell W Henchman Glenwood Ind
1b 124w; 2m 62w 33.02 G
M J Powell MD Bedminster N J
1b 120w; 2m 60w 47.54 G
Wm Lukens Hillsboro Ohio 1b 80w; 3m 80w 47.46 M
Long, Johnson & Fisher Funeral Home
Charleston W Va 1b 9w; 4m 9w 3.190 X
Horace N Davis DVM Lexington Ky
1b 120w; 3m 120w 47.58 M
Dr Marvin M Prentice New Plymouth Idaho
1b 124w; 2m 124w 47.58 G
Dr Harry R Munro Zeeland Mich
1b 50w; 1m 50w 47.54 G
Dr Robt L Prior Prosser Wash
1b 30w; 6m 30w 47.5 M
Paul E Neff Sheboygan Wis 1b 80w; 1m 30w 47.54 M
John G Thomas Antigo Wis 1b 120w; 1m 80w 47.58 M
Elgin S Scobell Wausau Wis
1b 120w; 1m 80w 47.66 M
Merrill Ranck Prospect Ohio 1b 20w; 1m 20w 47.66 M
Richwood Ohio 1b 20w; 1m 20w 47.66 M
Dr E L Stearly Phoenixville Pa
1b 120w; 2m 60w 47.46 M
Byrd & Bullington Vets Fayetteville Tenn
1b 120w; 4m 120w 47.5 M

STATE GUARD

Texas State Guard Box 613 Refugio Tex
Dallas Tex 1b 50w; 1b 132w 2.726 X

POWER UTILITY

Conn Power Co 266 Pearl St Hartford Conn
Torrington Conn 1b 120w 48.34 M
Northern States Power Co 15 S 5th Minneapolis Minn
Stillwater Minn 1b 70w 37.82 M
Aberdeen-Springfield Canal Co Aberdeen Idaho
1b 140w; 3m 30w, 10m 80w 47.86 M
West Penn Power Co Box 1736 Pittsburg Pa
Bellefonte Pa 1b 50w 47.9 L
Puget Sound Pr & Lt Co 860 Stuart Bldg Seattle 1
Burlington Wash 1b 120w 153.41 M
Puyallup Wash 1b 120w 153.41 M
Port Townsend Wash 1b 120w 153.41 M
Nr Electron Wash 1b 120w 153.41 M
Snoqualmie Falls Wash 1b 120w; 50m 120w; 50m .75w 153.41 M; 6p 60w 153.41 L
Tex Gas Util Inc Box 1092 Del Rio Tex
3b 500w; 15m 500w 48.50 R
Uvalde County Tex 2 us 150w 75.74 R
New Orleans Pub Serv 317 Baronne St

(Continued on page 43)

NEW APPLICATIONS

(Continued from page 41)

