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STARTING IN THIS ISSUE

PATTERN FOR TV PROFIT

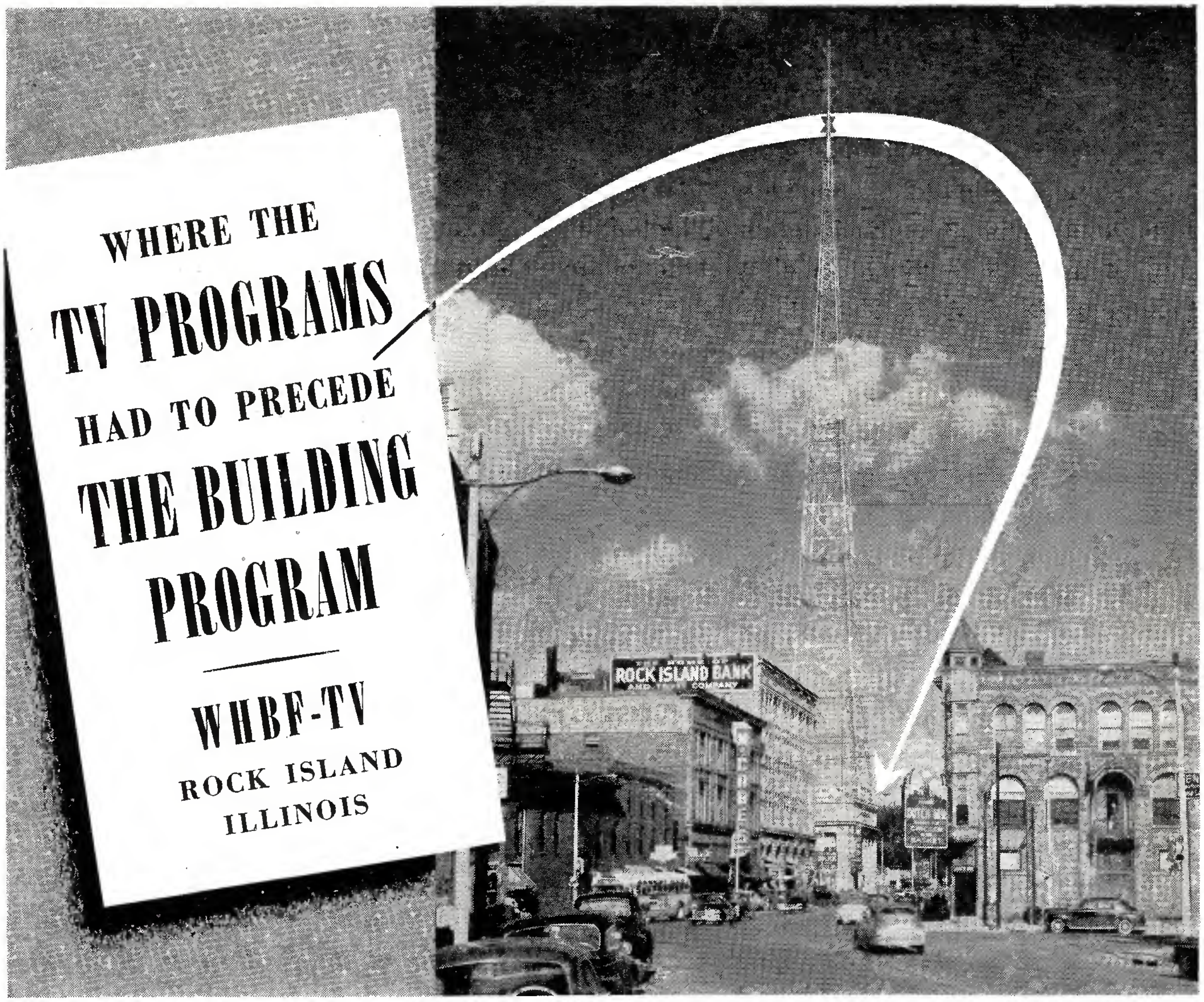
BY ROY F. ALLISON

in collaboration with

A. B. CHAMBERLAIN, CBS
RAYMOND GUY, NBC
RODNEY CHIPP, DuMont
THOMAS HOWARD, WPIX
FRANK MARX, ABC

"Pattern for TV Profit" is a basic text for the information and guidance of those planning to operate VHF or UHF television broadcast stations, either independently or as network affiliates. This series, making available the experience of the leading television broadcast engineers in the U.S.A., will cover all the problems of organizing, equipping, and operating TV stations in large and small centers of population.

★ Mobile, Point-to-Point, and Relay Communication ★
★ FM and TV Broadcasting ★ Audio Reproduction ★



WHBF's TV tower, with an overall height of 482 ft., was mounted on a specially constructed substructure 61 ft. high. Tower is designed to mount station call letters on all 4 sides, and carries an RCA custom-built, 5-section, Super Turnstile antenna.

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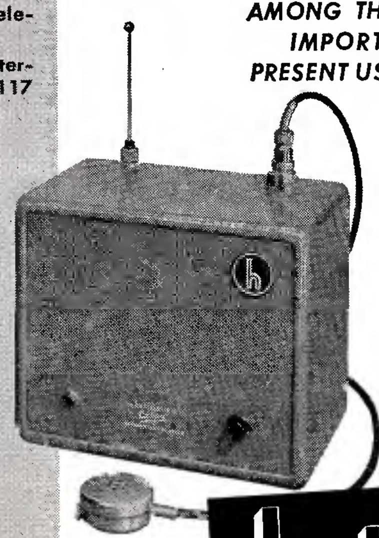

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FM-TV RADIO COMMUNICATION

Formerly *FM* MAGAZINE and *FM* RADIO-ELECTRONICS

VOL. 12 MARCH, 1952 NO. 3

INDUSTRY NEWS

BROADCASTING

APPARATUS DESIGN

COMMUNICATION

AUDIO SECTION

SPECIAL DEPARTMENTS

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CPA AUDIT

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

Set Production

THE RTMA report for January shows TV and FM set production continuing at consistent levels, with sharp shifts in AM home and auto models. Actually, AM home sets, at 248,969, hit the low point for the 5-year period covered by this Production Barometer. The steady sale of FM sets is noteworthy by comparison.

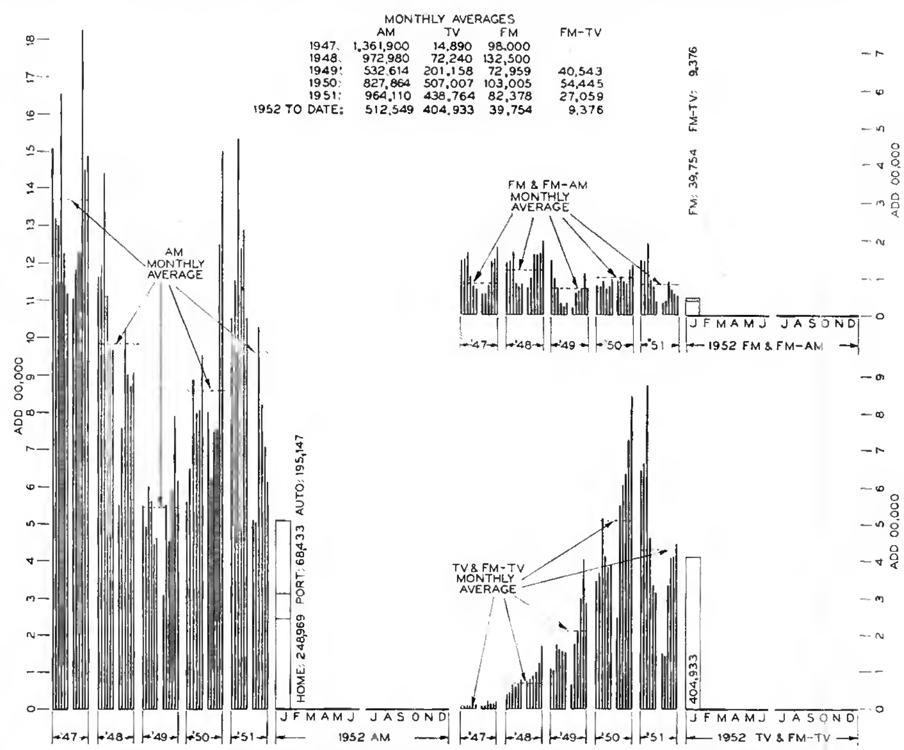
Of course, there is considerable competition for the dollars that might be spent for AM sets. Volume of tape-recorder sales is rising at a rapid rate. And more and more people who are unhappy over interference which spoils their AM reception at night, and who do not have adequate FM service, are spending their money for phonograph records.

Apropos of this, public enthusiasm over high-fidelity reproduction of phonograph records, and the improvement in LP's, is causing a great many people to lose what interest they had in listening to musical programs on AM. Time was when the audio capabilities of AM transmitters exceeded those of the receivers then available. Now the situation is reversed.

On the other hand, some of the FM stations — WXHR in Boston, for example — are doing such an excellent job of handling recorded programs that many listeners get better quality on FM than from playing the same records at home!

Here is something we just learned from W. F. E. Long, in charge of RTMA statistics, that may be news to many manufacturers: If the companies which manufacture FM tuners and audio equipment will compile their production data, RTMA will compile the monthly records and furnish the data to those companies, even through they are not Association members. In this way, industry statistics would be made available on the manufacture of tuners, amplifiers, pickups, turntables, speakers, and tape recorders.

Reports on the sale of magnetic tape show that the largest market and the greatest increase in sales is not among professional users but in the consumer market. Most of the tape recorders are being sold by photographic supply houses. Reason is that TV cut the sale of 16-mm. motion picture equipment sharply, and the stores took up tape recorders to replace that lost volume of sales. Further impetus will be supplied this year when aggressive promotion will start on pre-recorded tapes at 7½ ips., handling up to 12,000 cycles.



	AM	TV	FM	FM-TV
1947	1,361,900	14,890	98,000	
1948	972,980	72,240	132,500	
1949	532,614	201,158	72,959	40,543
1950	827,864	507,007	103,005	54,445
1951	964,110	438,764	82,378	27,059
1952 TO DATE	512,549	404,933	39,754	9,376

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

description of the proposed programming

involved, it will be covered separately in

located at the World Center Building.

the trend will be for network affiliations

entire first year of its operation, WDTV

of providing live programs immediately,

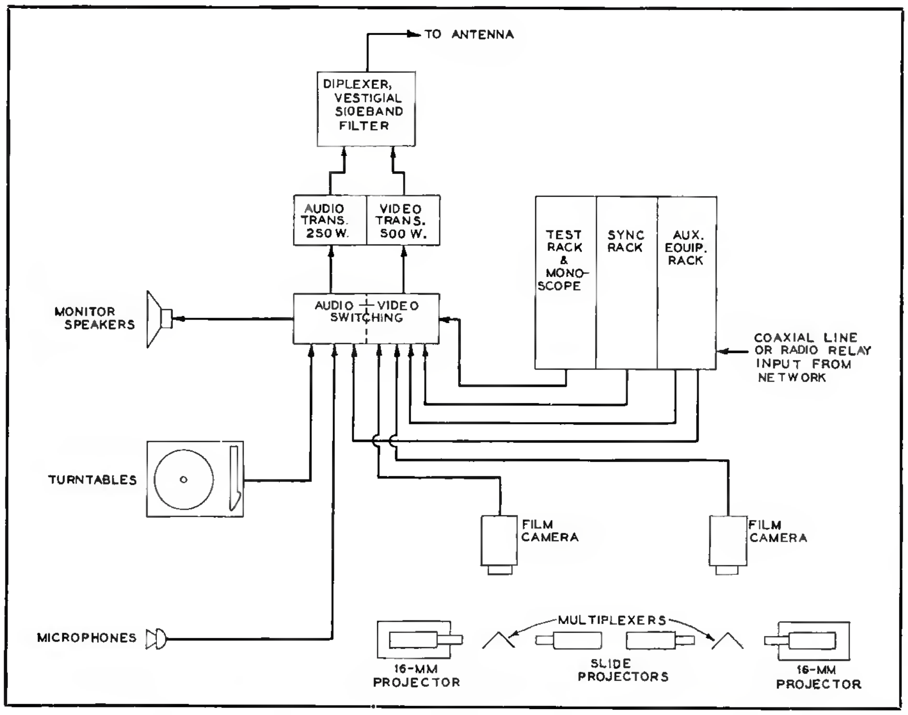


FIG. 2. EQUIPMENT NORMALLY CONSIDERED AS THE MINIMUM NECESSARY FOR NETWORK AND FILM

and are subjected to severe wind and ice loading. It must be ascertained that the building can withstand the additional load for which, in all probability, it was not designed originally.

Another factor which should be checked before carrying plans too far is that of CAA restrictions on antenna towers. During recent years, CAA regulations have been tightened considerably. Cities served by major air lines are affected particularly by these restrictions. It is advisable in all cases to check immediately with the local CAA representative on any proposed antenna site. There may be special requirements in a particular area, and it is time well spent to make sure that the antenna location and height do not violate CAA rules.

Cost of Facilities:

It has been said with good reason that while there is an irreducible minimum cost for a television station, there is no maximum at all. It is conceivable that a station could go on the air with a total capital expenditure of less than $125,000.

1. A network repeater station only. This is a station which is dependent entirely upon a network for programming. Transmitter power, 500 watts.

2. A station with network or remote-pickup facilities, or both, and film. Transmitter power, 500 watts.

3. A station with remote-pickup and film facilities, with or without a network connection. Transmitter power, 5 kw.

4. A station with studios for live-talent programs, and facilities for remote pickup and film operation, with or without network facilities. Transmitter power. 5 kw.

In each case, different totals are given for various modifications of the basic plans. For instance, the basic figures are calculated for the studio and transmitter located in the same place, and for cases where the transmitter and antenna are located remotely from the studio, so that an ST link is required.

All figures include installation cost, although this will vary in different sections of the Country. Also, it should be understood that costs for site procurement and development, which are in-

cost will undoubtedly be slightly higher for UHF equipment. However, to provide equivalent coverage, approximately 10 times the ERP is required at UHF as at VHF low channels. To obtain this increased ERP, the transmitter power, antenna gain, and tower height must be adjusted in an optimum combination. Probably all would be increased. Thus, a transmitting system for equivalent *coverage* will be considerably higher in cost at UHF. Exact figures are not available at the time of writing.

It should be mentioned at this point that equipment of all manufacturers is designed so that facilities can be expanded in the future without obsoleting any equipment already in use. Each of the four classes of stations described here can be expanded readily if it becomes desirable to do so.

Also, confusion may have been created by the term *studio equipment*. Any apparatus installed in the station for either film, video, or audio channels is normally called studio equipment. This is merely to differentiate it from the transmitter proper and the antenna, which may be at a different location. In addition, even though there are no live-talent studio facilities whatever, the program-control installation is termed the *studio*.

Because so much more equipment is needed in the studio, and because two transmitters (audio and video) are involved rather than one, the amount of test equipment required for television station maintenance is considerably more than that for a radio broadcast station. Therefore, the relatively high figures given for test equipment are realistic. This investment is increased further when a remote transmitter is employed.

Type 1 Station, 500 Watts Network Repeater Only

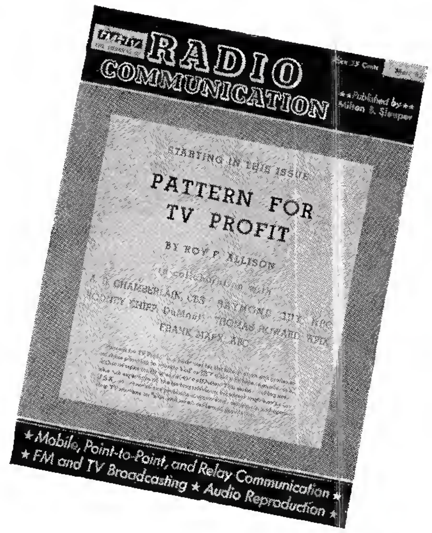
For the first method of operation, that of "living off the network," the equipment illustrated in Fig. 1 represents the virtually irreducible minimum for television broadcasting. This equipment and its cost is listed in the table below:

EQUIPMENT — TYPE 1 STATION

THIS MONTH'S COVER

Beginning this month, we shall present a series of articles of great interest to all those concerned with the planning of new TV stations. We are sure that prospective owners, station managers, and engineers will find this information invaluable, since it represents the consolidated experience of the five best-known authorities in the field today.

The first chapter deals with preliminary planning considerations and representative equipment and operating expenses. Subsequent chapters will cover station layout, discussion of and cost figures for all types of available equipment, studio design and lighting, and related subjects.



SPOT NEWS NOTES

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

Former Chairman Wayne Coy:

In accepting Wayne Coy's sudden resignation on February 21 as Chairman of the FCC, President Truman said: "The duties which you are now relinquishing were onerous and exacting. They required the patience of Job and the wisdom of Solomon, as well as judicial balance, tact, discretion, integrity and common sense. All these you have exercised in such a way as to make your administration memorable for efficiency and protection of the public interest." He was appointed FCC Chairman on December 29, 1947.

And from Senator Ed Johnson, Chairman of the Senate Interstate and Foreign Commerce Committee which makes FCC nominations: "His forthrightness, his great courage, his refusal to bow to all sorts of pressures which have been brought to bear, and the fine leadership he has displayed have been of such an unusual character that it will be truly a very great loss to the Country to have Mr. Coy give up his position as Chairman of the Commission."

We quote these tributes to Wayne Coy because we believe that they reflect the high esteem with which he is generally regarded by the radio industry.

Ides of March:

Wayne Coy resigned as Chairman of the FCC because, "My meager resources are much too near the vanishing point for comfort." Between the fabulous cost of living in Washington and the present level of income taxes, that "vanishing point" is no mere figure of speech, even when it is applied to a salary of $15,000 a year. But there is reason to wonder if that was the reason which impelled him to resign just three weeks before the middle of March — the target date for ending the TV freeze mentioned by Mr. Coy in an address on February 18. If he had remained in office three weeks longer, radio history would give him the full credit for the Commission's greatest, though belated, achievement: that of having successfully resolved the problems which brought on the TV freeze. Now, from many quarters, the question is being raised as to the possibility that Mr. Coy was distrustful of the forthcoming allocation plan to the point where he feared that more blame than credit will be attached to its adoption. Or that he foresaw further, indefinite delay in ending the freeze, and so decided to resign at once. Perhaps, by the time this issue is off the press, these questions will be answered.

Audio Channel Problem:

When mobile TV units were rushed to Elizabeth to cover the last plane crash there, the announcers were speechless. That is, they couldn't get lines for audio channels. It seems to be too complicated to transmit both video and audio signals by radio, even though some mobile TV units are equipped with audio transmitters.

FM Sets in Boston:

According to Pulse figures, FM set ownership in the Boston area was up to 19.9% in January. Thus it has almost doubled since WGBH went on the air last summer. WGBH is largely credited for this increase, partly because of the high standard it has set for other FM stations in that area. A complete story of the WGBH organization, program policies, and station facilities will be found in the Spring Issue of HIGH-FIDELITY.

(Concluded on page 7)

SPOT NEWS NOTES

(Continued from page 6)

FCC Chairman Paul A. Walker: Elevation of Commissioner Walker to the post of FCC Chairman is an honor well earned by his 18 years of service, dating back to the original Federal Radio Commission. Nevertheless, it has created the uneasy feeling that Mr. Walker was chosen because, at age 71, he may not have the rugged constitution and the fighting spirit to resist political pressure which could develop to proportions of desperation in a period which might be the present Administration's last opportunity to set up its supporters in the television broadcasting business.

Expansion Program: The LaPointe Plascomold Corporation, Windsor Locks, Conn., has purchased the Springville Mill at Rockville, Conn., a building of 156,000 square feet, to house the facilities of Press Wireless Manufacturing Company of Hicksville, Long Island. The latter has been acquired by La Pointe, but will be operated as a separate corporation. One of the first products to be manufactured at the new plant is a 24-hour continuous recorder, employing a single magnetically-sensitized sheet.

ESPRL Convention: The 14th annual conference of the Eastern States Police Radio League will be held at Hotel Kenmore, Boston, on June 2 and 3. Further information can be obtained from Secretary James L. Duggan, Revere 51, Mass.