New Orleans La 4b 30w 153.59 M
Mo Pub Serv Co Hout Bldg Warrensburg Mo
1b 70w 37.54 G
Tex Pr & Lt 1506 Jackson Dallas Tex
Denton Tex -b 150w 37.50 G
Ark Pr & Lt Pine Bluff Ark -b 60w; -m 60w 37.54 M
La Pr & Lt 142 Delaronde St New Orleans La
Westwego La 1us 5w 95.97 W
Kenner La 1us 5w 95.97 W
Choctawahatchee EC Inc Box 512 DeFuniak Sprgs Fla
Baker Fla -r 120w 45.79 M
Texas Gas Util Inc Box 1092 Del Rio Tex
-b 150w 48.50 R
Eagle Pass Tex -b 500w 48.50 R
P R Water Resources Auth San Juan P R
Isabella P R -us 30w 153.53 M
Wisc Pr & Lt 122 W Washington Av Madison Wisc
Prairie du Sac Wisc 1b 80w 37.78 M
Ark-Mo Power Co 104 S 5th St Blytheville Ark
Poplar Bluff Mo -b 30w 153.71 M
Blytheville Ark -m 30w 153.71 M
City of Provo Utilities Provo Utah
1b 140w; 12m 140w 153.41 M
Iowa Pub Serv Co 502 6th St Sioux City Ia
Stormlake Iowa 1b 60w 47.90 M
Cherokee Iowa 1b 60w 47.90 M
Carroll Iowa 1b 60w 47.90 M
Electric Energy Inc Box 165 Joppa Ill
6m 10w 153.71 M
Dallas Pr & Lt Co Dallas Tex
1b 150w; 25m 75w 48.02 M
Power & Light Co 1330 Baltimore Kansas City Mo
Pleasanton Kans 1s 150w; 1s 520w 37.74 M
Pueblo Gas & Fuel Co Pueblo Colo
1b 50w; -m 10w, 35w 158.19 G
Cumberland & Allegheny Gas Co
800 Union Trust Bldg Pittsburgh 19 Pa
Cumberland Md 1b 75w; 25m 10w 153.65 L
Alabama Pr Co 600 N 18 St Birmingham Ala
Nr Tallahassee Ala 1su 5w 952-960 W
Tallahassee Ala 1su 5w 950-960 W
Wis-Mich Power Co Appleton Wis
1b 120w; 10m 60w 158.13 G
Intercounty ECA Licking Mo
St James Mo 1b 30w 158.19 M
Cent West Util Co 602 Finance Bldg Kansas City Mo
Bonner Springs Kans 1b 120w; 5m 60w 153.47 M
Town of Easton Md 1b 120w; 10m 30w 153.41 M
Aberdeen & Springfield Canal Co Aberdeen Idaho
Rose Idaho 1b 140w 47.86 M
Southeast EC Inc Ekalaka Mont
1b 500w; 10m 120w; 5m 3w 47.94 M
Warren Rural Elec Coop 951 Cemetery Rd
Bowling Green Ky
Morgantown Ky 1b 60w 158.19 M
Kentucky Util Co Burgin Ky 1b 150w 48.3 G
Alabama Gas Corp Watts Bldg Birmingham Ala
Marion Ala 1b 120w 158.25 M
Wisconsin Elec Pr Co 231 W Mich St
Milwaukee 1 Wis
Port Washington Wis 1b 150w 37.7 G
Oak Creek Town Wis 1b 150w 37.7 G
St Francis Wis 1b 150w 37.7 G
Somerstown Wis 1b 120w 37.54 G
Burlington Wis 1b 120w 37.54 G
Watertown Wis 1b 120w 37.54 G
Wisconsin Nat Gas Co Waukesha Wis
1b 120w; 33m 120w 37.54 G
Penna Elec Co 222 Livergood St Johnstown Pa
Oil City Pa 1b 50w 48.46 G
Pacific Gas & Elec Co 245 Market San Francisco Calif
Chico Calif 1usq 60w 456.05 L
Paradise Calif 1b 120w 153.65; 1sr 60w 457.55 L
Hayfork Calif 1b 120w 158.25; 1usr 120w 75.70 L
Cottonwood Calif 1usq 120w 73.98 L
Oroville Calif 1b 120w 153.59 L
Colusa Calif 1b 120w 153.59 L
Emigrant Gap Calif 1b 120w 153.59; 1sr 60w 457.55 L
Alta Calif 1usq 60w 456.05 L
Electrical Dist 2 Pinal County Coolidge Ariz
1b 140w; 10m 80w 25-50mc M
Miss Pr & Lt Co Box 1640 Jackson Miss
Lexington Miss 1b 150w 37.62 K
Yazoo City Miss 1b 150w 37.62 K
Hazelhurst Miss 1b 150w 37.62 K
Greenbelt EC Wellington Tex
Nr Hericho Tex 1b 150w 48.38; 1r 150w 72-76 G
Central Lincoln Peoples Util Dist 204 SE Coast Hway
Newport Oregon
Springfield Ore 1b 50w 37.78 G
Texas Pr & Lt Co 1506 Jackson St Dallas Tex
Gainesville Tex 1b 150w 37.5 G

PIPELINE PETROLEUM

Interstate Petroleum Comm 1319 Shell Bldg
Houston Tex 10tb 60w; 1tb 500w 48.58 M
Nat Gas Storage Co of Ill 20 N Wacker Dr Chicago
Nr Herscher Ill 1b 250w; 10m 80w 33.3;
1us .1w 6.825 M
Nr Cabery Ill 1us .1w 6.705 M
Sinclair Pipeline Co Independence Kans
Brazoria Tex -b 60w; -b 30w 153.17 R
Limestone Tex -m 60w 153.17 M
Union Oil Co of Calif 617 W 7th Los Angeles Calif
-b 30w; -m ½w 48.90 M
Hunt Trust Estate Mercantile Bldg Dallas Tex
15m 300w; 6b 300w 49.14 G
Union Sulphur & Oil Corp Sulphur La

(Continued on page 44)

NEW APPLICATIONS

(Continued from page 43)

1b 500w 48.98 R
El Paso Nat Gas Co 1010 Bassett Tower El Paso Tex
1b 60w 48.74 M
So Union Gas Co 1104 Burt Bldg Dallas Tex
Port Arthur Tex -b 120w 158.31 M
Williams Drilling Co Box 763 St Joseph Texas
2tb 70w; 5m 70w 33.34 G
Penrod Drilling Co Tex Eastern Bldg Shreveport La
Shreveport La 1uq 50w 73.5 G
Nr Fillmore La 1ur 50w 75.86 G
United Fuel Gas Co Charleston W Va
2tb 150w 33.38 G
Cent Ky Nat Gas Co Charleston W Va
Greenup Ky 1b 80w 33.38 L
Interstate Oil Pipeline Co Box 1107 Shreveport La
New Iberia La 1b 124w 49.10 G
Atlantic Seaboard Corp Box 215 Falls Church Va
Dublin Md 1b 150w 33.38 G
Phillips Pipeline Co Bartlesville Okla
Nr Midland Tex 1b 60w 33.38 M
Keystone Pipeline Co 260 S Broad Philadelphia Pa
Mechanicsburg Pa 1us 30w 1935 F
Quentin Pa 1us 40w 1895 F
Grimville Pa 1us 40w 1965 F
Summit Station Pa 3us 30w 1935; 1us 30w 1965 F
Conewago Twp Pa 4us 30w 1865, 1895 F
York Pa 1us 30w 1965 F
Lancaster Pa 1us 30w 1965 F
Schaefferstown Pa 1b 30w 1895 F
Gen Petroleum Co Box 1652 Casper Wyo
Tip Top Wyo 1b 120w; 1tb 120w 47.02 M
Fairchild Aerial Surveys Inc 224 E 11th St
Los Angeles 15 Calif 2m 110w 1.614, 1.628, 1.652, 1.676, 1.700 X
Calif Production Serv 3252 Cherry Av
Long Beach Calif 1b 550w 153.35 G
Castaic Calif 1b 120w 153.35 G
Ventura County Calif 1b 120w;
25m 110w 153.35 G

FOREST PRODUCTS

Crown Zellerbach Corp White Bldg Seattle Wash
1b 120w; 30m 60w 49.62 M
No Georgia Timberland Co Box 473 Rome Ga
Coosa Ga 1b 500w; 30m 114w 49.42 M
Boise Payette Lumber Co Box 200 Boise Idaho
1b 124w 49.38; 1sr 110w 75.9; 1sq 110w 74.34, 74.58 G
Emmett Idaho 1sq 110w 74.34, 74.10; 20m 124w 49.38 G
MacGregor Logging Co 3507 Crescent Dr Boise Idaho
1sq 110w 74.34; 30m 124w 49.38 G
Council Idaho 1b 124w 49.38 G
Weyerhauser Timber Co Box 420 Centralia Wash
Nr Issaquah Wash 1b 15w 49.38 X
Dolly Varden Lumber Co Box 728 Arcata Calif
Redwood Creek Calif 1b 50w 153.17 G
Nr Berry Summit Calif 1b 50w 153.17; 1rq 35w 73.3 G
Nr Arcata Calif 1m 50w 153.17; 1rq 35w 74.3 G
Scott Lumber Co Burney Calif 1b 120w; 15m 60w; 4m 1w 49.62 M
Keyes Fibre Co Waterville Me 1b 30w; 10m 30w 153.11 M; 1b 30w; 10m 30w 152.93 M