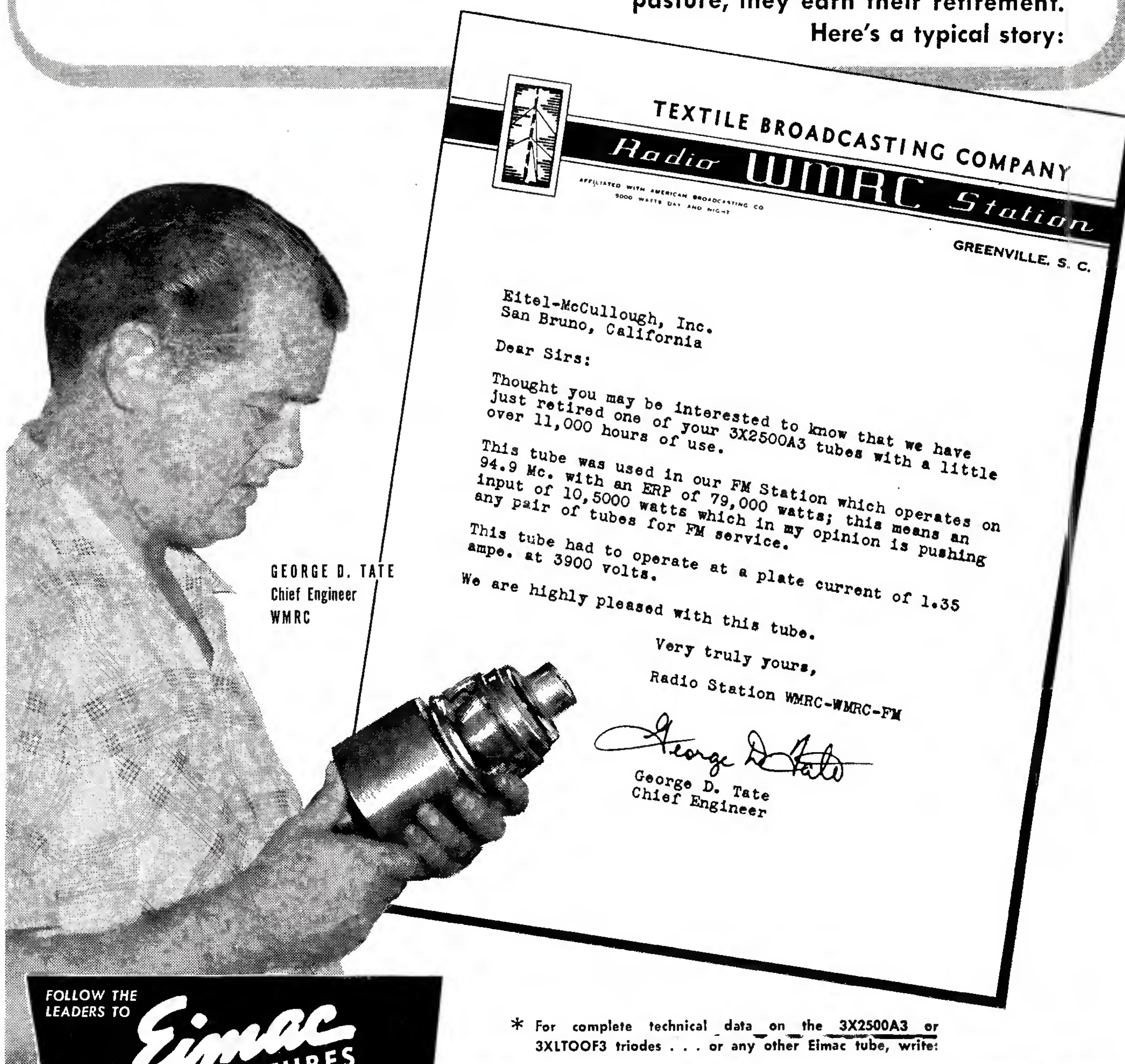
FCC Commissioner Bartley: Confirmation of Robert Taylor Bartley's appointment to fill Wayne Coy's unexpired term is generally regarded with enthusiasm by the radio industry. Born in Ladonia, Texas on May 28, 1909, he is the nephew of House Speaker Sam Rayburn (D-Tex.). He has had 3 years' experience in the FCC, served an apprenticeship in broadcasting under John Shepard III as executive secretary, and spent 4 years at NAB where, for part of that time, he headed the FM department. Subsequently, he has had a thorough course in government affairs at Washington as executive assistant to House Speaker Rayburn.

WFDR Closed Down: The operation of this union-owned station in New York City was not a financial success. The men who tried to sell time couldn't get sponsors into bargaining sessions they couldn't walk out of, and there wasn't any way they could get WFDR elected as the station all listeners had to tune in.

RETIRED...

*One Eimac 3X2500A3 . . . after 11,000 hours of FM broadcast service on 94.9 Mc

Before Eimac tubes are put out to pasture, they earn their retirement. Here's a typical story:



TEXTILE BROADCASTING COMPANY
Radio WMRC Station
GREENVILLE, S. C.

Eitel-McCullough, Inc.
San Bruno, California

Dear Sirs:

Thought you may be interested to know that we have just retired one of your 3X2500A3 tubes with a little over 11,000 hours of use.

This tube was used in our FM Station which operates on 94.9 Mc. with an ERP of 79,000 watts; this means an input of 10,5000 watts which in my opinion is pushing any pair of tubes for FM service.

This tube had to operate at a plate current of 1.35 ampe. at 3900 volts.

We are highly pleased with this tube.

Very truly yours,

Radio Station WMRC-WMRC-FM

George D. Tate
Chief Engineer

GEORGE D. TATE
Chief Engineer
WMRC

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PATTERN FOR TV PROFIT

A BASIC TEXT PREPARED FOR THE INFORMATION AND GUIDANCE OF THE EXECUTIVE STAFFS OF NEW VHF AND UHF TV BROADCASTING STATIONS

By ROY F. ALLISON, *in collaboration with* A.B. CHAMBERLAIN, RODNEY D. CHIPP, RAYMOND F. GUY, THOMAS E. HOWARD, *and* FRANK L. MARX

CHAPTER 1—FACTORS TO BE CONSIDERED WHEN MAKING INITIAL PLANS—OPERATING METHODS—EQUIPMENT, CONSTRUCTION, & OPERATING COSTS

OPERATION of a television station can be profitable. Generally speaking, a television station *must* be profitable if it is to continue in business over any extended period of time. This is true because a TV station is big business — even the smallest, minimum-type station cannot be compared with a radio broadcast station. It is on a totally different scale of operation.

TV capital investments and operating costs assume proportions that are staggering to one with little knowledge of such matters. On the other hand, commensurate profits are possible. But they can be realized only with equipment and operating methods specifically suited to the particular market served, and with astute management of those facilities.

One of the most vital requirements for a successful television station is a thorough, initial study of all aspects of the proposed enterprise. Haphazard experiments are costly, and may even be financially disastrous. Serious consideration must be given to the market area to be served by a station. This will determine the type of programming most likely to please the station's audience and that, in turn, will dictate the program facilities required at the station. Location, power gain, and height of the antenna, and the power of the transmitter should be the subject of another careful study, to determine the most efficient combination of these factors necessary to provide adequate coverage of the desired area, consistent with FCC Rules.

With such factors known, a fairly accurate estimate of capital investment and installation and operating costs can be obtained. Also, it is possible to anticipate both immediate and long-term revenues. No effort or expense should be spared on this preliminary investigation. In many cases, it will mean the difference between operating at a profit and at a loss, and it will always have an effect on the margin of profit.

Functions of the FCC:

The rapid development of radio broadcasting after World War I brought with it many problems, among the most important of which was mutual interference. Because there was no agency authorized at that time to control the carrier frequencies, power, or hours of operation of broadcast stations, the owners changed these factors at will. The result was intolerable confusion. In order to remedy this situation, Congress passed the Dill-White Radio Act in 1927, which created a five-member Federal Radio Commission.

The powers of this regulatory body were limited to the allocation of frequency bands for the various radio services, assignment of specific frequencies to individual stations, control of station power, and issuance of station licenses. The same act delegated to the Secretary of Commerce the authority to assign radio call signals, inspect radio stations, and to examine and license radio operators. In 1932, the latter functions were absorbed also by the FRC.

However, the FRC did not have jurisdiction over telegraph and telephone systems. These services were regulated by various other government agencies. Because this control was divided and overlapping, it was recommended that wire, ocean cable, and radio communication services be regulated by a single body. The Communications Act of 1934 created the Federal Communications Commission, put all these services under its control, and charged it with seeing that they were operated to serve the public interest.

The FCC consists of 7 commissioners appointed by the President for terms of 7 years, subject to confirmation by Congress. One commissioner is named Chairman by the President. The commission bas the power to issue and withdraw broadcast station licenses, as well as those in other radio services. Since, by law, radio transmitters must be licensed, the FCC has been authorized througb its licensing powers to control technical facilities and to police station program services, so that it can carry out its obligation to see that the frequency spectrum is utilized to serve public interest, convenience, and necessity.

License Procurement:

TV frequency allocations are intended to provide the maximum number of television stations in any one area. However, there may be many more applications for stations than there are channel assignments available.

First, the prospective television broadcaster must fill out FCC Form 301 or have it filled out for him by his engineering and legal counsels, and submit it to the FCC. This form consists of 22 pages of questions, covering practically all aspects of the proposed operation. It is an application for a permit to construct a station only and, if approved, does not constitute a license to operate the station.

Form 301 is composed of 5 sections, as follows:

1. *General information,* to identify the purpose of the application and the type of service (FM, AM, or TV).

2. *Legal qualifications of the applicant.* Statements of citizenship of the proposed owner or owners; whether the owner is an individual, partnership, corporation, or other legal entity; status of involvement in legal actions; and other related data are required in this section.

3. *Financial qualifications of applicant.* Complete statements of estimated initial cost of facilities, annual operating costs and revenues, and the basis of such estimates are required together with a showing of the applicant's financial position and an account of the sources of the money to be used in constructing the station.

4. *Statement of program services to be provided.* This consists of a detailed

description of the proposed programming policies of the applicant, showing percentages of time devoted to sustaining, network, and commercial classifications. Where there is competition for a given channel assignment, it may be wise to have an experienced program man make out this part of the application.

5. *Broadcast engineering data.* This section requires complete information on all the equipment to be employed, from the studio equipment to the antenna and antenna tower. Coverage data is also required.

If the CP (Construction Permit) application is contested, or if more than one application is made for the same channel assignment, the FCC may schedule a hearing. At the hearing, all interested parties present their cases before an FCC examiner, who makes a decision in the case and recommends action accordingly to the Commission. One applicant then receives a CP, which authorizes him to build the station. The equipment installed must correspond to that indicated in the application.

After it is built, he applies for a test authorization. This, when received, permits him to make test transmissions, from which he gathers and submits to the Commission his proof of performance data. If this is satisfactory, then — and only then — he receives a broadcasting license.

Regulations and Insurance:

The importance of familiarizing oneself with local ordinances, as well as the requirements of the National Board of Fire Underwriters cannot be emphasized too strongly. City ordinances with regard to fire protection, in particular, vary to a great degree. Stage sets and props are regulated rigorously in some cities.

Local regulations, in addition to those of the CAA, must usually be considered in choosing a site for the antenna. These regulations may affect the type of tower, as well as its location. Thus, it is manifestly impossible to proceed very far in planning facilities without a thorough investigation of local zoning and other ordinances. Usually, a copy of these ordinances can be obtained from the City Clerk for $1.00. Also, it is a very good idea to stipulate in any contract with a consulting firm that all such local and NBFU requirements will be met.

It is surprisingly easy to get in trouble by not securing proper licenses for broadcasting copyrighted literary and musical material. The problem is accentuated in television broadcasting because TV presentations of such material are more likely to be interpreted as dramatic performances than those of aural broadcast stations. Because the subject is so involved, it will be covered separately in the Appendix.

Insurance accounts for only a small part of the operating cost of a station, but is nonetheless a most important item. Workmen's compensation insurance is required in most states, and is a good investment even when not required. Fire, wind, and flood-damage insurance is essential for all stations. Public liability coverage is especially important when the antenna tower is located in an urban or suburban location, and whenever remote-pickup equipment is used.

Engineering & Legal Expense:

A most important part of the initial expense are the fees for an able engineering consultant and for an attorney to handle FCC matters concerned with obtaining a construction permit for the station and, subsequently, the station license.

While it might appear that a man qualified to act as the chief engineer of a television station would have sufficient knowledge of all the technical problems involved in planning and installing a new station, it has been found highly desirable, if not absolutely essential, to retain the services of a consulting firm.

One reason is that many points should be checked by an independent authority before final decisions are made. It is much less expensive to avoid mistakes in matters that involve so much investment in facilities and the cost of their installation, than to correct them later. This has been confirmed repeatedly in the experience of the pioneer television broadcasters.

The second reason is that so much of the initial planning must be coordinated with FCC rules, regulations, and practices. Therefore, the consulting firm selected should be one of long experience in matters which may be affected by FCC hearings, decisions, and the frequent changes in rules and requirements.

No estimate of fees can be offered because each station is a separate problem as to engineering services required. And, of course, charges vary according to the firm selected and the amount of travel time between the consultant's office and the city where the station is to be located.

It is customary to have the FCC application for a construction permit filed by an attorney who is a member of the Federal Communications Bar Association. Experience indicates that this is highly desirable because a lawyer who has not had experience before the FCC, whatever other qualifications he may have, may involve his client in long and expensive delays as a result of not being familiar with Commission procedures. Offices of the FCBA are located at the World Center Building, 16th and K Streets, Washington 6, D. C. Headquarters of the Association of Federal Communications Consulting Engineers are located in Washington also.

In practically all the large cities, more applications have been filed for television stations than the number of available channels. For that reason, the FCC must hold hearings to decide which applications are to be accepted, and which rejected. Wherever that situation prevails, delay, uncertainty, and legal expense must be anticipated.

The Local Market:

Television is not now the novelty it was once. In the early days, people would put up with almost anything in the way of programming, for the appeal of television lay not in the program itself but in the sheer wonder of seeing a moving picture on a glass tube. However, the American public has now accepted the idea of picture transmission by radio and, if a program is not interesting, sets are simply turned off or switched to other channels.

Another aspect is the slow but certain rise in cultural discrimination evidenced by the public. The transient interest in wrestling goes a long way to prove this. But this factor varies with location also. One station received 2,000 complaints recently when it discontinued its wrestling programs! Needless to say, there can be no profits if there are no viewers. It is necessary to serve the public interest in order to remain in the television business, and programs must be planned on that basis.

In rural communities, it is obvious that a fairly large percentage of time must be devoted to the interests of farmers. They want weather reports, market data for various crops, and farm demonstration programs. In an area where there is unusual interest in local sports events, it is important to provide some means for remote pickup of these attractions.

In primarily industrial areas, where two or more working shifts are common, some stations now schedule programs for the benefit of workers who arrive home between 12 and 1:00 A. M. Those who are on 4:00 to 12:00 shifts have few other facilities for entertainment, and respond enthusiastically to such service.

In television today, as in the theatre, the show is what draws and holds the audience. That is true even in single-station areas. It cannot be overemphasized where two or more stations are in competition.

Methods of Operation:

The three types of programs available for television presentation are 1) net-

A.B. CHAMBERLAIN

Born February 3, 1901, at Franklin, Mass., he acquired experience on the staffs of WGY Schenectady, WHAM Rochester, and the Buffalo Broadcasting Corporation. Joining CBS New York in 1931 as Chief Engineer, he was responsible for the design, installation, operation, and maintenance of broadcast equipment.

Mr. Chamberlain was called to active service with the Naval Reserve in 1942, and served with the Electronics Division, Bureau of Ships, for 3½ years. He rose to the rank of Captain and received the Legion of Merit for his work on airborne intercept and fire-control radar. He returned to CBS in December, 1945, and has supervised broadcast equipment development since then. He is a Fellow of the IRE.

RODNEY D. CHIPP

Born in New Rochelle, N. Y., 1910. Attended MIT, McKinley-Roosevelt, and Newark College of Engineering, where he did post-graduate work. After 2 years of radio operating experience, he joined WKAV (now WLNH) as Chief Engineer. From 1933 to 1941 he was with NBC New York, first in Audio Operations, then transferring to the TV Engineering Department in 1938.

Mr. Chipp spent the following 5 years in the Navy, devoting most of that time to the design of radar equipment, for which he received a commendation. Upon release, he joined ABC as Radio Facilities Engineer, transferring to the DuMont Network in 1948. He became Director of Engineering the same year. A registered Professional Engineer, he is a senior member of IRE.

RAYMOND F. GUY

A veteran of World War I, Mr. Guy graduated from Pratt Institute's engineering school in 1921. That same year, he became a member of the original staff of WJZ Newark. Thus, he has been a broadcast engineer for 31 years. He has also had 25 years of experience in television, since he participated in the construction of TV station 2XBS in 1927, as a member of RCA Research Laboratories. As Manager of Radio and Allocations Engineering, Mr. Guy has been responsible for the planning and construction of all NBC's AM, FM, TV, and short wave transmitting facilities.

He is active in industry activities. Among other posts held, he was president of IRE in 1950, and is now chairman of NARTB's Engineering Advisory Committee.

THOMAS E. HOWARD

Has accumulated 27 years of experience in all phases of radio and television broadcasting. After a consistently successful series of accomplishments in radio broadcasting, he served in the U. S. Air Force during the last war as Command Communications Officer of the First and Ninth Troop Carrier Commands in the U. S. and ETO. He was head of the Signal Branch, Air Forces Board, for 1 year, with the rank of Colonel.

After the war he was active in television broadcasting. He joined WPIX as Chief Engineer and was responsible for planning, procurement, and installation of facilities for this first high-channel station in the New York area, which now competes as an independent with the New York network stations.

FRANK L. MARX

Born in Birmingham, Alabama, Mr. Marx attended Shreveport College, the University of Virginia, William and Mary, and Columbia. He entered broadcasting in 1925 with WPAB and WRCV Norfolk. Later he joined KLRA Little Rock, and then KWKH Shreveport. In 1929 he became Chief Engineer of WPCH and WMCA.

The Blue Network engaged Mr. Marx as its Technical Advisor in 1944. He was made ABC's Director of General Engineering in 1945, and Vice President in charge of Engineering in 1948. He has been responsible for planning, construction, and operation of ABC's 5 owned stations. A registered Professional Engineer, Mr. Marx is an active member of industry committees and clubs, and is a senior member of IRE.

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work shows, 2) filmed material, 3) studio or remote live-talent originations. Some stations can employ all three mediums; others, a combination of two; and in some cases it is conceivable that only one will be utilized. In all cases, facilities must be provided for station breaks and identification announcements, and for the transmission of a test pattern with a recorded tone signal.

The usual minimum installation is the station equipped with both network and film facilities. Where it is impossible to procure a network affiliation, or it is not desired to do so, a small station must ordinarily depend on film and live presentations. Operation with film as the only program source is considered to be impractical, since the limited fare available and the high film costs would make profits improbable.

At larger stations, a varied fare of network, film and live program material is generally considered necessary.

Which of these are employed by a particular station will depend on a number of considerations. Among the most important are the financial resources of the owner; requirements to best serve the public interest, as outlined above; the availability of a network connection; competition; local construction costs and salary scale; and the size of the market to be served.

It is apparent, from a study of present television station revenues and expenses, that network-affiliated stations are, in general, more likely to show profits. Also, these profits are larger in most cases than those enjoyed by the smaller number of non-network stations which are running in the black. It would appear, therefore, that a network affiliation is desirable where it can be obtained.

The situation at present is such that new stations in certain localities can, so to speak, shop around for the most desirable terms from the four major networks. In such cases, stations can contract with more than one network, and select whichever programs they desire from each. Consequently, a few stations have been writing their own tickets, so far as network affiliation is concerned.

However, it should be emphasized that this situation cannot last indefinitely. As more and more stations go on the air, the trend will be for network affiliations to become fixed. With more receivers in the area served by any station, its coverage will increase. Since network payments to stations are determined by the local coverage, there will be a corresponding increase in payments to individual stations for network programs they carry. Then, network programs will become profitable for the individual stations, while at present they may not be. Perhaps this requires clarification.

Revenue from network programs is, in many cases, less than that from a locally-sponsored program. The substantial part of station revenue comes from local spot announcements preceding and following popular network programs. As has been pointed out, however, payments from the network to an individual station will increase as the station's audience increases. This will result in increased demand for network affiliations by a substantially increased number of stations.

Now, it might be thought this should create no problem — the networks could supply any number of stations in a given area. However, reflection will show why this is not the case. Although it is desirable from the networks' points of view to increase their coverage, it is definitely not desirable to have appreciably overlapping coverage. In many cases, there will be more stations in a given area than there are network affiliations available. Then it will not be possible for individual stations to take programs from more than one network, at their discretion. Also, it is doubtful that the FCC would approve multiple network outlets in the same area, since it would not be in the public interest to do so.

It has been the policy of networks, in the past, to grant a television affiliation to the station in any given area which is already a standard broadcast affiliate.

Where a network connection is not available, it may be possible to pick up and rebroadcast the programs of a larger independent station some distance away, providing arrangements can be made with such a station for this service.

The foregoing discussion should not be taken as implying that profitable operation without a network affiliation is impossible for a small station. The record indicates, however, that it is more difficult to get into the black without such facilities.

The general opinion is that there is still room for the minimal-type station, especially in smaller cities and rural areas. There is no reason why a station cannot begin with minimum facilities and expand later, when the market warrants it. DuMont's WDTV, in Pittsburgh, is a good example of the successful application of this philosophy. For the entire first year of its operation, WDTV employed no live-talent programming whatsoever, relying on network and film only. Subsequently, the station installed local studio equipment, which it now employs extensively.

Commercial films are an important source of revenue for both network and non-network stations. Therefore, film and slide equipment should be given the most careful consideration when making plans for program facilities. As a general rule, it is a good idea to provide two film camera chains for film operation. Not only is versatility increased, but the danger of being without film facilities when one camera chain requires maintenance is avoided. It is not wise to buy low-cost, minimum-quality film equipment, in an effort to economize. In the long run, the economy proves expensive.

Substantial savings on equipment can be made, however, by purchasing field-type camera chains for both studio and remote-pickup use. There is very little difference in cost between studio and field-type equipment, and the latter has the advantage that it can be used for both purposes. Thus, field cameras are suitable for very limited live-talent shows, such as commercial short features, within the confines of the station itself, even without studio facilities. This matter will be discussed in detail in a subsequent chapter.