SPECIAL INDUSTRIAL

Halliburton Oil Well Cementing Co Duncan Okla
Houston Tex 1b 300w 49.78 G
El Campo Tex 1b 70w 49.74 G
Bay City Tex 1b 70w 49.74 G
Columbus Tex 1b 70w 49.74 G
Conroe Tex 1b 300w 49.74 G
Liberty Tex 1b 70w 49.74 G
Beaumont Tex 1b 300w 49.74 G
Western Cold Storage Co Moses Lake Wash
1b 120w; 10m 30w 154.49 M
Iderado Mining Co Ouray Colo 1b 40w; 5m 40w; 5p 2w 43.14 M
S J Groves & Sons 511 Wesley Temple Bldg
Minneapolis Minn 6m 140w 152.9 M
Southeastern Constr Co Gen Del Fort Knox Ky
1tb 30w; 10m 30w 43.02 M
Baker & Co Inc 3475 Wash St Boston 30 Mass
1b 120w; 10m 60w 49.86 M
Utah Mud Inc Box 605 Aztec New Mex
-b 60w; -m 60w 43.06 M
Wagner Constr Co 115 S Wyoming Av Kingston Pa
-b 520w 49.90 M
Maurer Cattle Co 833 LS Exchg Bldg Kansas City Mo
Nr Boyero Colo -b 40w 43.14 M
Kaiser Steel Corp Box 217 Fontana Calif
San Bernardino Calif 2b 1.3w 152.87 M
Concrete Supply Co 424 S Brevard Charlotte N C
1b 120w; 40m 30-60w 152.99 M
DBA Ray C Implement Co 471-481 N Thornton St
Richmond Va -b 140w; -m 80w 48.00 M
Zellwood Fruit Dist Inc Box 103 Zellwood Fla
1b 70w 49.90 G
Union Bldg & Constr Co 631 Main Av Passaic N J
1b 150w 43.02 G
Dunn Grain & Milling Co 914 W Edison Brush Colo
1m 50w 49.94 G
Lone Star Boiler & Welding Co Box 277
Denver City Tex 1b 120w; 15m 120w 43.06 M
Panama Williams Co Rm 403 Melrose Bldg
Houston Tex 1b 120w; 15m 120w 43.02 M
Freeport Sulphur Co Amer Bank Bldg
New Orleans La 1b 120w 152.87 M
L E Roe Box 420 Stratford Calif b 120w 154.57 L
Coughlin Constr Co 161 Devonshire St Boston Mass
1b 120w; 6m 30w 43.14 M

Azzarelli Trucking & Excavating Co Kankakee Ill
1b 30w; 10m 30w 43.1 M
Sterling Sugars Inc Franklin La
10m 120w; 4m 60w; 2m 30w 30.62 M
Wright Constr Co Williamston Mich
Lansing Mich 1b 60w; 5m 30w 49.7 M
Modesto Tallow Co Modesto Calif
1b 120w; 10m 60w 49.74 M
Mason W Alger Homestead Fla
1b 120w; 1m 30w 154.57 M
Wapato Evaporating Co Wapato Wash
1b 120w; 10m 60w 152.93 M
Mojave Desert Agricultural Gypsite Box 935
Palmdale Calif 1b 60w; 4m 60w 43.18 M
Nr Palmdale Calif 1b 60w; 4m 60w 43.18 M
Mojave Calif 1b 60w; 4m 60w 43.18 M
Dow Chemical Co Midland Mich
1b 10w; 40m 10w -M
Newbery Elec Coop 1038 Venice Blvd
Los Angeles Calif 1tb 60w; 20m 60w 43.02 M
Roncari Constr Co 1001 Elm St Windsor Locks Conn
1b 120w 49.9 M
East Granby Conn 1b 30w; 50m 30w 49.9 M
Dowell Inc Kennedy Bldg Tulsa Okla
Houma La 1b 300w; 3tb 70w 43.18 G
Hunkin-Conkey Constr Co 1740 E 12 St
Cleveland Ohio
Babbitt Minn 1b 24w 43.06 R
F Mansfield & Sons Co 610 Quinnipiac
New Haven Conn 1b 120w 30.62 M
Madison Conn 1b 120w 30.62 M
Greenport N Y 1b 120w 30.62 M
So Norwalk Conn 1b 30w; 50m 30w 30.62 M
Nafziger Tillage Serv Coolidge Ariz
1b 120w; 8m 60w 25-50 M
Phillips Packing Co Cambridge Md
1b 120w; 10m 120w 43.06 G
Mid-Continent Supply Co Ft Worth Tex
Abilene Tex 1b 300w 43.14 G
Gainesville Tex 1b 300w 43.14 G
Bowie Tex 1b 70w 43.14 G
Wichita Falls Tex 1b 300w 43.14 M
Berry Drilling Co Box 1246 Saint Jo Tex
1tb 70w; bm 70w 33.34 G
J L Brock Co Saticoy Calif
1b 60w; 10m 15w 43.1 M
Louis H Dexter Inc Box 230 San Juan P R
1tb 50w 43.18 G
Collins Bros 12 Tallmadge Pl Mechanicsville N Y
Nr Schuyler 1b 120w 152.87 M
Southwest Welding & Mfg Co 3201 W Mission Rd
Alhambra Calif 1tb 120w; 6m 80w; 3p 2w 43.06 M
American Cyanamid Co Willow Isle W Va
1b 10w; 50m 1w 152.99 M
Moore Kelley & Reddish Orange Va
1b 120w 154.49; 10m 60w 152.99 M
Red Dot Foods Inc 1435 E Washington Av
Madison Wis
Rhinelander Wis 1b 120w; 10m 80w; 3m 40w; 2m 3w 43.18 M
D W Henning Co Box 111 Salinas Calif
1b 80w; 2m 80w; 2tb 80w 43.06 M
H E Sargent Inc Stillwater Me 1tb 60w 43.06 R
Upland Lemon Growers Assn Upland Calif
1b 80w; 5m 60w 152.93 R
R S Carlin Inc Snow Shoe Pa 1b 120w; 8m 60w; 2m 20w; 2m 1w 43.1 M
Parmer Co Implements Friona Tex
1b 120w; 10m 60w 43.06 M
Int'l Harvester Co Refrigeration Div Hway 41
North Evansville Ind 1tb 12w; 10m 12w 43.02 M