The concept of beginning operation on a limited scale, and expanding facilities as time goes on, is entirely practical. Even a large independent station can get along temporarily with one studio. WPIX, for instance, employed only one studio for nearly two years when it first went on the air. It maintained a 7-day schedule by carefully planning and executing back-to-back live shows, utilizing station breaks, spot commercials, and film during periods of transition between such programs. Now, WPIX has 4 studios in operation.

In most cases, provision for expansion should be made when laying out the station. Great economies can be effected by concentrating facilities around the central control equipment. For instance, the layout of the station may be such that two studios can be controlled from one position, in addition to film and announce booths. It may be a good idea to provide space for studios if future plans call for them, even though they are not used immediately.

One factor which may prove to be a disadvantage in the "start small — grow bigger" plan is that of license application requirements. Where more than one applicant is seeking an authorization in a given locality, it might well be that the authorization would be awarded to the applicant who expresses his intention of providing live programs immediately, in addition to network and film presentations, if the other applicants do not express similar intentions. Thus, initial program facilities may well mean the difference between getting and losing a license.

It can be seen that the problem of determining facilities and methods of operation requires most careful thought. Against the desire and the need to serve the public interest by providing variety and quality in programming must be balanced the very real financial danger of over-extension. The equation for success contains the variable factors of the capital necessary to carry the station until it is in the black, facilities necessary for programs that will build an audience and attract sponsors, and the cost of operating the facilities provided.

Studio & Transmitter Location: From the standpoint of profitable operation, the selection of a site or sites for the transmitter and studio is extremely important. The transmitter and antenna constitute the vital link between the television station and the audience. Although programming is of great importance, it can be of little consequence if the programs are not delivered properly to their intended destination — the potential viewer's set. Therefore, the success of a television station is dependent on its ability to deliver a clear, usable signal to the maximum number of receiving antennas in the area. In order to accomplish this, it is necessary to employ the optimum antenna at the optimum height at the optimum site, as determined by a complete coverage study and by financial considerations. A mistake in siting is always costly and may well be disastrous. Transmitters and antennas can be relocated, but the labor and some of the material that go into the first installation cannot be salvaged. These costs are a major part of the original investment. It is always wise to get the right answer the first time.

There are, generally speaking, 4 arrangements for locating the studio and transmitter. These are:

1. Studio and transmitter located in an urban area.
2. Studio in urban area, transmitter outside urban area situated on hill-top.
3. All facilities in a suburban area.
4. Television and standard broadcast studios, FM and TV transmitters and offices located on high ground well outside the urban area to be served. A typical example of this arrangement is WBZ, in Boston.

We shall make a general statement at this point which should be borne in mind constantly whenever planning any part of a television station system. This rule is simple and fool-proof. Briefly, it consists of the following truth: Other things being equal, it is more economical, with regard to both initial cost and operating expense, to have facilities concentrated in one place. Note, however, the phrase *other things being equal.* Precisely because these other factors are hardly ever equal, all four arrangements may call for consideration in some instances.

The best location for the studio depends on the method of operation to be employed, at least in most cases. If it is planned to employ live talent extensively in programming, it is more convenient to have the studios in the center of the urban area served by the station. That is not a major consideration in the case of a network-and-film-only station. For the latter type of station, accessibility may be much less important than having the studio outside the urban area, where rent or land and construction costs are low, particularly if the studio can be made a part of the transmitter building. The factor of cost may be more important than convenience in the former case also, since the presentation of live shows on any scale requires space for prop storage and set design and manufacture.

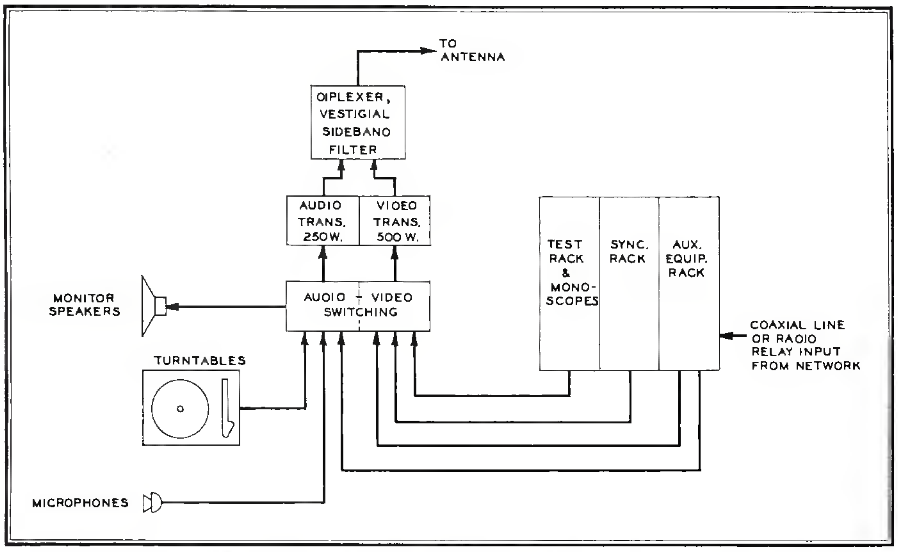


FIG. 1. BLOCK DIAGRAM OF EQUIPMENT FACILITIES REQUIRED FOR NETWORK-ONLY OPERATION

The best location for the transmitter and antenna is not so easily determined. The antenna site which will give optimum coverage can sometimes be estimated to a fair degree of accuracy by careful studies of the terrain and such propagation data as is available. However, variable factors such as roughness of terrain, ground contour, and the degree of industrial and residential development of the area make it difficult to predict performance and coverage very accurately. Particularly in the case of UHF, making an extensive propagation survey may be safer and more dependable in the long run than using theoretical approximations. Firms which contract to make surveys can be retained for a figure which, compared to the total investment to be made, is relatively small.

WPIX, which had been operating years before having the opportunity to move its antenna to the Empire State Building in New York, knew well the value of making a complete topographical survey also. Steeplejacks, trained to use cameras, were sent up the WPIX tower on the Daily News Building and then to the top of the Empire State Building. They took pictures of the terrain surrounding these towers in all directions. The photographs were used with other data in making the decision to move to the new location. WNBT, which has been at the Empire State location for many years, has made extensive propagation measurements and tests at both VHF and UHF frequencies.

Complete propagation surveys indicate exactly what coverage can be obtained from each site. These may be of additional value, because they may indicate that there are two or more suitable sites. For instance, it may be found practical to locate the antenna tower in the center of a city, at the same location as that proposed for the studios. This is likely to be the case in flat country. It may be possible to add a television antenna to an FM tower already existing. This was done at NBC's Cleveland station, WNBK. A directive antenna is employed there to concentrate radiation on two areas of large population. Alternatively, it may be practical to erect the television tower in another part of the city, away from the studios, but at a distance short enough so that a coaxial cable can be used rather than a microwave ST link.

Not only is the initial cost less when the studio and transmitter are located at the same point, but the operating cost is much less also. This is so because duplication of equipment and operating personnel is avoided, and less total space is required.

If the antenna is to be erected in a city, especial care must be taken to see that the location is such that shadows are not caused by heavily built-up or industrial sections. A large segment of desirable coverage can be lost by such shadows. Equally as important is the problem of avoiding reflections from high buildings and other large objects.

Another factor to be considered when locating the antenna tower in a city is that of antenna height. Some state unequivocally that the higher an antenna, the better. Others point out that it is possible for an antenna to be too high, particularly if a high-gain type is employed. While high gain and extreme height contribute to long-distance coverage, such conditions may cause serious vagaries in close-range reception because of inadequate or irregular radiation at angles approaching the vertical. Where the tower is in the center of a city, inadequate close-range coverage may mean the loss of some of the station's most important listeners. It has been observed that the percentage of returns in response to advertising — especially *immediate* returns — is higher from very close-range listeners than it is from those on the outskirts of an urban area. Thus, close-range listeners should not be ignored in order to obtain extended long-distance coverage. It should be stated that this is a problem that can be overcome by antenna development. Much effort is being directed toward its solution, and it is generally agreed that such a solution will be found.

The engineering survey may indicate that the most effective coverage cannot be obtained with the transmitter and antenna located in the urban area. That is very likely to be the case in cities surrounded by hills. In Salt Lake City it was found, for instance, that by moving out 5 miles from the center of the city the potential coverage was increased significantly with the same antenna and transmitter. In many cases, such a radical increase in coverage warrants locating the transmitter or both the transmitter and studio outside the urban area.

Of course, this may involve additional costs not immediately apparent. Typical of these are the increased cost of hauling material to the site, the cost of developing the site, and possibly even building roads to the location, in addition to water, fuel, and power costs.

If it is intended to erect the antenna tower on a city building, it will be necessary to have an engineering survey made of the building construction before proceeding very far with such plans. A tower and antenna are extremely heavy,

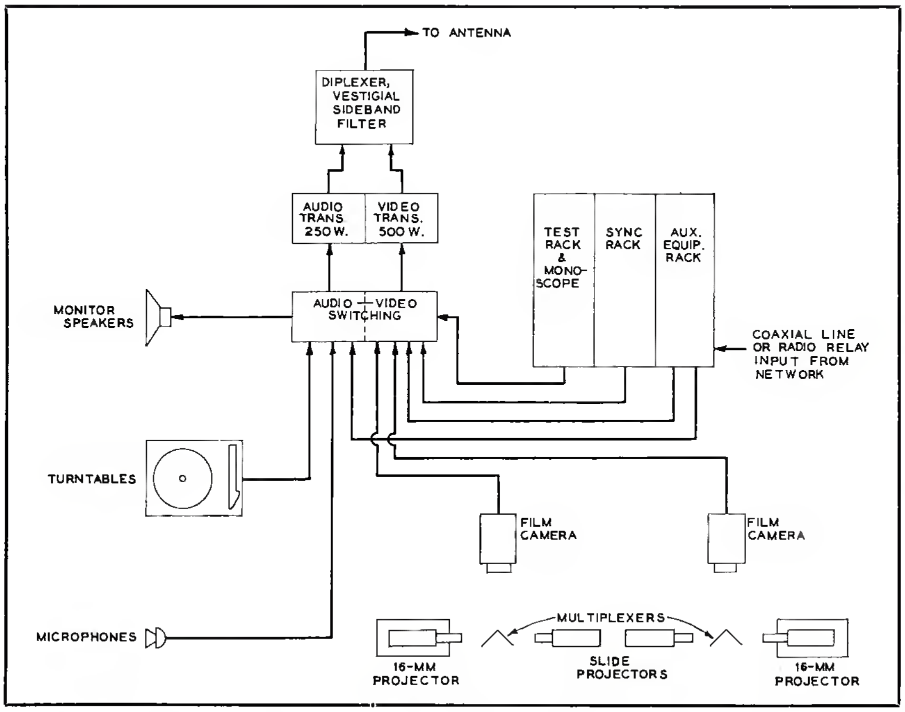


FIG. 2. EQUIPMENT NORMALLY CONSIDERED AS THE MINIMUM NECESSARY FOR NETWORK AND FILM

and are subjected to severe wind and ice loading. It must be ascertained that the building can withstand the additional load for which, in all probability, it was not designed originally.

Another factor which should be checked before carrying plans too far is that of CAA restrictions on antenna towers. During recent years, CAA regulations have been tightened considerably. Cities served by major air lines are affected particularly by these restrictions. It is advisable in all cases to check immediately with the local CAA representative on any proposed antenna site. There may be special requirements in a particular area, and it is time well spent to make sure that the antenna location and height do not violate CAA rules.

Cost of Facilities:

It has been said with good reason that while there is an irreducible minimum cost for a television station, there is no maximum at all. It is conceivable that a station could go on the air with a total capital expenditure of less than $125,000. On the other hand, it is also possible that conditions may warrant initial capital expenditures of over $1 million. In large cities, especially network origination centers, the figure may run into $2 to $3 million or even more. Between these extremes lies an optimum figure which represents the equipment necessary to provide the facilities required for the type of operation deemed most suitable under the circumstances.

The following tables are set up as examples of four possible variations in methods of operation. These are:

1. A network repeater station only. This is a station which is dependent entirely upon a network for programming. Transmitter power, 500 watts.

2. A station with network or remote-pickup facilities, or both, and film. Transmitter power, 500 watts.

3. A station with remote-pickup and film facilities, with or without a network connection. Transmitter power, 5 kw.

4. A station with studios for live-talent programs, and facilities for remote pick-up and film operation, with or without network facilities. Transmitter power. 5 kw.

In each case, different totals are given for various modifications of the basic plans. For instance, the basic figures are calculated for the studio and transmitter located in the same place, and for cases where the transmitter and antenna are located remotely from the studio, so that an ST link is required.

All figures include installation cost, although this will vary in different sections of the Country. Also, it should be understood that costs for site procurement and development, which are included also, will vary over a wide range. This variation may be as much as 20 or 30 to 1.

The costs for equipment to be used in UHF and VHF stations will be identical except for the transmitter and antenna. The difference in cost, for equal ERP, between a VHF transmitter and antenna and a UHF transmitter and antenna is not likely to be great. This is because a UHF transmitter costs more than a VHF transmitter of the same power, but a UHF antenna costs less than a VHF antenna of the same gain. The total cost will undoubtedly be slightly higher for UHF equipment. However, to provide equivalent coverage, approximately 10 times the ERP is required at UHF as at VHF low channels. To obtain this increased ERP, the transmitter power, antenna gain, and tower height must be adjusted in an optimum combination. Probably all would be increased. Thus, a transmitting system for equivalent *coverage* will be considerably higher in cost at UHF. Exact figures are not available at the time of writing.

It should be mentioned at this point that equipment of all manufacturers is designed so that facilities can be expanded in the future without obsoleting any equipment already in use. Each of the four classes of stations described here can be expanded readily if it becomes desirable to do so.

Also, confusion may have been created by the term *studio equipment*. Any apparatus installed in the station for either film, video, or audio channels is normally called studio equipment. This is merely to differentiate it from the transmitter proper and the antenna, which may be at a different location. In addition, even though there are no live-talent studio facilities whatever, the program-control installation is termed the *studio*.

Because so much more equipment is needed in the studio, and because two transmitters (audio and video) are involved rather than one, the amount of test equipment required for television station maintenance is considerably more than that for a radio broadcast station. Therefore, the relatively high figures given for test equipment are realistic. This investment is increased further when a remote transmitter is employed.

Type 1 Station, 500 Watts Network Repeater Only

For the first method of operation, that of "living off the network," the equipment illustrated in Fig. 1 represents the virtually irreducible minimum for television broadcasting. This equipment and its cost is listed in the table below:

TYPE 1 STATION

EQUIPMENT	
Antenna system	$17,000
Transmitter, video & audio	40,000
Monoscopes and sync generator	10,000
Video & audio control, monitoring, switching, and other miscellaneous equipment	15,000
Test equipment	7,500
Installation	10,000
Equipment Subtotal	$99,500
SITE AND BUILDING	
Site procurement and development	$4,000
Building construction or alterations	16,500
Antenna tower	15,000
Miscellaneous items	2,000
Site and Building Subtotal	$36,000
CONTINGENCIES	
15% of subtotals above	$20,500
TOTAL COST, TYPE 1 VHF STATION	**$156,000**

If the antenna is to be installed at an appreciable distance away from the studio, and a telephone company line or link is not available, a microwave system (ST link) will be required to carry the signals from the studio to the transmitter. In this case, not only will the equipment cost be increased, but the allowance for site and building facilities must be raised also. The total extra cost will be about $25,000, but will vary according to local construction costs.

TYPE 1 VHF STATION WITH ST LINK $181,000

Since no facilities are provided with the type 1 station for local commercial films or live commercials, it would appear that its prospects for success at the present time are even poorer than that of the film-only station. As has been pointed out, however, network revenues should increase in the future, with more receivers in the hands of the public. Then, the profit-making potentialities of such a station will be determined by the local market and the competitive situation.

If a flying-spot scanner is substituted for the monoscopes, it is possible to originate commercial announcements with still, transparent slides as illustrative material. This will increase the flexibility of operation considerably, but is a poor substitute for the versatility afforded by motion-picture projection and film camera facilities. These are provided as standard equipment for the Type 2 television station.

Type 2 Station, 500 Watts Network & Film

The type 2 station, diagrammed in Fig. 2, provides for both film and network originations. Almost without exception, it will be found that these are the minimum facilities required for profitable operation at this stage of TV development.

TYPE 2 STATION

EQUIPMENT	
Antenna system	$17,000
Transmitter, video and audio	40,000
Monoscope and sync generator	8,000
Video & audio control, monitoring, switching, and other miscellaneous equipment	25,000
Two film camera chains	25,000
Two 16-mm. film projectors and two slide projectors	10,000
Test equipment	7,500
Installation	12,000
Equipment Subtotal	$144,500
SITE AND BUILDING	
Site procurement and development	$4,000
Building construction or alterations	16,500
Antenna tower	15,000
Miscellaneous items	2,000
Site & Building Subtotal	$37,500
CONTINGENCIES	
15% of subtotals above	$27,500
TOTAL COST, TYPE 2 VHF STATION	**$209,500**
TYPE 2 VHF STATION WITH ST LINK	**$234,500**

It is quite possible that remote-pickup facilities will be found necessary in addition to the network and film equipment. Where a network connection is not available, the use of remote-pickup equipment is almost always mandatory. It should be pointed out again that portable field equipment can be used at the station also for live programming, even without live-talent studio facilities. Such applications include news broadcasts and stationary demonstrations or group discussions, as well as live commercials.

However, such equipment is expensive; it requires a small truck to carry it, and garage space for the truck. Operating expenses take a sharp rise upon the addition of remote-pickup facilities, primarily because of the increased personnel requirements. On the other hand, the attendant increase in revenues will more than compensate for the expense of such a unit in the majority of cases where the market served by the station is large enough to warrant it. The additional costs for remote-pickup facilities are itemized below:

REMOTE PICKUP FACILITIES

Two field cameras with associated equip.	$40,000
Radio relay system	15,000
Mobile unit	10,000
Lighting and miscellaneous equipment	3,000
Garage	2,000
Remote Pickup Subtotal	$70,000
TOTAL COST, TYPE 2 VHF STATION WITH REMOTE PICKUP	**$279,500**
TYPE 2 VHF STATION WITH REMOTE PICKUP AND ST LINK	**$304,500**

These figures are based on a radio relay system employing only one hop from the remote to the studio. Where more than one hop is required, the cost of each repeater will increase the total equipment cost by about $15,000.

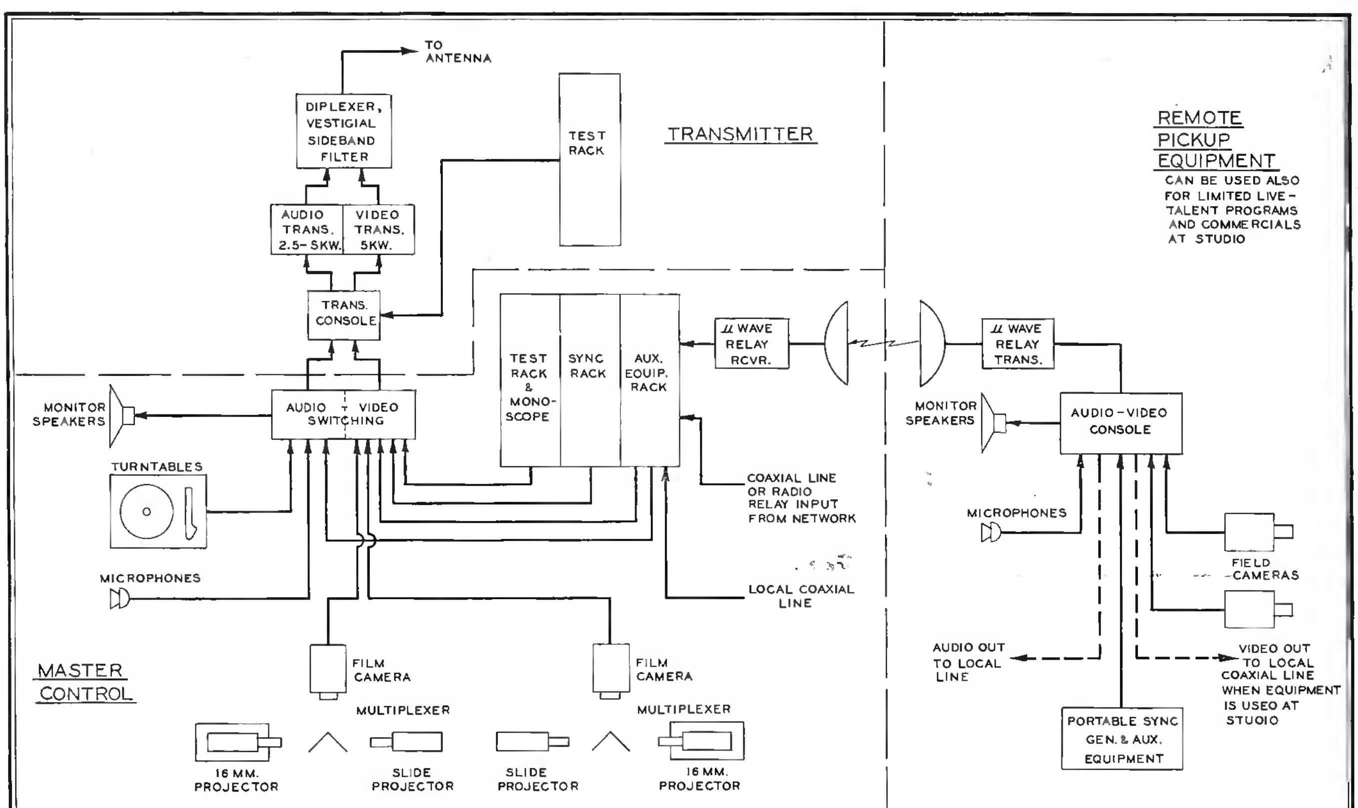


FIG. 3. FACILITIES FOR NETWORK, FILM, AND REMOTE-PICKUP PROGRAMMING. TRANSMITTER MAY OR MAY NOT BE LOCATED AT THE CONTROL STUDIO

Type 3 Station, 5 kw. Film & Field Unit Network or Independent Operation

Proposed FCC Rules will establish minimum allowable ERP's for stations in cities for various sizes, as well as maximum powers. The table below gives these minimum power requirements for antenna heights shown. For other antenna heights, the figures are adjusted accordingly.

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

Ordinarily, the minimum powers listed will not be limiting for, in most areas, the distribution of population around urban centers is such that considerably higher power will be warranted by the increased coverage obtained.

Nevertheless, since an increase in transmitter power from 500 w. to 5 kw. involves a considerable increase in equipment cost, especially for initial installations, it can be assumed that a decision to employ the higher power would be restricted to the case of a station intended to serve a city of at least intermediate size. For such a station, whether network-connected or not, both film and remote-pickup facilities would seem to be essential. Therefore, the following cost table for Type 3 stations is based on provisions for all three methods of programming, as indicated in Fig. 3.

Because planning will probably be more detailed, and cost estimates more precise for Types 3 and 4 stations, the figures for contingencies are calculated on the basis of 10% of the estimated total costs, rather than 15%.

TYPE 3 STATION

EQUIPMENT	
Antenna	$17,000
Transmitter, video and audio, and associated monitoring and control equipment	90,000
Monoscope and sync generator	8,000
Video & audio control, monitoring, switching, and other miscellaneous equipment	25,000
Two film camera chains	25,000
Two 16-mm. film projectors and two slide projectors	10,000
Test equipment	7,500
Remote pickup equipment	68,000
Installation	15,000
Equipment Subtotal	$265,500
SITE AND BUILDING	
Site procurement and development	$6,500
Building construction or alterations	25,000
Antenna tower (500-foot)	40,000
Primary power	2,000
Miscellaneous items	3,500
Site & Building Subtotal	$77,000
CONTINGENCIES	
10% of subtotals above	$34,500
TOTAL COST, TYPE 3 VHF STATION	**$377,000**
TYPE 3 VHF STATION WITH ST LINK	**$402,000**

Type 4 Station, 5 kw. Studio, Film & Field Unit Network or Independent Operation

The Type 4 station, as can be seen in Fig. 4, includes as initial equipment a live-talent studio with 2 camera chains, in addition to film and remote-pickup facilities.

Costs are estimated on the assumption that a 500-foot antenna will be employed, as was done for the Type 3 station. It may be found desirable to use a tower of greater height in many cases, up to 1,000 ft. or even higher. For a 1,000-foot tower, add about $220,000 to the costs shown.

Also, it can be seen that an opaque projector has been included in the equipment list for the Type 4 station, and that a more elaborate antenna has been included.

TYPE 4 STATION

EQUIPMENT	
Antenna	$40,000
Transmitter, video and audio and directly-associated monitoring and control equip.	90,000
Monoscope and sync generator	8,000
Two field cameras (studio) and associated equipment	50,000
Two film camera chains	25,000
Two 16-mm. film projectors, slide and opaque projectors	13,500
Video & audio control, monitoring, switching, and other miscellaneous equipment	44,000
Test equipment	7,500
Studio lighting equipment	6,500
Remote pickup equipment	68,000
Installation	20,000
Equipment Subtotal	$372,500
SITE AND BUILDING	
Site procurement and development	$8,000
Building construction or alterations	50,000
Antenna tower	40,000
Primary power	4,500
Miscellaneous items	3,500
Space Subtotal	$106,000
CONTINGENCIES	
10% of subtotals above	$48,000
TOTAL COST, TYPE 4 VHF STATION	**$526,500**
TYPE 4 VHF STATION WITH ST LINK	**$551,500**

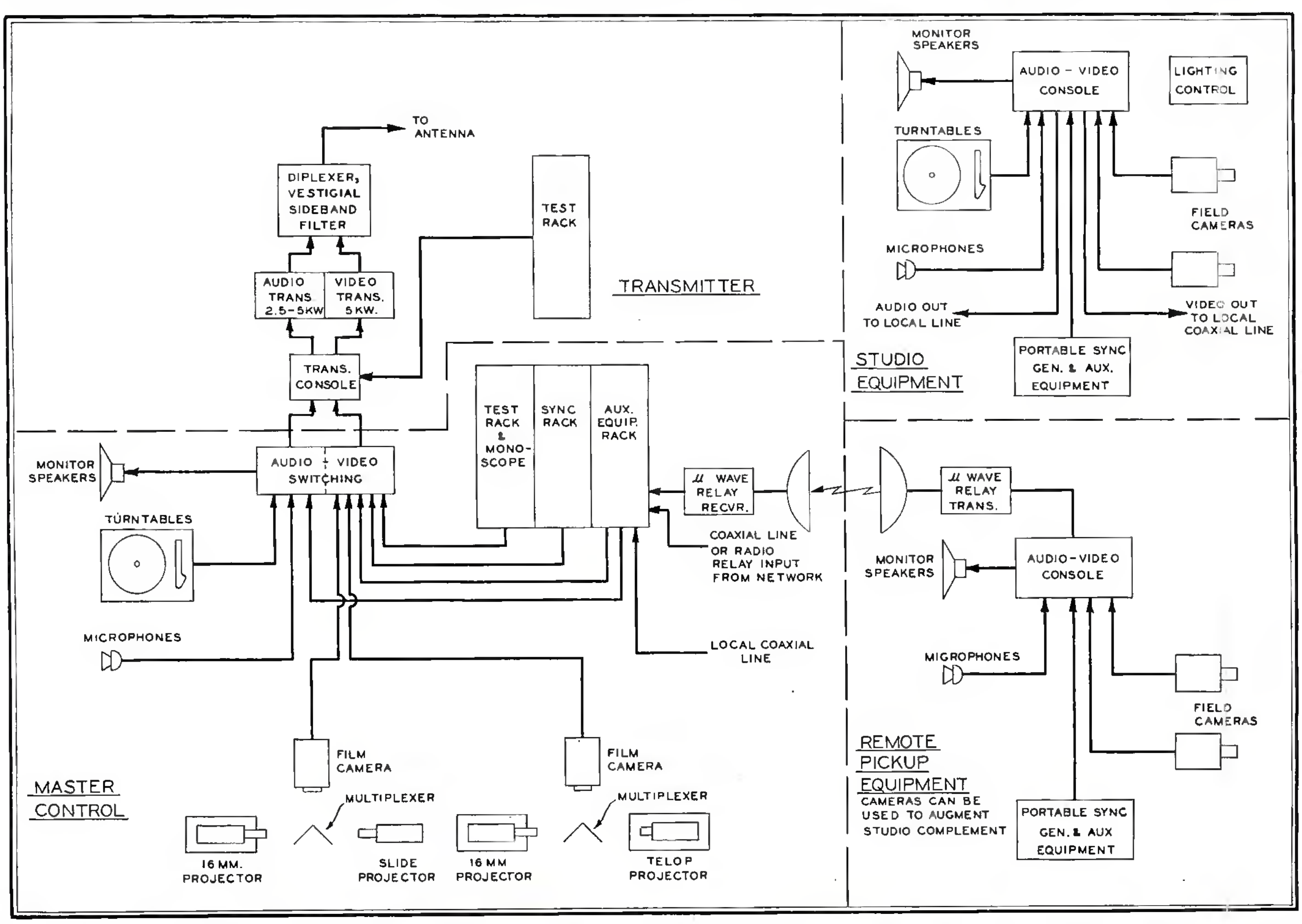


FIG. 4. HERE IS A BLOCK DIAGRAM OF THE MINIMUM EQUIPMENT REQUIRED FOR NETWORK, FILM, AND REMOTE AND LOCAL LIVE-TALENT PROGRAMMING

It will be noted that the addition of a live-talent studio increased the cost of master-control equipment, since a more elaborate and complex control center is required. Also, allowances for the antenna and tower were increased because it was assumed that greater antenna height and gain would be required.

In this connection, it should be noted that recent FCC proposed Rules would permit maximum effective radiated power (ERP) of 100 kw. on VHF channels 2 to 6, 316 kw. on VHF channels 7 to 13, and 1,000 kw. on UHF channels 14 to 83, with antenna heights of 500 ft. above average terrain. Transmitters and antennas to provide this increased ERP in the VHF band will, on the average, add to the total cost of a Type 3 or Type 4 station about $200,000 or more. At present, practical considerations limit the maximum ERP available from UHF equipment to about 200 kw. However, recent developments in transmitter design indicate that equipment for 1,000-kw. ERP at UHF is quite practical. Preliminary estimates place the cost at about $100,000 more than maximum-power equipment for channels 7 to 13.

Two camera chains are provided for the remote-pickup unit and 2 more for the studio. In many cases, 3 or more cameras are required for live-talent productions. Since field-type cameras are employed in the studio, however, one or both cameras of the remote equipment can be used to complement the studio cameras when necessary. Also, the studio cameras can be used with the remote-pickup equipment to provide good coverage of the more elaborate outside events.

Under some conditions, particularly in large cities where many applicants are competing for channels, the costs indicated in these tables may not be representative.[1] In order to impress others with the size and scope of the proposed operation, the facilities planned may be more elaborate.

The average capital investment in stations on the air in 1950, as revealed by FCC figures, was $481,250 before depreciation. The average for stations in market areas of less than 100,000 was $166,000; for market areas of 250,000 to 500,000, $440,535; and for market areas of over 1 million population, $752,850. It should be remembered that prices for equipment, basic materials, and labor have increased substantially since those installations were made.

Operating Costs and Personnel: It is difficult to estimate accurately the operating costs of a typical TV station simply because there are no typical stations. The factors which determine operating costs are so numerous and variable that any given set of conditions valid for one station may not be approached even approximately at another station. Some of these factors which vary for stations of identical size and with the same equipment are listed below:

1. Local Conditions

A. *Salary Scale:* This will generally be higher in large cities and industrial areas than in rural sections, and higher in northern and eastern parts of the Country than in southern and western sections. An exception is the California area.

B. *Union Position:* This has an effect not only on salary ranges but on the number and type of personnel required.

C. *City and State Taxes:* This factor of expense varies, of course, according to location.

D. *Climate:* Cost for heating and air-conditioning depend on local conditions.

2. Network or Non-Network Operation.

If the station does not have a network connection, a more extensive and expensive programming department is required, in addition to extra technical personnel. Some interesting and pertinent statistics from the FCC's report on broadcast financial data for 1951 follows:

Of the 106 TV stations reporting, 93 reported profitable operation, as against 53 in 1950. Total revenues were $239.5 million, more than double those of 1950. Networks, including their 15 owned stations, reported TV revenues of $132.2 million, expenses of $119.8 million, and income of $12.4 million before taxes. This was the first year of profitable TV operation for the networks. The remaining 93 TV stations reported total revenues of $107.3 million, expenses of $76.1 million, and income of $31.2 million.

Ten stations reported income between $.6 million and $1 million; 8 stations between $1 and 1.5 million; and 5 stations more than $1.5 million. Median income of profitable stations was $350,000. Only 6 stations reported increased loss or decreased income in 1951 compared to 1950. Income increased for 50 stations, while 33 reporting a loss in 1950 reported a profit in 1951.

3. Prevalence of Competition.

This will determine, to an appreciable extent, the grade of program material and the number of hours of operation. Both have significant effects on overall operating costs. For instance, if it is possible to adjust programming schedules so that all live-talent and remote originations are produced during a 5-day period, and to operate with network and film the other 2 days, the number of operating personnel required is decreased.

4. Affiliation with a Radio Broadcast Station.

Where the cost of personnel and of some facilities such as space can be shared with an audio broadcast station, operating costs may be reduced.

5. Depreciation of Equipment.

This is a very large item, and is not fixed. It varies for equipment and building facilities also.

6. Studio & Transmitter Locations.

Personnel requirements, equipment maintenance costs, and depreciation (because of greater initial cost) all increase with a remote transmitter and antenna.

It can be seen that salary expenses are at once the largest and most variable single item of operating costs. Thus, the following tables should be taken as a general guide only. It is assumed that the station will operate 60 hours per week, and minimum personnel requirements are provided. Operating expenses listed include salaries for the entire staff, maintenance of all equipment and buildings, rent, telephone and telegraph fees, travel and entertainment, overtime, office supplies, RTMA membership, and insurance. They do not allow for depreciation, broadcast rights, or program costs of any kind. *These extra costs may double the figures shown here.*

Type 1 Station Annual Operating Expense

SALARIES	
Non-technical personnel (2)	$8,500
Technical personnel (3)	11,000
OTHER EXPENSES	
Power	$2,500
Tubes	1,000
Maintenance	1,500
Rent[1]	2,000
Miscellaneous	1,500
Type 1 Station, Annual Operating Expense	**$28,000**

Where the transmitter is separated from the studio, at least 2 more technical people must be employed. This, in addition to extra maintenance expense will increase the operating expense by about $9,000.

Type 1 Station with ST Link, Annual Operating Expense	**$37,000**

Type 2 Network Station Annual Operating Expense

For a station operating with both film and network program facilities, the personnel requirements are increased as follows:

SALARIES	
Non-technical personnel (5)	$20,000
Technical personnel (6)	25,000
OTHER EXPENSES	
Power	3,000
Tubes	6,000
Maintenance	3,000
Rent	2,500
Miscellaneous	3,000
Type 2 Network Station, Annual Operating Expense	**$62,500**
Type 2 Network Station with ST Link, Annual Operating Expense	**$71,500**

Six to eight more employees will be required if remote-pickup equipment is

[1]Note: There was not complete agreement among the collaborators as to the statements contained in this paragraph, since conditions may change after the TV freeze has ended.

[1]This figure is a mean for rent, if the station does not own its building, or building maintenance and taxes if it does.

added. Other cost figures will change also, so that operation of such additional equipment will cost about $40,000 per year.

Type 2 Network Station with Mobile Unit, Annual Operating Expense	$102,500
Type 2 Network Station with ST Link and Mobile Unit, Annual Operating Expense	$111,500

If network facilities are not available to the station, and it must rely on film and remote-pickup programs only, at least 3 additional employees will be necessary. Increased use of the film equipment and the remote pickup facilities will add maintenance, tube, and power costs, so that non-network operation would cost about $15,000 extra annually. Film rental fees, which are not considered here, will increase also.

Type 2 Independent Station with Mobile Unit, Annual Operating Expense	$117,500
Type 2 Independent Station with ST Link and Mobile Unit, Annual Operating Expense	$126,500

Type 3 Network Station Annual Operating Expense

Since the Type 3 station is intended to serve a larger market area, the scope of its activities must be expanded accordingly in order to operate efficiently. Normally, additional sales and program department personnel are required. The technical staff must be increased in order to meet the increased operating and maintenance load. The following table gives representative cost data:

SALARIES	
Non-technical personnel (15)	$70,000
Technical personnel (20)	80,000
OTHER EXPENSE	
Transmitter & film, tubes and maintenance	$25,000
Mobile unit power, tubes, supplies, and maintenance	12,000
Rent	3,000
Miscellaneous	7,000
Type 3 Network Station, Annual Operating Expense	**$197,000**

Because still more personnel must be added for a separate transmitter installation, the extra operating expense for an ST link will be about $20,000.

Type 3 Network Station with ST Link, Annual Operating Expense	$217,000

It is estimated that, for non-network operation, the cost of operation of a Type 3 station will be increased by about $90,000, in addition to extra program costs.

Type 3 Independent Station, Annual Operating Expense	$287,000
Type 3 Independent Station, with ST Link, Annual Operating Expense	$307,000

Type 4 Network Station Annual Operating Expense

The cost of studio equipment for live-talent programming is insignificant compared to the increased cost entailed by the operation of these facilities. Script writers, stage-hands, camera and microphone operators, control console operators, lighting operators, and directors, among others, must be added to the payroll. Minimum operating cost figures for a Type 4 station, operated in conjunction with an aural broadcast station, are given in the following table:

SALARIES	
Non-technical personnel (32)	$140,000
Technical personnel (38)	190,000
OTHER EXPENSE	
Transmitter power, tubes, and maintenance	35,000
Studio equipment, power, tubes, supplies, and maintenance	36,000
Mobile unit, power, tubes, supplies and maintenance	15,000
Rent	6,000
Miscellaneous	15,000
Type 4 Network Station, Annual Operating Expense	**$437,000**
Type 4 Network Station with ST Link, Annual Operating Expense	**$457,000**

The extra cost of operation of a non-network Type 4 station is estimated at about $150,000 because of increased personnel requirements and more extensive use of local facilities.

Type 4 Independent Station, Annual Operating Expense	$587,000
Type 4 Independent Station, with ST Link, Annual Operating Expense	$607,000

With more live-talent studio facilities, and more versatile remote-pickup equipment, the cost of operation may well exceed $1 million per year. This is in addition to talent, royalties, and other program expenses, and depreciation. Total annual expense will be about double the figures shown here, particularly for Types 3 and 4 stations.

Check List of Expenses:

It may be helpful, in estimating probable expenses more closely, to use the following detailed check list. This gives an eye-opening picture of the expenses incurred by the larger stations.

Executive Department

Salaries	Travel
Entertainment	

Program Department

Salaries	Overtime
Travel	Entertainment
Local Transportation	Miscellaneous

Program Services

Talent	Scripts
Records	Photographs & photostats
News wire services	Sports statistics
Broadcast rights fees	Prizes and prize money
Costumes	Sound effects
Miscellaneous	

Production Department

Salaries (Administration)	Overtime (Administration)
Salaries (Art Division)	Overtime (Art Division)
Salaries (Stagehands)	Overtime (Stagehands)
Transcription library services	Scenic materials & supplies
Art supplies	Props
Studio lighting	Make-up supplies
Lighting equipment & supplies	Air-conditioning expense
Repairs to studio, art, carpentry shops	Trucking and express
Miscellaneous	

Press Information

Salaries	Entertainment
Local Transportation	Still photos
Stationery supplies & postage	Miscellaneous

General Operations

Salaries	Postage
Entertainment	Overtime
General trucking & express charges	Local transportation
	Local telephone service
Company-owned television set maintenance and repairs	Stationery
Telegraph	Rent
Long distance tolls	Insurance
Office supplies	Membership fees in associations and organizations
Miscellaneous	

Building Operations

Salaries	Overtime
Electricity	Cleaning services
Elevator service	Maintenance supplies and repairs
Miscellaneous	

Sales Department

Salaries	Travel
Entertainment	Local transportation
Stationery supplies and postage	Miscellaneous

Depreciation

Technical Operations (Administration)

Salaries	Local transportation

Transmitter (Technical)

Salaries	Overtime
Supplies	Power
Tubes	Rent
Maintenance	Miscellaneous

Control Room & Studio (Technical)

Salaries	Overtime
Local transportation	Line charges
Supplies	Loops & connections
Power	Coaxial cables
Tubes	Microwave links
Air-conditioning	Audio lines
Miscellaneous	Private lines

Field-Remote (Technical)

Salaries	Overtime
Local transportation	Line charges
Repairs	Coaxial cables
Supplies	Audio lines
Power	Private lines
Tubes	Remote pickup bus expenses
Miscellaneous pickup expenses (gratuities, porter service, etc.)	Miscellaneous

Film Department

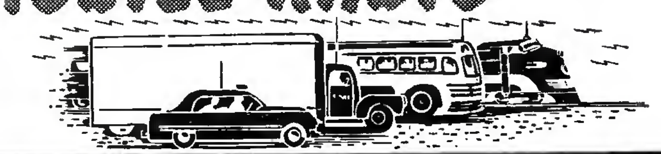
Salaries	Overtime
Local transportation	Raw stock
Processing	Film rentals
Camera car expenses	Camera repairs, maintenance, and supplies
Cutting room supplies	
Miscellaneous	

Summary:

From the foregoing, it is clear that astute organizing, careful planning, and strong financial resources are required of those planning to enter the television broadcasting business. It is an entirely different situation from that in the days when there were only 100 standard broadcast stations on the air. Then, the initial cost was no more than the owner chose to spend. There was no promise of operating profits and, therefore, virtually no competition. No standards of programming had been established in the public mind. Most listeners were more impressed by hearing the call letters of a distant station than by an entertaining program originating nearby. Stations did not have audiences in the present-day sense. Government regulation was concerned principally with granting applications for transmitter frequencies, a relatively simple matter since there were few men who knew enough about radio to select and assemble transmitters, and rig up antennas. There were no commercial managers or sales managers because there was no business to manage, and time was not sold. The title of program manager had not come into use because programming was generally dele-

(Concluded on page 25)

MOBILE RADIO



NEWS AND FORECASTS

AN interesting operation has been set up by Motorola in Phoenix, Arizona, where that company operates a large research and development laboratory. Under the direction of Charles Meyer, the Phoenix Radio Message Service has been organized as a miscellaneous common carrier. The purpose is to test new developments in equipment, to improve maintenance techniques, and to gather data on costs and operational problems of MCC service under continuously controlled conditions.