LOW POWER INDUSTRIAL

George S May Co 205 W Wacker Dr Chicago 6 Ill
1m .5w 154 A
Robt C Crabb 1640 Glorietta Av Glendale Calif
3m 3w 154.47 GA
Robt Finlay 104 Brookside Av Ridgewood N J
1m 3w 154.57 A
Radio Elec Serv Co of Pa 7th & Arch Phila 6 Pa
—m 3w 154.57 A
Pacific Airmotive Corp 2940 Hollywood Way
Los Angeles Calif 20m 1w 154.57 M
Hallicrafters Co 4401 W 5th Av Chicago 24 Ill
30m 3w 154.57 A
David C Graves 618 N Bdway Burnsville Ohio
4m 3w 42.98 X
Kay Sales Co 3760 Bdway Kansas City Mo
1m 3w 154.57 A
Newark Electric Co 223 W Madison Chicago 6 Ill
2m 1w 154.57 A
Humble Oil & Refining Co 1216 Main Houston Tex
1m .25w 42.98 M
Atronic Corp 1253 Loyola Av Chicago 26 Ill
2m 1w 154.57 A
Caterpillar Tractor Co Box 1504 Joliet Ill
25m .5w 154.57 A
Delaware Electronics Supply Co 205 W 4th St
Wilmington Dela 2m 3w 154.57 A
Eastern Air Lines Inc Int'l Airport Branch PO Box 787
Miami 48 Fla 9m 3w 154.57 M
Tovrea Land & Cattle Co Box 2010 Phoenix Ariz
15m 3w 42.98 M
Fred B Hill Co 256 1st Av N Minneapolis 1 Minn
2m 3w 154.57 A
Casselberry Gardens Inc Casselberry Fla
2m 2w 35.02 A
Mercury Business Systems 4065 W Pico Blvd
Los Angeles Calif 6m 1w 154.57 M

COASTAL & MARINE RELAY

Empire Menhaden Co Empire La
1b 60w; 16m 35w 156.4 C
RCA c/o Freq Bureau 60 Broad St New York N Y
marine relay 200w 2.051 R

(Continued on page 46)

NEW APPLICATIONS

(Continued from page 45)

RELAY PRESS

El Mundo Inc Box 1072 San Juan P R
1b 250w; 50m 12w 173.37 G

ALASKAN FIXED PUBLIC

Morrison Knudson Co Box 320 Anchorage Alaska
—s 100w 2.986, 3.190, 5.137, 5.167, 5.622, 5.652 NN
Alaska Aeronautics & Communication Comm Box 121 Juneau Alaska
Nikolski Alaska 1b 15w 2.632, 2.986, 3.190, 3.202, 3.265, 5.622, 5.652 K
Port Graham Alaska 1b 30w same channels H
Akutan Alaska 1b 75w same channels A
Perryville Alaska 1b 20w same channels A
Belkofski Alaska 1b 30w same channels R
Tyonek Alaska 1b 15w same channels X

COASTAL & FIXED

Alaska Aeronautics & Communication Comm Box 121 Juneau Alaska
East Point Alaska 1b 50w 2.474, 2.512, 5.622, 5.652 X
Howard Chester Hayes Box 856 Juneau Alaska
1s 15w 2.474, 2.632, 3.190, 2.512, 5.622, 5.652 -