Of particular interest is the fact that the entire system will operate on a 20-kc. channel, instead of using a conventional 60-kc. channel. Prof. Daniel Noble explained that this is strictly a pilot operation. He is well known as a proponent of channel-splitting as a means of increasing the traffic handling capacity of the present frequency bands. Data collected will be made available to the Joint Technical Advisory Committee for use in formulating recommendations to the FCC on the further reduction of channel widths.

Low-Power Industrial Rules:

During the last two or three months, we have had a number of inquiries about FCC requirements concerning the operation and adjustment of low-power industrial radio equipment. This is the hand-carried type of transmitter-receiver made by several companies, and used in a great variety of applications where communication up to 1 mile or more is required. One reason for the increasing popularity of these units is that authorization for their use may be granted by the FCC to "any person engaged in commercial activity or industrial enterprise." Further details of their use, and the list of frequency assignments will be found on page 20 of the Mobile Radio Handbook.

Rather than attempting to speak for the FCC in the matter of operator and maintenance Rules, we addressed an inquiry to the Commission, and received a reply, signed by T. J. Slowie, Secretary, which is quoted in full below:

You are correct in assuming that adjustment of transmitters licensed in the low-power industrial radio service must be made by a licensed operator holding at least a second class commercial radio telephone operator license. In this respect the operator requirements are identical with those for the other industrial services. The regulation which bears on this point in Rules Paragraph 11.154 (a), quoted herewith:

"11.154 *Operator Requirements.* (a) All transmitter adjustments or tests during or coincident with the installation, servicing, or maintenance of a radio station, which may effect the proper operation of such station, shall be made by or under the immediate supervision and responsibility of a person holding a first or second class commercial radio operator license, either radiotelephone or radiotelegraph, who shall be responsible for the proper functioning of the station equipment: Provided, however, That only persons holding a first or second class commercial radiotelegraph operator license shall perform such functions at radio telegraph stations transmitting by any type of the Morse Code."

Since only voice telephone is permitted in the low-power industrial service, the proviso in the rule regarding telegraph operation is inapplicable.

You also inquire as to whether or not a commercial radio operator license is required for those persons who operate the transmitters as distinguished from maintaining and adjusting them. Subject to a few unusual situations, described in detail in several Paragraphs of Rules Section 11.154, no commercial radio operator license or permit of any kind is required in this service during the course of normal rendition of service. The regulation applicable to this situation is Rules Paragraph 11.154 (c), quoted in part herewith:

"11.154 (c) . . . an unlicensed person may operate a mobile station during the course of normal rendition of service when transmitting on frequencies above 25 mc. after being authorized to do so by the station licensee."

The low-power industrial radio service is unusual as to operator requirements (for normal rendition of service as distinguished from maintenance) because the regulations governing that service provide that even though a transmitter is installed and operated at a fixed location, it is nonetheless considered to be a mobile station for licensing purposes. It is for this reason that all stations in this service can be operated by unlicensed personnel, even including those which in other services would be classified as base station. As you know, base station operators are required to hold at least a Restricted Radiotelephone Operator Permit. The Commission, however, has not waived in any degree its general requirement that the station licensee shall be responsible for proper operation of his licensed equipment. Similarly, there has been no waiver of the requirement that any person operating a licensed transmitter in the industrial radio services must do so with the permission of the station licensee.

Citizens Radio:

Edwin L. White, FCC Chief of the Safety and Special Services Bureau: "The Citizens Radio was established as a service in an effort to meet the cost question and enlarge the use of radio. However, there has been very little development in that part of citizens radio which might be termed every man's radio. Basically, this service was established in the 460 to 470-mc. band for use by the non-technical person on a mass-use basis, with no interference protection as between users of this service. For this reason, it seems necessary for the Commission to maintain relatively close control over the design of equipment proposed to be used lest it stray off frequency, and cause untold interference to services on adjacent frequency bands. This is done by requiring that it be demonstrated that the equipment will meet published standards. There are a number of equipments which have met Class B type approval tests. These are the low power hand portable walkie-talkie types of equipment. Nonetheless, they have never been put into production, possibly because they cannot be sold at a price which the manufacturers believe the average man is willing to pay."

Robert L. Batts:

Back in 1928, just out of Purdue University, Bob Batts helped design and build what Detroit claims to be the first police radio system in the world. Now after 22 years with the City of Indianapolis, where he developed one of the outstanding police and fire radio installations in this Country, Captain Bob Batts has joined Motorola as a communication engineer and field representative. He has always had an active part in the progress of mobile radio. He is a past president of the Associated Police Communications Officers, and was chairman of APCO's frequency allocation committee from 1937 to 1941, and chairman of the police radio committee of RTPB Panel 13 during the years from 1943 to 1945.

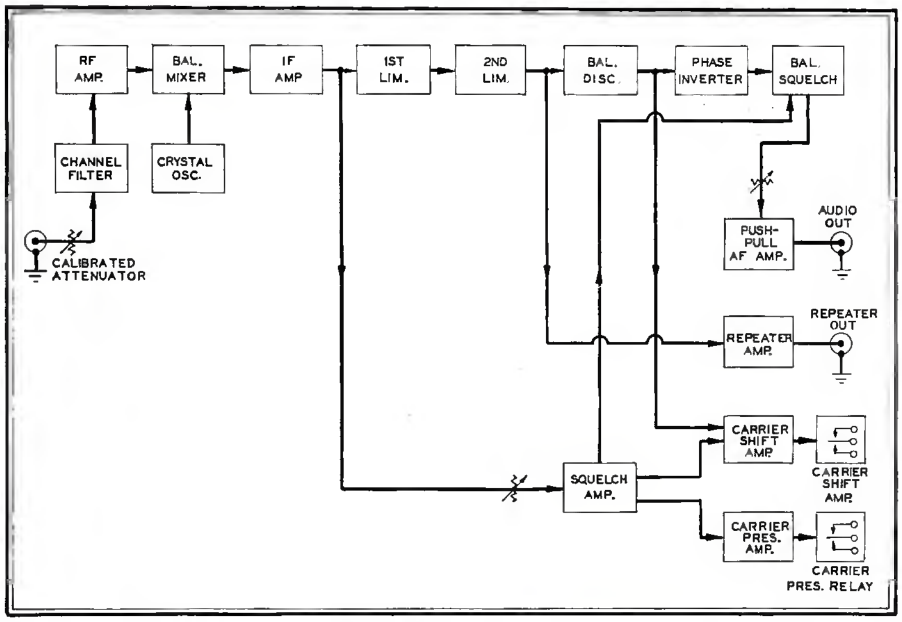


FIG. 1. BLOCK DIAGRAM OF THE MOTOROLA RECEIVER UNIT FOR POWER-LINE CARRIER OPERATION

FM Carrier Equipment for

POWER-LINE SYSTEMS

POWER-LINE CARRIER EQUIPMENT PROVIDES DEPENDABLE COMMUNICATION — *By* JOHN DOREMUS*

FOR efficient control of the normal operations of a power company, continuous communication is absolutely necessary between the various operating points throughout the system. Communication networks linking central offices, power generation plants, and substations, both attended and unattended, are required.

Operating instructions, meter readings, and orders can be carried over voice channels. Teletype and telemeter channels can carry a continuous stream of information. Supervisory control can provide completely automatic operation of remotely-located devices, with continuous checks on performance. Automatic load and frequency-controllers can maintain power generation at the required levels, making corrections instantaneously as required. All these functions can be provided for in the spectrum normally occupied by a single voice channel.

The facilities most commonly used to carry these communication signals are leased telephone circuits, private telephone circuits, and power line carrier systems. Telephone circuits are quite costly to install and maintain, and are limited in versatility.

For a power line carrier system, on the other hand, the only cost is that of terminal and coupling equipment, because the power transmission lines themselves are employed. This type of circuit provides more reliable service, since the outage time is determined by that of the more ruggedly-constructed transmission lines.

Power line carrier equipment, because it is completely owned, maintained, and operated by the power utility, provides extremely versatile service. It is inherently well-adapted to furnish a channel for voice communication, telemetering, teletype, or supervisory control wherever required in a power system. The equipment is reasonable in cost and flexible in application.

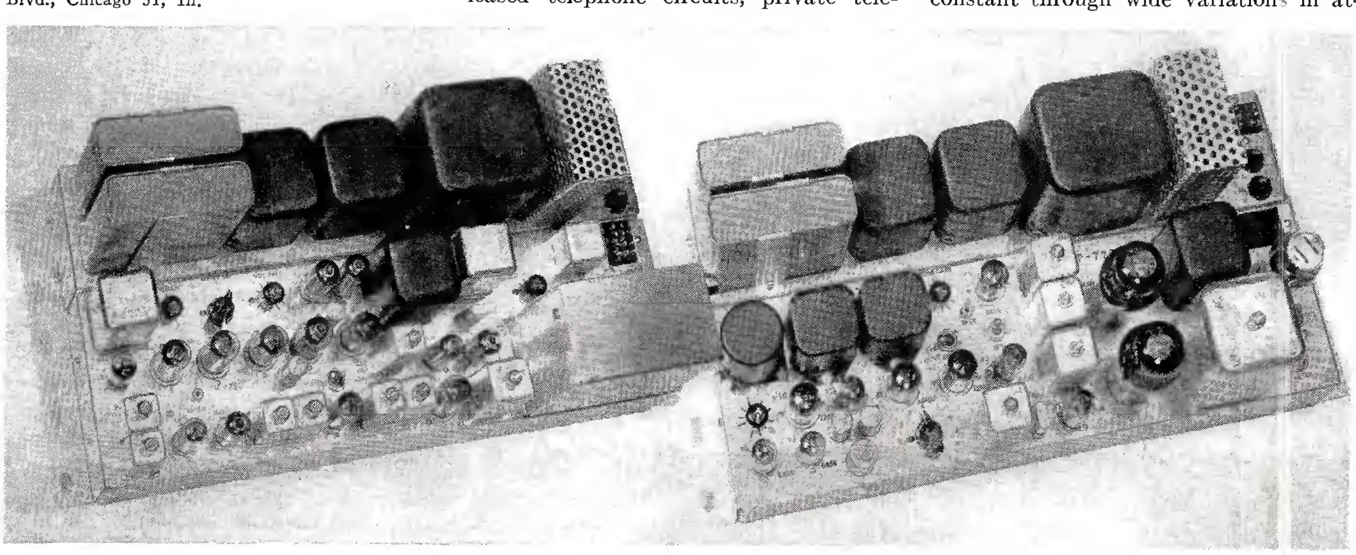
Design Considerations: Such a unit must be designed specifically to provide a voice or signaling circuit, or both, over high-voltage power transmission lines. This can be accomplished by modulating either the frequency or amplitude of an RF carrier, and superimposing it through a suitable coupling device upon the high-tension lines, which serve as the wire circuit.

The frequency of the carrier is generally in the 50 to 200-kc. band. Power outputs range from a few watts to more than a hundred.

During the past few years, Motorola has developed a system designed to make most effective use of the limited spectrum space available for this service. A number of major improvements have been found possible through the use of narrow-band FM.

One of the most important advantages of FM for a power line carrier is that the audio level in the circuit remains constant through wide variations in at-

*Chief engineer, Carrier and Control Development Department, Motorola, Inc., 4545 Augusta Blvd., Chicago 51, Ill.



FIGS. 2 AND 4. RECEIVER AND TRANSMITTER CHASSIS, LEFT AND RIGHT. A POWER SUPPLY IS MOUNTED ON THE NARROW CHASSIS ABOVE EACH UNIT

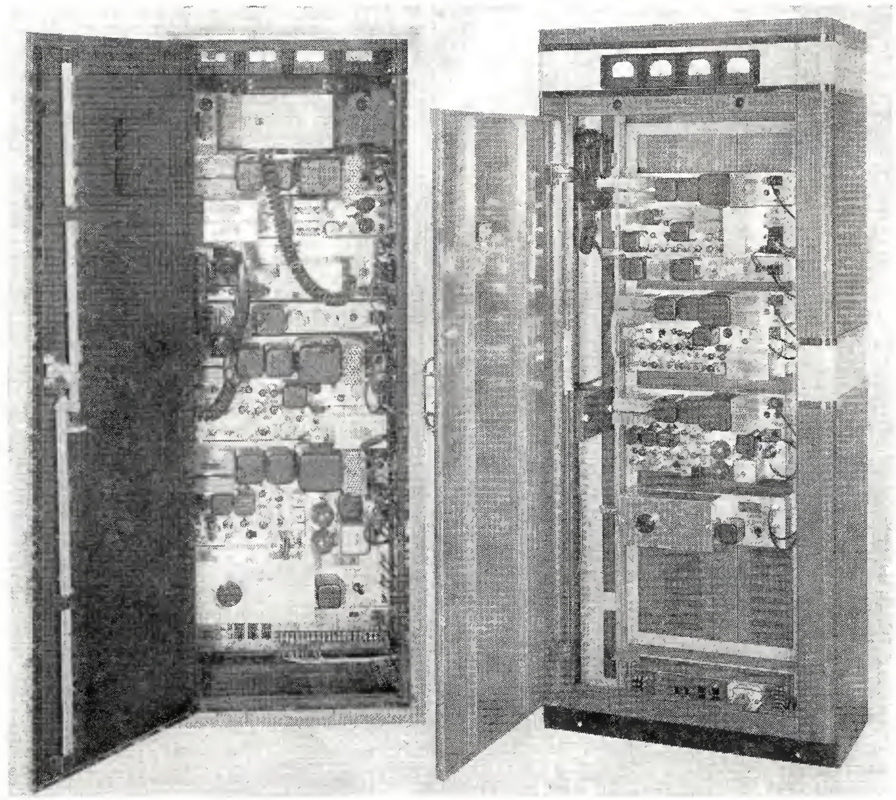
tenuation on the power line, which may be produced by switching operations on the line or adverse weather conditions, such as snow, sleet, and rain. This constant level is particularly important when the carrier circuit is to be interconnected with a telephone system or a VHF radio circuit.

Investigations have shown that even with a low modulation index, FM provides a definite improvement in signal-to-noise ratio over an AM system with corresponding transmitter power. The very narrow bandwidth used in this equipment, made possible by accurately-controlled modulation levels in the transmitters and highly selective filters in the receivers, permits a further improvement in signal-to-noise ratio.

As a result, lower transmitter power is required to accomplish a given job. Low transmitter power, in turn, provides a reduction in radiation from the power lines. Thus, interference with other radio services using the same portion of the spectrum is reduced also.

For low-power transmitters, less input power is required. This is particularly important when an installation is made for telemetering or supervisory control at a substation where no AC power is available. In this case, the carrier set can be operated from a station battery or from a potential device or a metering transformer.

The greatest improvements in this power-line carrier system have been achieved through the coordinated design of all its components. Close channel spacing is possible only through improvements of all units in the system, not through increased receiver selectivity alone. As a result of incorporating into its design the most recently-developed methods for controlling selectivity, intermodulation, desensitization and spurious responses, exceptional performance has been achieved in power line carrier equipment. Almost twice the number of channels can be derived in the 50 to 200-kc. section of the spectrum generally available for this service. All units, including the coupling equipment, are of completely new design.



FIGS. 5 AND 7. EQUIPMENTS FOR FULL DUPLEX OPERATION, LEFT, AND AUTOMATIC SIMPLEX, RIGHT

Rigorous control of transmitter spurious output — both harmonics and sideband components — makes close channel-spacing possible. Modulation components are contained within assigned channels by a fast-acting deviation control and a selective transmitter output stage. The reduction in spurious power reduces both co-channel and adjacent-channel interference problems, and permits a further reduction in required transmitter power. As a result, a channel frequency can be used more often throughout an interconnected power system.

Standard channel frequencies have been established in multiples of 5 kc. Filters and crystals for these frequencies are manufactured in quantity as standard items, while units for other frequen-

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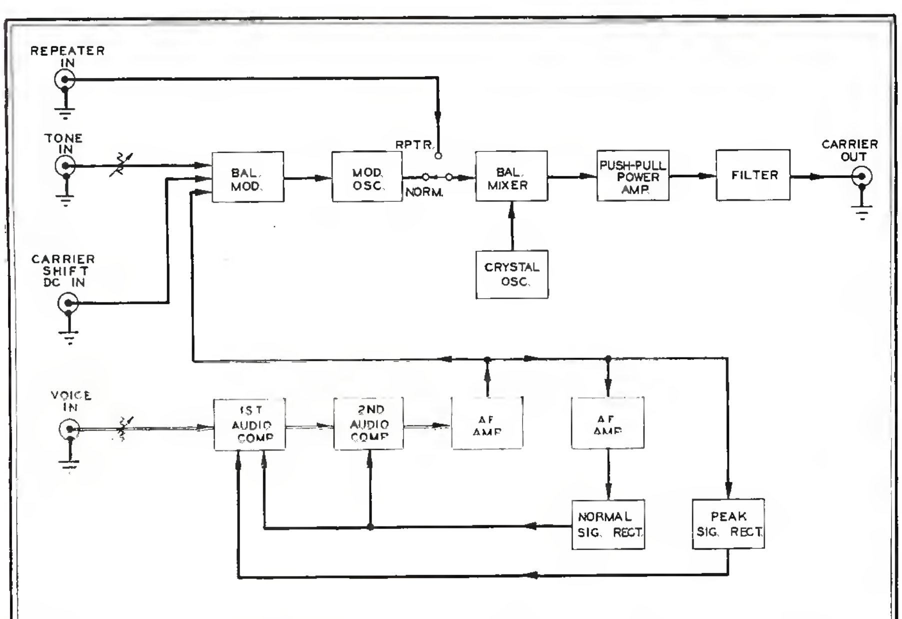

FIG. 3. THE STANDARD TRANSMITTER CHASSIS USED FOR ALL TYPES OF OPERATION.

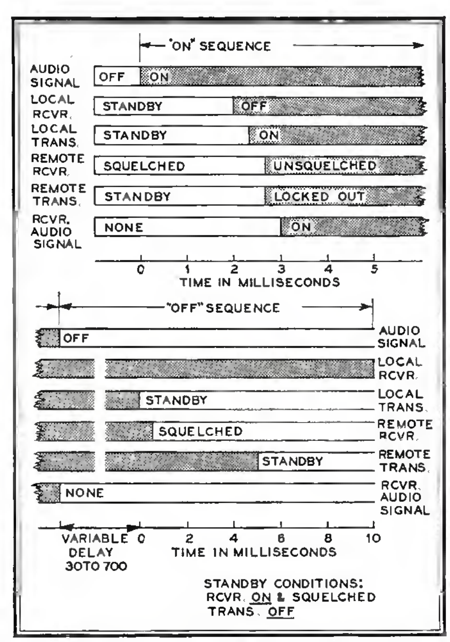

FIG. 6. SEQUENCE OF EVENTS IN AN AUTOMATIC SIMPLEX SYSTEM

THE TD-2 RELAY LENS ANTENNA

CONSTRUCTION DETAILS OF THE LENS-TYPE ANTENNAS USED IN THE TD-2 TRANSCONTINENTAL FM MICROWAVE REPEATER SYSTEM — *By* A. H. LINCE*

A motorist traveling the highways near the transcontinental TD-2 radio relay system can see many of the repeater station towers, usually with four antennas: two aimed toward the east and two toward the west. One of these antennas looking eastward toward the preceding station perhaps 25 miles away is a receiving antenna, and its mate looking westward toward a succeeding station is a transmitting antenna; the pair take part in relaying telephone messages and television programs from east to west at frequencies in the neighborhood of 4,000 mc. The other two of the four take part in relaying traffic in the opposite direction. By means of a specially constructed lens, these antennas focus the radio waves in narrow beams on the antennas of adjacent stations.

Theory of Operation:

In outward appearance this antenna, known as the KS-5759 delay lens, is a sheet-aluminum structure consisting of a lens housing at the front, 10 ft. square and 3 ft. deep, and a pyramid-shaped horn at the back. Four of the antennas atop a typical relay tower can be seen in Fig. 1. The horn feeds RF energy from the connecting wave-guide to the lens. The lens inside the housing is protected from the weather on the front by a cover of resin-impregnated fiberglas. This material is transparent to radio-frequency energy but is mechanically rugged, and is capable of withstanding many years of exposure to all kinds of weather.

*Transmission Systems Development Dept., Bell Telephone Laboratories, Inc., 463 West Street, New York 14, N. Y. This article appeared originally in the *Bell Laboratories Record* for February, 1952.