MARITIME RADIO LOCATION

Humble Oil & Refining Co Box 2180 Houston Tex
Grand Isle La 1b 30w 9.320, — 9.500 X

RAILROADS

Chicago South Shore & South Bend RR
Michigan City Ind 1b 60w 161.37 M
Beaufort & Morehead RR Co Beaufort N C
1b 30w 159.51 K
Terminal Rway Ala State Docks Mobile Ala
1b 30w 159.75 M
Atlantic Coast Line RR Wilmington N C
20m 30w; 10m .25w 161.79 MT
Seaboard Air Line R R Rm 706 SAL RR Bldg Norfolk Va
Savannah Ga 1b 15w 160.89 T
So Pacific Co 65 Market St San Francisco 5 Calif
Colfax Calif 1b 60w 161.79, 161.45 M
Emigrant Gap Calif 2b 60w 160.29, 161.55, 161.79 M
Norden Calif 2b 60w 160.29, 161.55, 161.79 M
Truckee Calif 2b 60w 160.29, 161.55, 161.79 M

TRANSIT UTILITY

New Orleans Pub Serv Inc New Orleans La
1b 60w 44.5 M

TAXICABS

Danny's Taxi Brentwood N J
1b 120w; 5m 30w ch 3 M
Robinson's Taxi Cambridge Md
1b 24.8w; 3m 24.8w ch 3 G
Cliff's Cabs Newport News Va
1b 120w; 20m 20w ch 3 M
Prospect Cab Co Mt Prospect Ill
1b 60w; 20m 10w ch 2 M
Colonial Cab Co Houston Tex
1b 120w; 25m 20w ch 4 M
American Taxi Port Arthur Tex
1b 20w; 5m 20w ch 2 M
Soo Cab Co Sioux Falls SD
1b 60w; 10m 20w ch 3 M
Admiral Cab Ocean City N J
1b 24.8w; 2m 24.8w ch 3 G
Pony Express Cab Co San Lorenzo Calif
1b 20w; 8m 20w ch 3M
Joe's Cab De Soto Mo 1b 60w; 10m 30w ch 2 M
Service Cab Co Mardan N D
1b 60w; 6m 30w ch 4 M
Landon's Taxi Crisfield Md
1b 120w; 3m 24.8 ch 2 G
Homewood Cab Co Homewood Ill
1b 140w; 4m 40w ch 3 M
Campus Cabs Poughkeepsie N Y
1b 120w; 10m 30w ch 3 M
West End Taxi Gloucester Mass
1b 120w; 6m 30w ch 4 M
Scarborough Taxi Cranford N J
1b 120w; 66m 24.8w — G
Safety Cab Inc Indianapolis Ind
1b 120w; 25m 30w ch 3 LM
Floyd's Taxi Winchester Ky
1b 120w; 7m 30w ch 3 M
Fair Deal Taxi Serv Montrose N Y
1b 120w; 3m 30w ch 3 M
Harkins Taxi Woburn Mass 1b 120w; 6m 10w ch 3 M
Checker Cab Co Rhinelander Wis
1b 60w; 6m 30w ch 3 M
Mitchells Yellow Cab Tomahawk Wis
1b 30w; 3m 30w ch 1 M
DeLuxe Cab Wood River Ill 1b 10w; 5m 60w ch 1 M
Tri-City Cab Louisville Ky
1b 120w; 15m 60w ch 4 M
Scott Cab Serv Norman Okla
1b 30w; 10m 30w ch 3 M
Yelloway Cab Terrell Tex 1b 40w; 7m 40w ch 1 M
Dozier Hicks Miami Fla 1b 120w; 15m 50w ch 3 T
Thos O Barrieau Yellow Cab Co 210 Wash St Bremerton Wash 1b 120w; 10m 120w ch 3 M
Bryan College Traction Co 114 E 26th St Bryan Tex
1b 20w; 15m 20w ch 4 M
Blue & Gray Cab Co 7802 Harford Rd Parkville Md
1b 40w; 10m 15w ch 2 T
Laurel Taxi Laurelton LI NY 1b 120w 152.39 G

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INDEX OF ADVERTISERS

FOR YOUR CONVENIENCE, TELEPHONE NUMBER OF EACH COMPANY IS SHOWN HERE

NEW APPLICATIONS

(Continued from page 46)