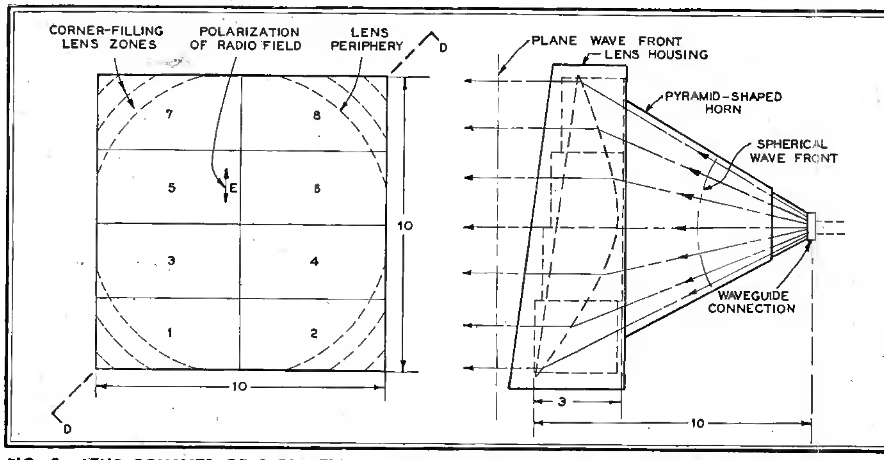

FIG. 2. LENS CONSISTS OF 8 PLASTIC BLOCKS CONTAINING STRATEGICALLY-PLACED METAL STRIPS

A cross-section of the housing, Fig. 2, shows the position of the lens within. Radio waves from the waveguide connection at the rear of the housing diverge as indicated until they encounter the lens. Their phase velocity is then decreased by the lens structure, and the thickness of the lens at the center is adequate to introduce delay equal to that of the geometrically longer path by way of the edge. The diverging rays from the focal point thus become essentially parallel rays at the front. Because of this action, the device is called a delay lens. A glass lens acts in much the same manner toward light, and is thus also a delay lens. The ratio of the velocity of the wave in free space to that in the lens is the index of refraction, which is about 1.5 for both a glass lens and the antenna lens. Based on this value, the lens shape is designed to produce a plane wave front at the front of the lens from a spherical wave front radiating at the focal point.

Because the radiated energy is concentrated into a narrow beam instead of

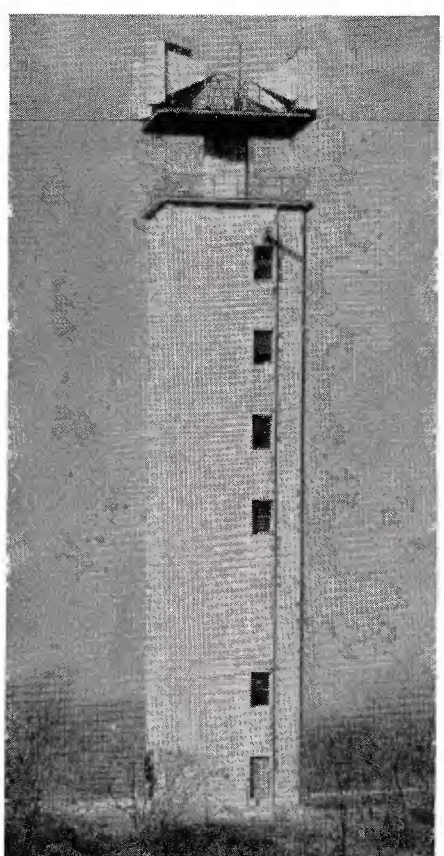

FIG. 1. EACH REPEATER REQUIRES 4 ANTENNAS

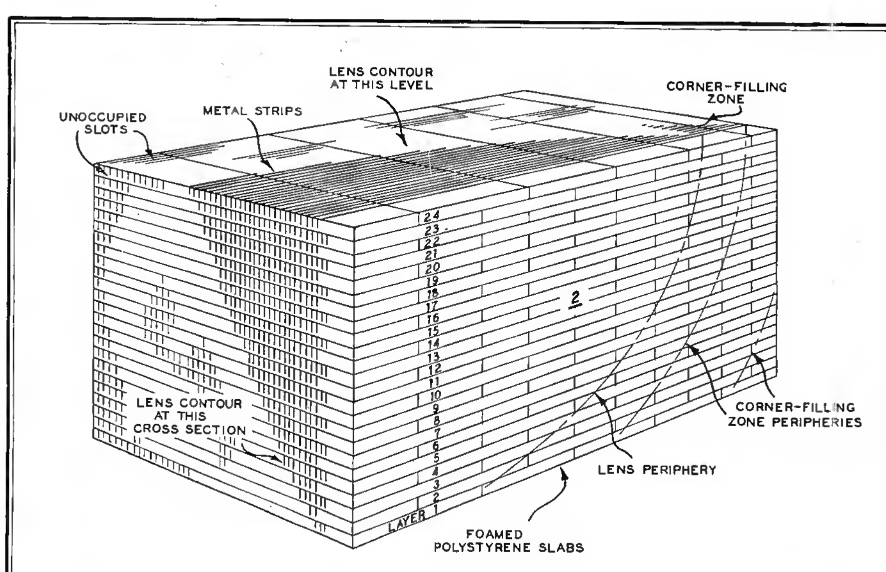

FIG. 3. HOW INDIVIDUAL SLABS ARE INTERLOCKED TO MAKE UP 1 BLOCK OF THE 8-SECTION LENS

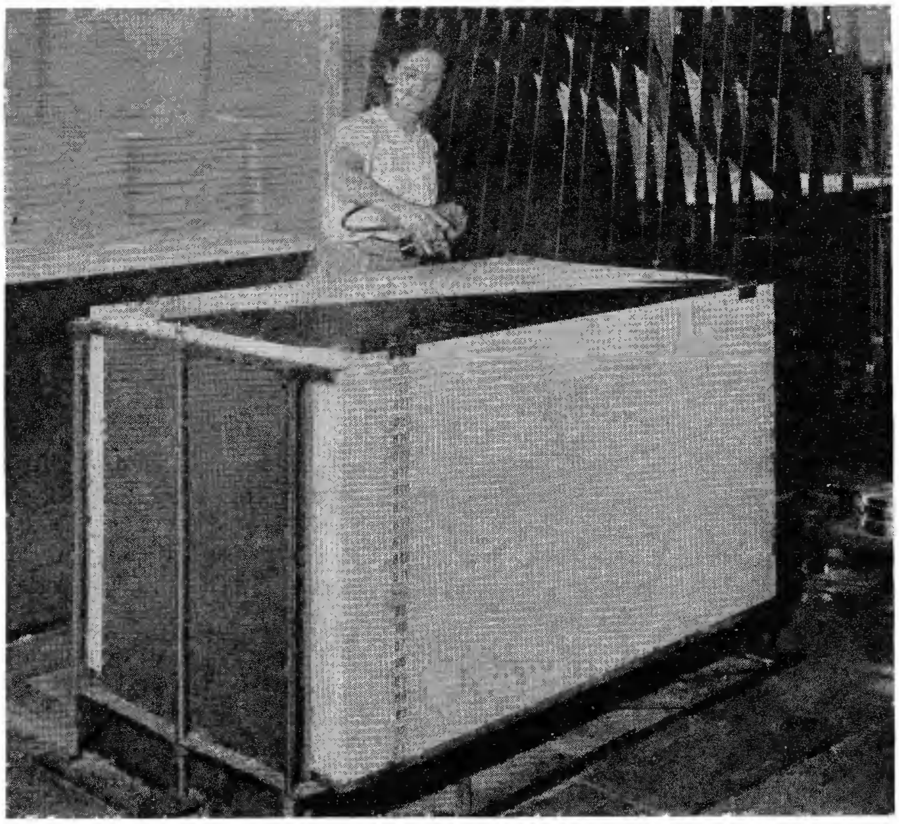

FIG. 4. EACH LAYER OF SLABS IS MARKED BY TEMPLATE TO SHOW LENS OUTLINE AT THAT LEVEL

being permitted to diverge in all directions, as it would if there were no lens or other directing elements, the distant antenna receives much more energy than it otherwise would. The antenna is spoken of as having gain, which is measured by the ratio of the intensity of the energy at the receiving point when a lens is used to what it would be if the transmitting antenna radiated equally in all directions. The gain of the TD-2 antenna is nearly 40 db; the energy is concentrated in a beam only about two degrees wide at the half-power points. This is about the degree of concentration of a high-quality searchlight.

Construction:

As will be noticed in Fig. 2, the face of the lens is not vertical, but is tilted back slightly. This is done to prevent the portion of the energy reflected by the face of the lens from being focused back on the waveguide outlet. The protective covering on the front of the antenna is sloped back for similar reasons. The reflections are further reduced by the construction of the lens itself, as will be described later.

Although the lens for the TD-2 antenna acts much the same as a glass lens, it actually consists of a large number of narrow aluminum strips held in place by slabs of foamed polystyrene. This material is very light and porous; it weighs less than 2 pounds per cubic foot, or about one-sixth as much as cork. Its dielectric constant is so nearly that of air that it can be neglected in designing the shape of the lens. The retarding action of the lens is due entirely to the aluminum strips. Their effect is essentially the same as that of the molecules of the glass in retarding light waves. The strips are a much coarser array, however, in proportion to the TD-2 wavelength, than the molecular structure of glass is with respect to light wavelength. However, the focusing action is effectively the same.

The lens for the TD-2 system is built up in eight sections, each about the size of an office desk and consisting of 24 layers of polystyrene foam slabs. Successive layers of each section are cemented together to form a single mass, which is then wrapped in polyethylene sheet for protection. The individual slabs are 1¼ inches thick and either twelve or six inches wide, and are laid up brick-like as indicated in Fig. 3. The use of two 6-in slabs in place of one 12-inch slab in alternating layers permits the joints in one layer to be laid opposite the center of the slabs above and below it. The top of each slab is slotted transversely every three-eighths inch, and into these slots are placed the aluminum strips that comprise the lens. Each lens contains about 7 miles of such strip.

The strips, however, are not inserted over the entire slab, but only over the area that is to be used as the lens. This area is determined from the lens shape calculations by making ninety-six cross-sections — one for each layer of slabs. Half of each cross-section thus shows the area to be used in each layer in each of the eight sections. An aluminum template duplicating the half cross-section is prepared and is numbered with the section and layer to which it applies. After the first layer of slabs of a section has been laid down, the proper template is placed on it, and dye is sprayed around its edge to mark the cross-section on the slab, as shown in Fig. 4. The aluminum strips are then placed in all the slots

FIG. 5. METAL STRIPS ARE INSERTED IN SLAB LAYER WITHIN AREA MARKED BY TEMPLATE OUTLINE

within this cross-section. This operation is illustrated in Fig. 5. Tabs from the template project over the edge of the slab and carry a stencil of the number of the template, and this number is sprayed on the edge of the slab so that after the section is complete, it can be ascertained that the proper templates have been used for each layer.

Since the face of the lens tilts backward, the successive sections are offset slightly back from the ones below them, as indicated in Fig. 6. Sections 1 and 2 are nearest the front of the housing, 3 and 4 are offset slightly back from them, 5 and 6 slightly more, and 7 and 8 are stepped back the same amount. In placing the metal strips in the slots that will determine the face of the lens, the slot just in front of the ideal face of the lens is used in one layer and that just back of the face of the lens for the adjacent layers, and so on up through the entire lens. This, in effect, roughens the face of the lens, and assists in making the reflected rays out of phase at the waveguide, thus adding to the effect of tilting the face backwards. This staggering of the strips gives an effect essentially the same as that of a coated optical lens.

With a 10-foot diameter lens in a 10-foot square housing, there is an area in each of the four corners of the housing unoccupied by the lens, and the energy reaching these corners from the wave guide would not be directed toward the distant antenna. To avoid this loss of energy, lens contours have been designed to fill this corner area. Their general shape and position are indicated in Figs. 3, 4, and 7. On the diagonal there are two of these corner lens sections, but farther around, as on slab 24 shown in Fig. 3, there is only one. The vacant corners could have been avoided, of

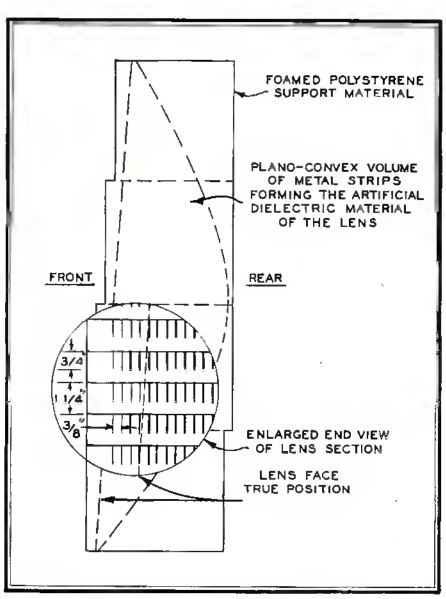

FIG. 6. SIDE VIEW OF THE LENS CROSS-SECTION

course, by making the diameter of the lens equal to the diagonal of the square and then not using the segments at the four sides. This would have resulted in a much thicker lens, however, and more material throughout.

Considerable investigation was necessary to secure a satisfactory adhesive to hold successive slabs together. Although polystyrene foam is a stable substance, it was found that the solvents used with many adhesives satisfactory in radio-frequency loss, holding power, and aging, were not suitable for use with polystyrene foam. The adhesive selected is a dispersion of acrylic resin in water. It is applied by rolling on, much as are some of the well-known water emulsion wall finishes. After nearly all the water has evaporated from the applied film, a pressure sensitive adhesive remains on the surface. The completed lens section

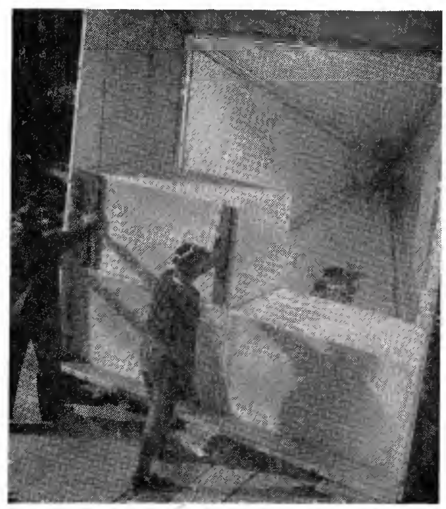
FIG. 8. ANTENNA IS ASSEMBLED AT TOWER SITE

needs only to be clamped in a press for several hours under pressure to accomplish the bonding.

The gain of the lens is constant within about 1 db across the frequency band from 3,700 to 4,200 mc. The assembled antennas resemble each other in all transmission characteristics to a rather high degree, high enough to make unnecessary any transmission measurements associated with shop production.

A fixed iris is inserted between the antenna waveguide flange and the connecting waveguide to compensate for the small reactive component of the antenna impedance. This reactance is undesirable because it represents an impedance mismatch and a source of reflections. Reflections of this kind would produce echoes in television pictures and crosstalk in telephone conversations. The iris is an inductive reactance located near the source of capacitive reactance of the same magnitude at the apex of the antenna horn.

The waveguide running between the repeater equipment and the antenna is often 100 ft. in length, sometimes more and sometimes less, depending on the tower height and the location of the repeater room in relation to the tower top. Short sections of flexible waveguide join the antenna to this transmission line and

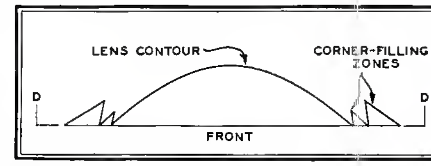

FIG. 7. SECTION D-D OF FIG. 2, SHOWING THE CONTOUR DIAGONALLY ACROSS THE SQUARE LENS

join the line to the repeater bays. This flexibility isolates antenna vibration from the waveguide and permits dimensional changes with temperature.

To avoid impedance disturbances resulting from water of condensation that would collect inside the waveguide under certain cycles of humidity and temperature, the waveguide is blocked off by mica windows placed inside the waveguide near the antenna and the repeater bay. The entire length between these windows is filled with a dry atmosphere. Ordinarily, a barrier of any material in the waveguide would be a source of reflection of transmitted radio energy. Since the level of reflections permitted by the broadband TD-2 system is low, steps had to be taken in the design of the pressure window to minimize the reflections introduced. This was accomplished by sloping the mica sheet, comprising the window at a critical angle so that reflection from the upper and lower halves would cancel each other.

The sheet aluminum housing and mounting details for the antenna were designed for manufacture in shops equipped for aircraft and similar fabrication, and require no unusual machinery or tools. The base and support details include facilities for aiming the antenna both laterally and vertically. At the apex of the horn where precise dimensions are necessary to achieve impedance uniformity, machined castings of aluminum alloy are employed. The antenna metal work and lens units are shipped to relay tower locations and assembled on the ground, as shown in Fig. 8, by contractors employing laborers who are usually in the rigger and bridge-worker categories. The completed assembly is lifted by a temporary derrick or boom rigging on the building to a position on the antenna deck of the tower. The assembly instructions are in the form of Bell System Practices.

The development of the delay lens antenna was initiated by W. E. Kock, and the first antenna of this type — considerably smaller than those used with the TD-2 system — was built and tested under his direction at the Holmdel Laboratories.

TV PROFIT

(Continued from page 18)

gated to whomever had a little spare time and an interest in music or amateur theatricals.

From such uncertain beginnings, radio broadcasting grew up to be one of the major industries in this Country.

If the end of the FCC's television freeze is considered the real beginning of nation-wide service, then this is a business born full-grown and completely defined by established practices — however they may be modified subsequently — in matters of engineering, regulation, business administration, sales promotion, programming, and competition, as well as by studies of public reaction to television broadcast services.

Thus, the cost of going into television is far greater than it was for broadcasting 30 years ago, but there is assurance of commensurately large returns for those who pioneer in this field, and the expectation of establishing extremely valuable properties in the years to come.

POWER-LINE CARRIER

(Continued from page 21)

cies can be made for special applications.

Receiver Design:

Design of the receiver, Fig. 1, is based on the same principle followed in Motorola 2-way mobile radio equipment. This principle, proven by many years, is simply that selectivity should precede amplification in order to obtain finest performance. Thus, the received signal is passed through the channel filter before it is amplified. This filter, which can be seen at the lower right in Fig. 2, establishes the bandwidth of the set. All the following tuned stages are broadbanded intentionally, and contribute virtually nothing to the selectivity. The filter is preceded by a calibrated attenuator, which is adjusted for proper operation of the receiver over the existing range of signal-input levels. This device is useful also in measuring signal strength on the line, and in protecting the input filter from extremely strong signals.

The channel filter, made up of 15 tuned circuits imbedded in a solid resin to provide permanent selectivity characteristics, has a response less than 5 db down at ± 3 kc., and more than 100 db down at ± 8 kc.

Following the filter is an RF amplifier, a balanced mixer, an IF amplifier, 2 limiter stages, and a discriminator. A crystal-controlled oscillator is employed, with a flat temperature-frequency characteristic throughout the operating range.

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POWER-LINE CARRIER

(Continued from page 25)

A circuit is included which is sensitive to steady changes in the DC output of the discriminator. These are caused by shifts in the transmitter carrier either above or below its normal operating frequency by a fixed amount. The carrier shift circuit in the receiver activates a relay, Fig. 1, which closes signaling sircuits for ringing or dialing.

The receiver has a balanced squelch circuit that provides squelch operation without injecting clicks into the audio. The audio output stage is operated push-pull for minimum distortion, and the audio response is flat within 5 db from 100 to 2,500 cycles. Power output is 1 watt at either 3 ohms or 500 ohms impedence.

Receiver sensitivity is such that full output is possible with signals of 300 microvolts or more. Spurious responses, including images, are more than 100 db down. There can be no desensitization from a signal on the same circuit that is removed in frequency by 10 kc.

The Transmitter:

The basic transmitter circuit is shown in Fig. 3. The output frequency of this 10-watt unit is the difference beat between a fixed-frequency oscillator centered on 455 kc., which is frequency-modulated by the audio signal, and a crystal oscillator whose frequency is determined by the desired output frequency. The advantages of this type of circuit are:

1. Modulation bandwidth is maintained constant, regardless of output frequency.

2. The modulated oscillator, which operates on a specific frequency regardless of output frequency, can be almost perfectly compensated for drift resulting from ambient temperature changes or variation in supply voltages.

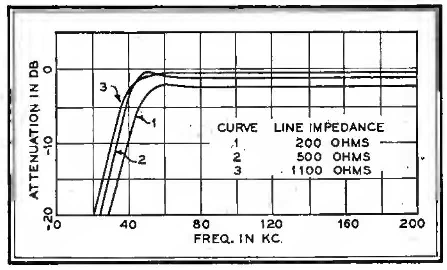

FIG. 8. RESPONSE OF A HIGH-VOLTAGE COUPLER

3. It can easily be adapted to repeater operation by applying a received but not demodulated signal to the transmitter mixer, in place of the signal from the local modulated oscillator.

The oscillator is frequency-modulated by a balanced modulator which is compensated for voltage variations and for tube aging. There are 2 audio inputs. One, for supervisory control or telemetering tones, leads directly to the modulator through a low-pass filter. The second, for voice signals, is first passed through a 4-tube automatic level-control circuit. This circuit is unique in that it has multiple time-constants, capable of handling signals with both fast and slow attack times. It is not a clipper-type circuit, but an automatic-gain-controlled amplifier which adds no appreciable distortion to the signal within its operating range. It permits higher average modulation levels, with resulting improvement in the signal-to-noise ratio. This level-control circuit holds deviation within ± 3 kc. of the carrier.

Response of the carrier transmitter is flat within 5 db from 100 to 2,500 cycles. Audio sensitivity is sufficient to provide full deviation on signals as low as −30 dbm.

A push-pull class A amplifier is utilized as the transmitter output stage to minimize harmonic generation. Spurious outputs are reduced further by a low-pass filter in the transmitter output circuit. This design has reduced all spurious outputs, including harmonics, to more than 80 db below the carrier level. The transmitter is shown in Fig. 4.

Methods of Operation:

The basic power line carrier units are employed for 3 methods of operation, referred to as full duplex, push-to-talk simplex, and automatic simplex.

A conventional telephone instrument can be used with the equipment for any

(Continued on page 27)

POWER-LINE CARRIER

(Continued from page 26)

type of operation. Provision is also included for the use of a microphone and loudspeaker, rather than a telephone, for push-to-talk operation.

Two frequencies are required in full duplex operation, because the carriers for communication in each direction are on continuously. Only one carrier frequency is required for push-to-talk and automatic simplex operation. However, conversation can be handled in only one direction at a time.

Facilities for ringing, dialing, supervisory signals, and revertive ringing signals, and a complete hybrid unit for connection to any type of telephone system, are included in the duplex control unit. Either local-battery or common-battery operation can be employed. Fig. 5 shows terminal equipment for a duplex carrier system, installed in a weatherproof housing.

The termination unit for a push-to-talk system is not so complex in design as the duplex system, and is adaptable only to common-battery operation. The push-to-talk button on the handset is used to start and stop the transmitter. Either voice calling or magneto ringing can be employed. Operation can be extended over conventional telephone circuits to a maximum of 1,000 ohms loop resistance.

Automatic simplex operation is gaining popular acceptance rapidly because it permits normal conversation over a single frequency channel. An electronic transfer unit, designed as part of this carrier system, transfers a station from the *receive* to the *send* condition in response to a voice signal. This unit employs no relays, because their operation would be much too slow for satisfactory results.

When speech is initiated at one station, the local receiver on the same frequency is first locked out. Then, the transmitter is made operative. At the remote station, the received signal locks out the transmitter and then connects the receiver output to the telephone. The total delay in this operation, from the time speech is begun until the sound emerges from the distant telephone, is less than 5 milliseconds. The time sequence for both ON and OFF functions is shown in Fig. 6. As can be seen, a variable time delay is provided after the speech is interrupted before the equipment reverts to the standby condition. This is to retain the connection between speech syllables.

Extreme care has been taken in the design to insure that the transfers occur without the introduction of clicks. This

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POWER-LINE CARRIER

(Continued from page 27)

system operates with a smoothness that makes it difficult to distinguish between it and a full duplex system. At the same time, it can be extended through normal duplex telephone facilities. Fig. 7 is a photograph of a typical terminal equipment rack for an automatic simplex system.

Carrier equipment is available in a number of standard packages. Five cabinet types — fixed rack, swinging rack, weatherproof housing, open rack, or switchboard cubicle, cover all possible applications. All parts are accessible for servicing. Built-in metering facilities with an ample safety factor. All include the required protective gaps and grounding switch. Tests are adequate to insure complete conformance to AIEE Spec. 31. Mechanical and electrical tests carried out in Northwestern University laboratories have demonstrated that the design theory is sound. It is noteworthy that the unit designed for a 69-kv. system passed the AIEE tests for the next higher voltage class.

Conclusion:

Tests made on actual installations have shown conclusively the superiority of FM for power line carrier equipment, and have verified the desirability of the design parameters chosen. Many in-

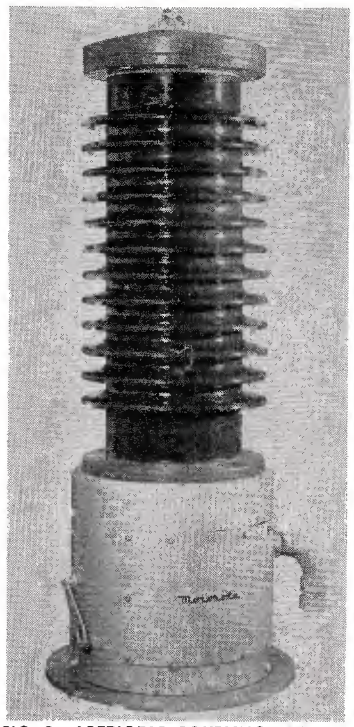

FIG. 9. APERIODIC COUPLING UNIT. FIG. 10. TELEMETER RECORDERS AT A LOAD DISPATCH CENTER

are available for test, alignment, or constant monitoring of circuits, as desired.

Coupling Units:

A completely new approach has been employed to solve the problem of coupling the signal to a power line. Rather than the usual series-resonant circuit, a single constant-K high-pass filter is used.

When a T section is used, the series arms require capacitive reactances and the shunt arm an inductive reactance. For nominal values of transmission line impedance, the required capacitance is well within the range of practical design. Frequency response of a 138-kv. coupler is given in Fig. 8. For a 69-kv. unit, a value of .006 mfd is required. A complete line of these Aperiodic coupling devices, one of which is shown in Fig. 9, are in production for all nominal system voltages.

In the design of these units, every precaution was taken to produce couplers stallations have been made on lines of all voltages and all types of construction. In all cases, the use of FM has provided a better signal-to-noise ratio circuit than could be obtained with AM equipment. At the same time, variations in audio level due to line attenuation changes have been virtually eliminated.

Because of the high quality of the channels provided by this type of equipment, they can be subdivided to handle several types of communication simultaneously. Several systems have been built which provide for transmission of voice in addition to four simultaneous channels for telemetering. In this type of application, the voice band occupies the channel from 100 to 2,400 cycles, and the telemetering channels are accommodated in the range from 2,400 to 3,000 cycles. A photograph of a load dispatch center, where telemeter readings are brought into the dispatcher's office by this method, is shown in Fig. 10.

New FCC Applications

This list includes applications for mobile, point-to-point, control, and relay communication facilities filed with the FCC during February, 1952.

This listing, planned 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 respective 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

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.
C Comco	O Farnsworth
D Doolittle	P Philco
E W. Coast Electronics	Q Collins
F Federal Tel. & Radio	R RCA
G General Electric	S Railway R. & S.
H Harvey	T Bendix
J Comm. Equipment	U Western Electric
K Kaar	W Westinghouse
L Link	X Miscellaneous

AERONAUTICAL & FIXED

Arctic Radio Tel Co Box 1601 Anchorage Alaska
Bethel Alaska 1b 6.652, 5.622, 5.122
Seward Alaska 1b 5.622, 5.652; 2m 2.748, 2.64B, 8.015, 1.554.
Kodiak Alaska 1b 5.622
Fairbanks Alaska 1b 5.122, 5.622, 5.652
Aeronautical Radio 1523 L St NW Washington D C
Blythe Calif 1b 131.1
El Centro Calif 1b 131.1
Middle River Md 1b 122.92 T
Alaska Airlines Inc Box 649 Fairbanks Alaska
Eagle Alaska 1b 5.6525, 5.6225, 2.922 —

FLIGHT TEST

Westinghouse Radio Stations Inc 1625 K St NW Washington D C
Wilmington Del 1b 122.92, 150.12 X

AERO MOBILE UTILITY

Eastern Airlines Inc c/o Aeronautical Radio Inc 1523 L St NW Washington D C 1m 121.9 C
T M Hollis Flying Serv Henderson Tex 1b 122.B —
Gopher Aeronautical Corp Chamberlain Field Minneapolis Minn 1m 121.9 —
Lockheed Aircraft 1705 Victory Pl Burbank Calif 1m 121.9 Q

AIRDROME ADVISORY

Robert L Shannon Westchester Pa 1b 122.8 NN
Mitchell Industries Mineral Wells Tex 2b 112.8, 114.9 —
Hoequist Airport Orlando Fla 1b 122.8 NN
McDonald Field Airport Plymouth Fla 1b 122.8 NN
Kutztown Aviation Serv Inc Kutztown Pa 1b 122.8 —
Bell Aircraft Corp Box 482 Ft Worth Tex Hurst Tex tower control 122.8, 123.1 or 123.3, 123.5
Cooper-Bessemer Corp Mt Vernon Ohio 1b 122.8 NN
State Line Airpark Inc Box 8167 Kansas City Kans 1b 122.8 X
Virgil N Lorenz Federal Wyo 1b 122.8 X
Anderson Charter & Flying Serv Inc Anderson Ind 1b 122.8 NN
F C Russell Chestertown Md 1b 122.B NN
Mun Airport Dodge City Kans 1b 122.8 NN
Acy B Duhon Orange Tex 1b 122.8 NN
Fred L McCaulon Newport Ohio 1b 122.8 NN
Erie Aviation Inc Erie Pa 1b 122.8 NN

(Continued on page 30)

NEW APPLICATIONS

(Continued from page 29)

Parker Aircraft Sales & Serv Wheeling Ill
 1b 122.8 NN
Clearwater Flying Co Clearwater Fla 1b 122.8 NN
Aero Enterprises Inc Denver Colo 1b 122.8 NN
Clover Flying Serv Friendswood Tex 1b 122.8 NN
Kalamazoo Flying Serv Kalamazoo Mich 1b 122.8 NN
Southwestern Skyways Inc Santa Fe N M
 1b 122.8 NN
Waterloo Flying Serv Waterloo Ia 1b 122.8 NN
Skyline Flying School Dallas Tex 1b 122.8 NN
Basco Flying Serv Pottstown Pa 1b 122.8, 121.5 NN
Goodall-Sanford Inc Sanford Me 1b 122.8 X
Geo J Wedekind Middletown Ohio 1b 122.8 X
Jack K Wasson Shawano Wis 1b 122.8 NN
Beer's Field Marshall Tex 1b 122.8 NN

CIVIL AIR PATROL

Maryland Wing Friendship Int'l Airport Baltimore Md Hagerstown Md 4b 2.374, 4.325, 4.585, 148.14 —, 3m 2.374, 4.325, 4.585, 148.14 —
Plainfield Sqdn Ind Wing Plainfield Ind
 1b 4.585; 5m 4.585
Renton Sqdn Grp II Wash Wing Renton Airfield Wash 1b 4.585, 2.374 Q
New York Wing Oswego N Y 3b 2.374, 4.585, 5.500; 9m 2.374, 4.585, 5.599, 148.14 AQ
Fergus Falls Sqdn Fergus Falls Minn 1b 4.585, 4.507, 148.14; 1m 4.585, 4.507, 148.14 T
Mich Wing Grp 635 Battle Creek Mich 1b 148.14 X

POLICE

Essex County Sheriff Court House Newark N J
 2m 156.21 M
Village of Vandalia Ohio 1m 39.78 M
City of Trenton Mo 2b 155.13, 155.37; 8m 155.13 M
Stevens County Sheriff Hugoton Kans
 1b 39.9; 5m 39.9 M
Wis State Motor Vehicle Dept Madison Wis Highland Ia 1r 7206 R
Harper County Sheriff Anthony Kans
 1b 39.58; 12m 39.58 M
City of Boulder Colo 1b 156.75; 18m 156.75 M
City of Little Falls Minn 1b 155.55; 5m 155.55 M
City of Grand Blanc Mich 1m 155.85 M
City of Talledega Ala 1b 155.01; 10m 155.01 M
Ohio State Patrol Columbus 5 Ohio Fremont Ohio
 1b 39.10 M
Commonwealth of Va Box 1299 Richmond Va
 Nr Wytheville Va 1b 74.50 L
Davis County Sheriff Washington Ind 5m 155.85 M
City of Ft Mead Fla 1m 155.31 M
City of Cimarron Kans 1m 39.58 M
El Dorado County Sheriff Box 592 Placerville Calif
 1b 45.5; 30m 37.42 G
 Lake Tahoe Calif 1b 45.5 G
City of Osceola Ark 1b 37.1; 10m 37.1 M
Village of Milford Mich 351 Main
 2m 155.73, 155.97 M
Town of Galax Va 1b 35.9; 12m 35.9 M
Fluvanna County Sheriff Palmyra Va 3m 42.7 L
Insular Police Box 3826 Puerto Nuevo P R
 Guaynabo P R 1b 155.13, 154.89 M
 1b 155.13, 154.89 M
 Trujillo Alto P R 1b 155.13, 154.89 M
 Rio Piedras 1b 155.13, 154.89 M
 Catano P R 1b 155.13, 154.89 M
 Loiza P R 1b 155.13, 154.89 M
 Carolina P R 155.13, 154.89 M
 Hato Rey P R 155.13, 154.89 M
Village of Fayette Ohio 1b 39.58; 9m 39.58 M
Jessamine County Sheriff Nicholasville Ky 1b 37.1 G
Town of Jamestown Rhode Island Town Hall
 2m 39.78 M
Bayfield County Sheriff Washburn Wis
 1b 39.58; 3m 39.58 M
City of Columbus Ohio 4b 2.455 X
Aroostook County Sheriff Houlton Me 5m 39.1 M
City of Perryton Tex 6m 37.18 M
City of Cisco Tex 1b 37.18; 6m — M
Ochiltree County Sheriff Perryton Tex
 1b 37.18; 8m 37.18 M
Hansford County Sheriff Spearman Tex
 1b 37.18; 6m 37.18 M
City of Spearman Tex City Hall 6m 37.18 M
City of Avon Park Fla 1b 155.61; 7m 155.61 M
Thomas County Sheriff Colby Kans
 1b 39.58; 15m 39.58 M
Village of N Aurora Ill 1m 154.89, 155.49 M
Twp of Burlington Jacksonville Rd Burlington N J
 1m 155.49 M
Sheriff of Page Co Luray Va 1b 39.5, 10m 39.5 M
N D State Police Patrol Capitol Bldg Bismarck N D
 2b 155.01, 42.38 M
 Mandan N D 1b 159.15 M
 Devils Lake N D 1b 155.01, 159.15 M
Ala State Police Patrol Montgomery Ala Kilby Ala
 1b 44.62 M
 Speigner Ala 1b 44.62 M
City of Edinburg Tex 7m 37.26 LR
Giles County Sheriff Pearisburg Va
 1b 39.5 L, 20m 39.5 G
Calif State Police Patrol Sacramento Calif
 Berkeley Calif 1b 42.34 —
 Los Angeles Calif 1b 42.34 —
 Nr La Jolla Calif 1b 42.34 —
 Redlands Calif 1b 42.34 —
Kans State Hiway Patrol 10th & Van Buren Sts Topeka Kans
 Phillipsburg Kans 1b 44.98 M
 Atwood Kans 1b 44.98 M
City of Sinton Tex 3m 37.18 M
Coffey County Sheriff Burlington Kans
 1b 39.58, 10m — M
City of Ogdensburg N Y 1b 155.55, 3m 155.55 G
City of Charleston S C 1b 39.14; 40m 39.14 G
Stephens County Sheriff Breckenridge Tex
 1b 37.18; 10m 37.18 G
City of Baylor Tex Police Dept Seymour Tex
 1b 37.18, 15m 37.18 G
City of Brentwood Mo 1b 155.43, 15m 155.43 M
Newton County Sheriff Neosho Mo 2m 155.13 —
City of Burlington Ia 412 Valley St 1p —
City of W University Place 3800 University Blvd Houston Tex 1b 155.25; 19m 155.25 GM
City of Hanford 696 Bowman Av Columbus Ohio
 3m 35.58M
Skamania County Sheriff Stevenson Wash 1b 39.82 M
Highland County Sheriff Monterey Va 3m 42.7 G
Brunswick County Sheriff Soupthport N C
 8m 155.01 M
 Raleigh N C Box 1246 3p 2.455
City of Seneca Falls N Y 1b 39.18, 5m 39.18 M
City of Prineville Ore 1b 156.57, 30m 156.57 M
 Prineville Junction Ore 1b 156.57 M

FIRE

Willimantic Conn Fire Dept 1b 33.90; 19m 33.90 M
Lewiston Pa Fire Dept 1b 46.06; 25m 46.06 M
Attleboro Mass Fire Dept 12b 46.18 GL
Norton Mass Fire Dept 1b 46.18; 4m 46.18 G
Mission Twp Fire Dept Overland Park Kans Mission Kans 1b 154.25; 20m 154.25 G
City of Hopewell Va Fire Dept 2b 39.5 G
Hoboken N J Fire Dept 1b 170.15; 22m 170.15 M
Waterloo Iowa Fire Dept 1b 154.25; 20m 154.25 M
Kings Park Fire Dist Kings Park N Y
 1b 46.46; 7m 46.34, 46.46 M
Riverhead Fire Dist Riverhead N Y
 1b 46.46; 10m 46.34, 46.46 M
Elkins Park Fire Co Elkins Park Pa
 1b 154.13; 10m 154.12 —
E. Bridgewater Mass Fire Dept 1b 33.9 G
Union Fire Co 401 S Pa Av Morrisville Pa Abington Twp Pa 1b 154.13; 9m 154.13 P
Pocomoke City Md Vol Fire Co #1
 1b 46.38; 10m 46.38 G
Spenard Vol Fire Dept Box 1964 Anchorage Alaska
 Spenard Alaska 1b 154.13; 3m 154.13 M
Columbus Ohio Fire Dept 1b 153.77; 20m 153.77 M
Huntington Fire Dist Huntington N Y
 1b 46.46; 8m 46.34, 46.46 M

Miss State Fire Marshalls Office Woolfolk Blvd
Jackson Miss 10m 42.02, 42.18 L
Warrenton Vol Fire Dept Warrenton Va
1b 46.5; 10m 46.5 G
Ridge Culver Fire Dept Rochester N Y
1b 154.31; 5m 154.31 M
New Egypt Vol Fire Co New Egypt N J 8m 33.78 —
Adams Mass Fire Dept 1b 154.31; 12m 154.31 M
Flourtown Fire Co Flourtown Pa
1b 154.13; 6m 154.13 P

FORESTRY

Fla State Bd of Forestry Box 1200 Tallahassee Fla
Crawfordsville Fla 1b 159.27, 159.33 M
Ala State Dept of Conservation 607 Monroe St
Montgomery Ala
Nr Womack Hill Ala 1b 159.45 M
Aquila Community Ala 1b 159.45 M
Melvin Ala 1b 159.45 M
Alberta Ala 1b 159.45 M
Dadeville Ala 1b 159.45 G
Miss State Forestry Comm Box 649 Jackson Miss
Leesdale Miss 1b 31.22, 31.30, 31.42 R
Sharon Miss 1b 31.22, 31.30, 31.42 R
Madison Miss 1b 31.22, 31.30, 31.42 R
Natchez Miss 1b 31.22, 31.30, 31.42 R
S C State Forestry Dept Box 357 Columbus S C
Nr Mont Clare S C 1b 159.27 M
Spartanburg S C 1b 31.78, 31.9 G
Fla State Forestry Dept 219 Canal St New Smyrna
Beach Fla
Crestview Fla 1b 46.82 M
Live Oak Fla 1b 46.82 M
Lake Park Fla 1b 46.82 M
Lakeland Fla 1b 46.82 M
Jacksonville Fla 1b 46.82 M
Panama City Fla 1b 46.82 M
Myakka State Park Fla 1b 46.82 M
Calif State Forestry Dept Sacramento Calif San Diego
1b 159.27, 159.33, 159.39, 159.45 L
Nr La Jolla 1b 159.27, 159.33, 159.39, 159.45 —
Los Angeles 1b 159.27, 159.33, 159.39, 159.45
Berkeley 1b 159.27, 159.33, 159.39, 159.45
Redlands 1b 159.27, 159.33, 159.39, 159.45
N C State Dept of Forestry 211 Education Bldg
Raleigh N C
East Lake N C 1b 31.34, 31.46 M
Texas State Dept of Forestry Walton Bldg Austin Tex
6 tb 31.22 M
Priest Lake Timber Protective Assn Coolin Idaho
1b 159.45 C; 6p 159.45 A; 6m 159.45 C

HIGHWAY MAINTENANCE

Los Angeles County Road Dept 108 W 2nd St Los
Angeles 12, Calif
Palmdale Calif 1b 37.94 M
Comm of Va Dept of Hiways Richmond 19 Va
Wise County Va 1b 47.22; 1r 72.82 L
Bristol Va 1q 160.05 L
Multnomah County Road Dept Portland Ore
1b 161.13; 50m 161.13 M
Los Angeles City Dept of Hiways Rm 700 City Hall
County of L A 1b 37.94; 1r 955; 100m 37.94. G
Los Angeles Cal 1r 955 G