Montgomery Taxi Co 108 W Miss St Marianna Ark
—m 15w ch 2 M
Lima Radio Cabs Inc 116 W Market Lima Ohio
—m 40w ch 4 WW
Glenco Cab Co 527 8th St Wilmette Ill
1b 120w; 60m 30w ch 3 G
666 Cab Co 1913 3rd St Lidell La —m 50w ch — G
Radio Taxi Co 512 Bahama St Key West Fla
—b 30w; —m 30w ch 2 M
-m 40w ch 4 WW
West End Cab Co Auburn Ala
Arrow Cab Inc Eau Claire Wis
1b 30w; -m 10w ch 1 M
Williamsburg Serv Taxi Inc 1103 E Gun Hill Rd
Bronx 69 N Y 1b 58w; —m 8w ch 1 G
Tenny Taxi Co Buckhannon W Va
1b 60w; 15m 10w ch 2 M
Yellow Cab Co Renton Wash 1b 60w 152.33 M
Eveready Cab Co Newton Kans
1b 60w; 4m 30w ch 1 M

AUTO EMERGENCY

Tony's Garage Charleton City Mass
1b 30w; 3m 30w 35.70 M
Carson Buick Shippensburg Pa
1b 120w; 6m 120w 35.7 G
Rowe Motor Co Peabody Mass
1b 120w; 10m 30w 35.7 M
Lawrence Auto Body Wks Flushing N Y
1b 120w; 5m 60w 35.7 R
Pool's Garage Van Dyke Mich 1b 120w 35.7 M
Dayton Tire Sales Oak Park Ill
1b 60w; 10m 30w 35.7 G

HIGHWAY TRUCKS

Anderson Trans Co 236 10th Av Anchorage Alaska
MATS Term Elmondorf AFB —b 40w 35.90 M
J W Pickett Box 197 Mumford Ky 114w —m 35.86 R
Gas Engineering Co Daytona Beach Fla
1b 120w; 15m 60w 35-78 mc band M
Fruit Belt Motor Serv Inc St Joseph Mo
1b 30w; 5m 10w 35.94 M
R F Hall & Son Wilmington N C
1b 120w; 5m 60w; 5m 30w 35.78 M
Whiteville N C 1b 120w; 5m 60w; 5m 30w 35.78 M
Franks Piston Service Co 120 E 1st St Marion Ind
1b 124w; 20m 60w 35.74 G
Peru Ind 1b 124w 35.74 G
Portland Ind 1b 124w 35.74 G
Huntington Ind 1b 124w 35.74 G
Nolin Bros Refrigeration Inc Montgomery Ala
1b 250w; 15m 60w; 15m 30w; 15m 12w 35.94 M
Howard Butane & Propane Co Elk City Okla
1b 60w; 15m 60w 30-50 band M

ONE-WAY SIGNALING (Radio Paging)

Amer Tel Ans Serv 419 E 6th Long Beach Calif
1b 500w 35.58 Y
J S Barber 312 E Wis Av Milwaukee Wis
1b 500w 43.58 Y
Arthur Optner 1113 N Homan Av Chicago Ill
1b 500w 35.58 L
Page Boy Inc 225 Bdway New York N Y
1b 500w 35.58 Y
W C Rogers 55 E Washington Chicago Ill
1b 500w 35.58 X
J J Freke-Hayes 160 Central Pk So 1b 500w 35.58 Y
NY Tech Inst of Cincinnati 105 W Adams Chicago Ill
1b 500w 43.58 G
Washington Radio Paging Serv Stansbury Masonic Temple Georgia av & Missouri Av Washington DC
1b 500w 35.58 M
Baltimore Radio Paging Serv Fidelity Trust Co Charles & Lexington Baltimore 1b 500w 35.58 M
Telephone Message Bureau 1010 Euclid Av
Cleveland Ohio 1b 500w 35.58 Y
W F Corbin 450 Sutter San Francisco
1b 500w 35.58 Y
W B Johnson 3 mi E of Boise Idaho
1b 500w 35.58 Y
Air Signal Corp of Wash 733 15th St NW
Washington DC 1b 500w 43.58 R
Mobile Radio Message Serv 4215 Graustark
Houston Tex 1b 500w 43.58 Y
N Y Tech Inst of Cincinnati 375 Midland St
Highland Park Mich 1b 500w 43.58 G
Solomon Schiller 216 NE 2nd Av Miami Fla
1b 500w 43.58 X
Radio Dispatch Serv 3035 W Wis Av Milwaukee Wis
1b 500w 35.58 Y
Contact 2411 Bdway Oakland Calif 1b 500w 43.58 M
Telephone Secretarial Serv 914 Margaret Pl
Shreveport La 1b 500w 43.58 Y

MISCELLANEOUS COMMON CARRIER

Machine & Supply Co Box 335 Morehead City N C
1b 20m 152.03, 158.9 K
Answering Serv Bankers Trust Bldg 39 E Ohio St
Indianapolis Ind 100m 152.15, 158.61 G
Lakeco Radiophone Serv 119 Richmond St
Painesville Ohio 1b 33m 152.09, 158.55 M

COMMON CARRIER

Southwestern Bell Tel Co 1010 Pine St Louis Mo
1b 125m 152-162 X
Crest Labs Inc 2117 Mott Av Far Rockaway N Y
1m 157.77, 157.83, 157.89, 157.95, 158.01, 158.07 G

BROWNING Model MD-33: *A Completely New*

MODULATION MONITOR

Before you buy any type of modulation monitor, study carefully the specifications of the BROWNING Model MD-33 Universal Modulation Monitor. This is a completely new design, engineered to meet all present and future requirements of communication systems[1] *operating on any channels in the band from 25 to 174 mc.*

CONTINUOUS COVERAGE, 25 TO 174 MC.

By employing the latest techniques developed for continuous VHF tuning, the BROWNING Model MD-33 has been designed for use on all communication channels between 25 and 174 mc. This entire range is covered with only two bands. The accuracy of this monitor meets or exceeds all FCC requirements, yet it is independent of crystal control.

BOTH STANDARD and SPLIT-CHANNEL SYSTEMS

With split-channel operation already coming into use, a modulation monitor intended only for 15-kc. modulation may well become obsolete before its cost can be written off. Accordingly, the BROWNING Model MD-33 has been designed for both standard and narrow-band modulation. A simple switch adjusts the peak-modulation flasher for either range. The modulation meter has straight-line calibration from 0 to 20 kc.

COVERS SCATTERED FREQUENCY ASSIGNMENTS

The advantages of the tremendous tuning range of this instrument are immediately apparent to the technician maintaining several installations with frequency assignments scattered throughout the widely separated bands. This one instrument checks FM modulation swing at any frequency from 25 to 174 mc. without crystal or coil changing inconvenience. The carrier is tuned in and readings made in a few seconds. Automatic frequency control locks instrument to station frequency for continuous monitoring.

WRITE FOR COMPLETE ENGINEERING DATA

Before you decide on the purchase of a modulation monitor, get the complete engineering information on the BROWNING Model MD-33. See for yourself how the unique design of this monitor 1) assures long-time precision and stability, 2) how this single instrument covers *all* communication channels, and 3) how it can be used for both standard and split-channel transmitters.

[1] FCC Rules require that each fixed and mobile transmitter in every radio system be checked for modulation every 6 months, and whenever an adjustment is made that might affect the modulation. Records of these tests must be entered in the station log, where they can be seen by the Radio Inspector.

Browning Laboratories

700 MAIN STREET, WINCHESTER, MASS.

In Canada: Measurement Engineering, Ltd., Arnprior, Ont.

BROWNING LABORATORIES, Inc.
700 Main St., Winchester, Mass.

Please send me technical details and prices on the following Browning precision products:

☐ MD-33 Universal Modulation Monitor

☐ Standard Frequency Meters for Mobile Systems

Name .....

Address .....

.....

NEW MOTOROLA 460 MC. with A.F.C.

20 FULL WATTS* of Mobile Transmitter Output at 460 Mc.

AUTOMATIC FREQUENCY CONTROL

Motorola's new crystal controlled A.F.C. system provides positive barriers so that the receiver cannot jump to a strong adjacent channel signal.

This new Motorola A.F.C. technique is fortified with extraordinary system stability. The A.F.C. crystal controlled oscillator provides a full 10 to 1 correction ratio and keeps the receiver tuned on the nose to the distant transmitted carrier.

The new U. H. F. tuned circuits and research design cavities for ground grid amplifier operation provide phenomenal circuit stability, spurious rejection and extraordinary efficiency.

TRANSMITTER

The Motorola 460 Mc. system with 9 tuned circuits provides 18* to 20* Watts with *Efficiencies of more than 65%!*

SILVER PLATED SEALED TUNED CAVITIES

By use of silver plated line sections, high standards of selectivity protect the receiver from high power U.H.F., TV intermodulation.

Motorola

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