SPECIAL EMERGENCY

Daniel & Son Funeral Home Rome Ga
1b 47.5; 6m 47.5 M
Mountain States Tel & Tel Co Box 960 Denver Colo
Nr Sante Fe New Mex 1 sq 161.97 M
Rio Arriba County New Mex 1b 161.97; 1tb
161.97; 1qr 157.47 M
Dr Guy C Brown Hudson Ia 1b 47.58; 1m 47.58 M
Dr Orin N Emerson & Dr Wayne L Emerson Eagle
Grove Ia 1b 47.58; 2m 47.58 M
Louis Kerlikowski Amb Serv St Joseph Mich
1b 47.62; 5m 47.62 M
Dr E P Hammer Summerville Ga
1b 47.54; 3m 47.54 M
L H Shultzman Orriville Ohio 1b 47.62; 4m 47.62 M
R W Emery Gering Neb 1b 47.46; 1m 47.46 M
Dr O H Setzepfandt Bird Isl Neb
1b 47.66; 1m 47.66 M
D M Seagles Tillamook Ore 1b 47.62; 2m 47.62 M
F P Todd DVM Miamiville O 1b 47.58; 2m 47.58 M
Dr Emmett Full Mt Airy Md 1b 47.66; 1m 47.66 M
T T Bowstead DVM Dewitt Ia 1b 47.58; 2m 47.58 M
G P Shindel DVM Dewitt Ia 1b 47.66; 2m 47.66 M
K J McKenzie DVM Baxter Ia 1b 47.46; 3m 47.46 M
O G Feuerback Preston Ia 1b 47.46; 2m 47.46 M
E F Damer DVM Chillicothe Mo 1b 47.46; 5m 47.46 M
S S Von Wiemokly DVM Morristown N J
1b 47.5; 1m 47.5 M
Adel Vet Clinic Adel Ia 1b 47.5; 1m 47.5 M
Nelphi Clinic Nelphi Idaho 1b 47.62; 7m 47.62 M
Akron Amb Serv Akron Ohio 1b 47.46; 24m 47.46 M
G E Pleasant Kenton Ohio 1b 47.54; 4m 47.54 M
Malloy & Chapman Vets Cascade Ia
1b 47.54; 4m 47.54 M
Aero Coach Lines Tonawanda N Y
1b 47.62; 12m 47.62 M
J R Francella Coatesville Pa 1b 47.58; 3m 47.58 G
Fred Starbuck Merkel Tex 2q 37.98; 1m 37.98 R
Clovis J Altmaier Marion O 1b 47.54; 1m 47.54 M
D E Mossbarger DVM Bloomingsburg Ohio
1b 47.62; 1m 47.62 M
R E Swinderman Kewanee Ill 1b 47.54; 1m 47.54 M
Vande, Garde & Wellings Vets Sioux Center Ia
1b 47.46; 3m 47.46 M

STATE GUARD

Texas State Guard Box 616 Refugio Tex 1b 2.726 X

POWER UTILITY

Southwestern G & E Co Box 1106 Shreveport La
Mt Pleasant Tex 1b 48.10 G
N J Pr & Lt Co 9 W Blackwell Dover N J
Dover N J 2q 457.95 L
Hackettstown N J 1q 457.92 L
Scholley's Mt N J 1r 456.05 L
Mine Hill N J 1r 456.05 L
Flemington N J 1q 457.95 L
L I Lighting Co 250 Old Country Rd Mineola N Y
Riverhead N Y 1b 37.46 L
E Meadow N Y 1b 37.46; 50m 37.46 L
Va Elec & Pr Co 7th & Franklin Sts Richmond Va
Covington Va 1b 48.14 M
Alexandria Va 1b 48.14 M
Grayson REC Grayson Ky Morehead Ky 1b 3.762 —
Southern Colo Pr Co Box 75 Pueblo Colo Ordway
Colo 1b 47.86 G
Texas Pr & Lt Co 1506 Jackson St Dallas Tex
Killeen Tex 1b 37.5 G
Cleburne Tex 1b 37.5 G
City of Rocky Mt N C Utility Dept
1b 153.71; 10m 153.71 G
Black Hills EC Inc Custer S D
1qs 72.18 G; 1sr 72.18 G
Pringle S D 1qs 72.18 G
Consumers Gas Co Reading Pa 1b 48.02; 50m 48.02 G
Mojave EC Inc Box 711 Kingman Ariz
Hualpai Mt Ariz 1sr 158.13 M; 1sr 72-76 mc band
Kingman Ariz 1sq 72-76 mc; 15m 158.13 M
Consumers Pub Pr Dist Columbia Neb
Grant Neb 1b 48.18 M
Rushville Neb 1b 48.18 M
Big Springs Neb 1b 48.18 M
Clear Lake Water Co Woodland Calif
1b 48.18; 15m 48.18 M.
Houston Nat Gas Corp Houston Tex
1b 153.53; 20m 153.53 M
Preston County Pr & Lt Co Masontown W Va
1b 48.26; 15m 48.26 G
Pacific G & E Co 245 Market St San Francisco
Woodland Calif 1b 153.71 L
Salmon Riv Elec Coop Inc Challis Idaho
1b 47.94; 12m 47.94 M
Montana-Dakota Util Co 831 2nd Av Minneapolis
Culbertson Mont 1b 48.26; 1r 72.74 G
Wheelock N D 1b 48.26; 1r 73.02 G
Kincaid N D 1b 48.26 G
Kenmore N D 1b 48.26 G
Glendive Mont 1qs 75.70, 75.86 G
Williston N D 1qs 75.70, 75.86 G
Dairyland Power Corp Lanesboro Minn 1b 37.62 M

(Continued on page 32)

NEW APPLICATIONS

(Continued from page 31)

Holy Cross EA Inc Glenwood Spgs Colo 1qs 73.90; 1 mr 153.53; 3p 153.53, 158.13; 6m 158.13 M
Tri-County REC Inc Mansfield Pa Nr Tioga Pa
  1b 48.06; 50m 48.06 M
Medina EC Inc Hondo Tex
  Rio Grande City Tex 1b 158.25; 10m 158.25 M
  Bruni Tex 1b 158.25 M
Fall River Elec Lt Co Fall River Mass
  1b 48.18; 25m 4B.18 G
City of 8eaumont Walnut & Mulberry 8eaumont Tex
  Burns 8luff Tex 1b 37.62 G
New Haven Gas Lt Co 80 Crown St New Haven Conn
  1b 158.19; 50m 158.19 G
Kans-Neb Nat Gas Co Albion Neb 1b 37.50 M

PIPELINE PETROLEUM

Texas Co 516 Munsey Bldg Washington 4 D C
  Lockport Ill 1b 158.43 G; 30m 158.43 AG
  Rio Blanco County Colo 1b 33.30; 4m 33.30 G
Humble Pipeline Co Drawer 2220 Houston Tex
  5 tb 48.86 —
  Nr Talco Tex 1b 48.86 G
  Nr Dalby Spgs Tex 1b 48.86 G
Great Western Drilling Co Box 191 Lubbock Tex
  Farmington New Mex 1b 4B.9 G
Texas Eastern Trans Co Box 1612 Shreveport La
  Baytown Tex 1b 48.94 M
Winters Phillips & Winters 1430 Nye st
  San Rafael Calif 3p 169.47, 171.95 X
Peoples Nat Gas Co 545 Wm Penn P1 Pittsburgh 19
  Nr Vinco Pa 1b 48.70 L
Premier Oil Refining Co of Tex 8ox 75 Ranger Tex
  Breckenridge Tex 2b 30.7 M
  Nr Ranger Tex 1b 30.7 M
  Desdamonia Tex 1b 30.7 M
Garvey Drilling Co 100 Derby 8ldg Wichita 2 Kans
  Great 8end Kan 1b 4B.62; 4tb 48.62; 15m 48.62 M
Sun Oil Co Box 2B31 Beaumont Tex 1tb 49.06 G
Sun Pipe Line Co Box 2B21 Beaumont Tex
  Nr Conroe Tex 1b 4B.62 G
  Nr Daisetta Tex 1b 48.62 G
  Nr Humble Tex 1b 48.62 G
Gulf Refining Co Drawer 2100 Houston Tex
  Leeville Area La 1b 49.02 R
Gulf Refining Co Box 661 Tulsa Okla
  Cleves Ohio 1b 49.10 R
  Lima Ohio 1b 49.10 R
  Union City Ind 1b 49.10 R
  Dublin Ind 1b 49.10 R
  Breese Ill 1b 49.10; 30m 49.10 R
  Nr Seminole Okla 1b 49.10 R
  Nr Tulsa Okla 1b 49.10 R
  Nr Pryor Okla 1b 49.10 R
  Nr Anderson Mo 1b 49.10 R
  Nr Monette Mo 1b 49.10 R
  Nr Springfield Mo 1b 49.10 R
  Nr Lebanon Mo 1b 49.10 R
  Nr Steelville Mo 1b 49.10; 50m 49.10 R
  Greenwood Ind 1b 49.10 R
  Jordan Ind 1b 49.10 R
  Terre Haute Ind 1b 49.10 R
  West York Ill 1b 49.10 R
  Edgewood Ill 1b 49.10 R
  Patoka Ill 1b 49.10 R
  Centralia Ill 2b 49.10 R
  Valameyer Ill 1b 49.10 R
B & R Drilling Inc Drawer 232 Russell Kans
  1b 48.74; 1sq 72.38 M
  Elmwood Kans 1b 48.74; 1r 75.82 M
  Palco Kans 1b 4B.74; 1r 75.B2; 1tb 48.74; 50m 48.74
Interstate Petroleum Comm Inc 1319 Shell Bldg Houston Tex
  Morgan City La 1b 2.292; 4m 2.292 —
Phillips Pipeline Co Bartlesville Okla
  Nr Webb City Okla 1b 33.38; 45m 33.38 M
  Nr Bowers City Tex 1b 75.46 M
  Bowers City Tex 1b 33.38; 20m 33.38 M
  Kingsville Tex 1b 72.9 M
The Ohio Fuel Gas Co 99 N Front St Columbus Ohio
  Nr Galion Ohio 1b 33.3B L
  Athens Ohio 1b 33.38 L
Delaware Drillers Inc Phillips & Talley Bldg San Angels Tex 3tb 25.26 C
Cities Serv Ref Corp Lake Charles La 1b —; 25m — M

FOREST PRODUCTS

L C Conner Albany Ky 1b 49.22; 5m 49.22 R
R B Stovall Inc 6541 Forest Pk Rd Dallas Tex
  1tb 49.94 G
Penobscot Purchasing Co Great Wks Me 1b 49.34 M
S I Storey Lumber Co Armuchee Ga
  Rome Ga 1b 49.26 M
Dierks Lumber & Coal Mt Pine Ark
  Broken 8ow Okla 1b 49.34 M
  Nr Hot Spgs Ark 1b 49.34; 1r 72.98 M
  Dierks Ark 1c 73.78 M
  De Queen Ark 1b 49.34; 1c 73.78 M

SPECIAL INDUSTRIAL

Status Development Co Zoarville Ohio
  1b 49.94; 70m 49.94 M
Barre Wool Combing Co Barre Mass
  1b 154.49; 15m 154.49 G
Ralph Hicks Catoosa Okla 1b 154.49; 6m 154.49 M
Quinn & Conant Los Angeles Calif
  1b 154.57; 5m 154.57 R

Gen Motors Research Corp 3044 W Grand Detroit
Lansing Mich 1b 152.93; 10m 152.93 M
Milford Mich 1b 152.93; 10m 152.93; 19p 152.57, 152.93 M
Kansas City Kans 1b 154.49; 10p 154.49; 10m 154.49M
Hardaway Contr Co Port Tampa Fla
1b 27.43; 3m 27.43 M
E O Mitchell Inc Arvin Cal 1b 43.1; 15m 43.1 G
Hayter Bulldozing Serv Cushing Okla
1b 43.18; 13m 43.18 CP
Berlanti Constr Co 15 Oakland Av Harrison N Y
Trenton N J 1b 154.49 M
Cinder Prods Co Inc Jerome Idaho 1b 154.49 M
Twin Falls Idaho 1b 154.49; 10m 154.49 M
Line Constructors 544 Benson Bldg Sioux City Ia
1tb 43.06; 13m 43.06 M
F E Squire & Sons Corcoran Calif
1b 49.86; 10m 49.86; 2tb 49.86 M
Perini Walsh Mills & Blythe Bros Constr Co
Chattahoochee Fla
Nr Chattahoochee Fla 1b 154.49; 25 PM 154.49 M
Andrews Concrete Prods & Supply Co Mason City Ia
1b — 17m — M
Green Giant Co Beaver Dam Wis 1b 43.1; 25m 43.1 R
Fox Lake Wis 1b 43.1; 38m 43.1 R
A W Soderberg Constr Co Wichita Kans
1b 154.47; 10m 154.48 M
Harold H Kastner Co Sanford Fla
1b 49.54; 35m 49.54 C
Christy Corp Sturgeon Bay Wis
1b 154.49; 15p 154.49; 15m 154.49 M
Cardiff Bros Katy Tex
1b 154.49; 20p 49.90; Bm 154.49 K
G T Key Co Montgomery Ala 20p 49.90 M
A J Galasso Lancaster N Y Dunkirk N Y
1b 43.10; 20m 43.10 M
Bayer & Mingolla Constr 550 Park Av Worcester Mass
1b 43.06; 4tb 43.06; 50m 43.06 M
D G Hansen Logan Kans 1b 43.02; 10m 43.02 M
Southwestern Portland Cement Co 1034 Wilshire Blvd
Los Angeles Calif
Nr Victorville Calif 1b 27.47 M
Victorville Calif 1b 27.47; 25m 27.47 M
Halliburton Oil Well Cementing Co Duncan Okla
McCamey Tex 1b 49.74 G
Berg Constr Co Blue Island Ill
1b 43.14; 6m 43.14 M
E C Gardiner Inc 2704 Sackett St Houston Tex
2b 43.02; 20m 43.02 M
A L & W Morse Trucking Contractors Boosier City La
1b 43.02; 10m 43.02 G
Independent Eastern Torpedo Breckenridge Tex
Oklahoma City Okla 1b 49.82 G
Nr Caddo Tex 1b 49.82; 1tb 49.82 G
Santa Maria Distribution Inc Santa Maria Calif
1b 49.98; 5m 49.98 M
Campanella & Cardi Constr Co 780 Jefferson Blvd
Beaumont Tex
Georgetown Mass 1tb 43.02 R
Glassboro Serv Assoc Glassboro N J
1b 49.98; 10m 49.98 M
Hunkin Conkey Constr Co 1740 E 12 Cleveland Ohio
Beaver Bay Minn 1b 43.06; 20m 43.06 R
Norshore Minn 1b 43.06; 20m 43.06 R
H H Gunther Constr Co Galesburg Ill
1b 43.14; 10m 43.14 M
Elec Storage Battery Co Philadelphia Pa
1b 152.99; 30m 152.99 G
P L Anderson & Son Danville Va
1b 154.49; — m 154.49 X
Dowell Inc Kennedy Bldg Tulsa Okla Eureka Kans
1b 43.18 G
F M Slazie Co Alton Ia 1b — 15m — M
Halliburton Portland Cement Co Box 1200 Corpus Christi Tex 1tb — M
Luxora Gin Co Inc Luxora Ark
1b 154.49; 10m 154.49 L
Old Colony Constr Co of Quincy Quincy Mass
1b 49.98; 25m 49.98 M
Leslie B Finnell Constr Co Holliday Tex
1b 43.02; 25m 43.02 M
Ohio Edison Co 47 N Main St Akron Ohio
Knox Twp Ohio 1b 49.98; 15m 49.98 L
Reliable Packing Co 1440 W 47th St Chicago Ill
Nr Will County Line Ill 1b 152.87; 18m 152.87 M
Haley Gravel Co Lansing Mich 1b 49.86; 3m 49.86 M
R O Semmel Allentown Pa 1b 30.62; 6m 30.62 G
Vaillette EC Inc Leominster Mass
1b 43.14; 6m 43.14
Kerr Elec Co Auburn Me Brunswick Me 1b 43.18 M
Gen Elec Co Electronics Park Syracuse N Y Evandale Ohio 2b 154.49 G; 60p 154.49 D; 60m 154.49 G
Rock Valley Canning Co Belvidere Ill
1b 152.87; 15m 152.87 M
Knight Ideal Coal Co Wellington Utah
2b 154.49; 10m 154.49 M
Coal Creek Mine Utah 1b 154.49; 10m 154.49 M
Pacific Tallow Co Box 241 Turlock Calif
1b 43.02; 10m 43.02 M
Paul C Miller 101 N Park Comstock Mich
1tb 43.1; 4m 43.1 M
T K Ellis Hot Springs Va 1b 49.9; 10m 49.9 G
Gulf Industries Weather Network 120 N Chaparrel
Corpus Christi Tex 1b 5.24 —
Nr Victoria Tex 1b 5.24 —
Houston Tex 1b 5.24 —
Lake Charles La 1b 5.24 —
Nr New Orleans La 1b 5.24 —
Crucible Steel Co of America Box 977 Syracuse N Y
Geddes N Y 1b 154.49; 30m 154.49 M

(Concluded on page 34)

NEW APPLICATIONS

(Continued from page 33)

Clifford E Hahn Box 3115 Eastchester Branch Anchorage Alaska 1b 152.93; 10m 152.93 M
Electric Smith Inc c/o BKM Mail Pouch Anchorage Alaska 1b 43.10; 8m 43.10 M
Isbell Constr Co Box 2351 Reno Nev 1tb 154.49; 15m 154.49 M
Phillips Elec Serv 357 11 Av West Eugene Ore 1b 49.9; 10m 49.9 G
McLellan Stone Co Box 651 Bowling Green Ky 1b 43.18; 10m 43.18 R
C A Rutledge Constr Co Box 310 Winder Ga 1b 43.02; 10m 43.02 M
Bell Aircraft Corp Box 482 Ft Worth Tex 1b 154.9; 15m 154.9 M
P & W Transport Co Box 772 Post Tex 1b 49.9; —m 49.9 K
Carrier Corp 300 S Geddes St Syracuse N Y 1b 152.87; 50m 152.87 M

LOW POWER INDUSTRIAL

Southern Bell T & T Co 67 Edgewood Av SE Atlanta Ga 16p 154.47 M
Lebanon Cemetery Assoc of Queens Inc 7800 Myrtle Av Brooklyn N Y 6m 35.02 M
Bosworth Mfg Co Rte 1 Avon Ohio 6m 154.57 M
Dairy Dell 408 Franklin Johnstown Pa 7m 154.57 GD
Yolo Engineers & Surveyors Assoc 412 1st St Woodland Calif 6m 42.98 M
Wisc Tel Co 722 N Broadway Milwaukee 2 Wisc 50m 154.57 MA
Philco Corp Tioga & C Sts Phila Pa 2m 42.98 P
Allied Radio Corp 833 W Jackson Blvd Chicago Ill — P 33.14, 35.02, 42.98, 27.51, 154.57 A
Interstate Service Corp 37 W Van Buren Chicago Ill 6p 154.57 M
Spencer Van Noy Salt Lake City Utah 3m 154.57 A

COASTAL & MARINE RELAY

Crown Zellerbach Corp Camas Wash 1b 156.60 M

ALASKAN FIXED PUBLIC

Colorado Creek Mining Co McGrath Alaska
Colorado Creek Alaska 1b 2.512, 3.190 X
Alaska Aeronautics & Communications Comm Box 121 Juneau Alaska 1b 2.632, 2.986, 3.190, 5.207, 5.652, 5.622 —

COASTAL & FIXED

Clarence Sinclair Box 1349 Ketchikan Alaska Polk Inlet Alaska 1b 2.382, 2.450, 2.466, 2.538, 2.632 —
Hiebert Bros Wrangell Alaska 1b 2.466, 2.482, 3.190 H
Kanai Packers 2800 W Viewmont Way Seattle 99 Wash Kanai River Alaska 1b 2.382, 2.422, 2.430, 2.538, 2.986, 5.137; —p 2.382, 2.422, 2.430, 2.538, 2.986, 5.137 X

RAILROAD

Chesapeake Western RR 141 Bruce Harrisburg Va McGaheysville Va 1b 159.81 M
Chicago Great Western RR 309 W Jackson Blvd Chicago 6 Ill
Ingalton Ill 1b 159.57, 160.17 S
Hayfield Minn 1b 160.17, 159.57 S
Marshalltown Ia 1b 160.17, 159.57 S
Manitou & Pikes Peak RR Box 563 Colorado Spgs Colo Manitou Spgs Colo 1b 161.55 M
Atop Pikes Peak Colo 1b 161.55; 6m 161.55 M
Denver & Rio Grande Western RR Box 2040 Denver Colo 2b 160.83, 161.13 T
Southern Pacific Co 65 Market San Francisco Calif W Oakland Calif 1mr 160.23 M
Tracy Calif 1b 161.43, 161.55 M
Mojave Calif 1b 161.79, 161.55 T

TRANSIT UTILITY

Peoria Transit Lines Inc Peoria Ill 1b 44.58 M
Larchmont Rapid Taxi Corp Larchmont N Y 1b 30.66; 30m 30.66 L

INTERCITY BUS

Nat'l Bus Communications Inc 141 W Jackson Blvd Chicago 4 Ill
Minneapolis Minn 1b 43.87 M
Seattle Wash 1b 43.94 M
Lexington Ky 1b 44.14 M
New Orleans La 1b 44.30 M

TAXICABS

City Cab Portsmouth N H 1b 152.33; 10m 157.59 L
Joseph E Nutt Jr & Georgiana Nutt Princeton N J 1b 152.33; 6m 157.59 G
Upper Darby Taxi 420 Elm Av Upper Darby Pa 6m 157.53 G
De Lux Cab Russell Kans 1b 152.45; 5m 157.71 M
City Cab Co Iola Kans 1b 152.27; 10m 157.53 M
West Side Cab Evanston Ill 1b 152.45; 5m 157.71 M
A & G Taxi Texas City Tex 1b 152.45; 5m 157.71 M
Pub Serv Cabs Emporia Va 1b 152.27; 5m 157.53 G
ABC Cab San Diego Calif 1b 152.45; 10m 157.71 M
F A Wolfe Uhrichsville O 1b 152.39; 4m 157.65 M
Roanoke Cab Roanoke Va 1b 152.33; 10m 157.59 M
Pontiac Co Palo Alto Calif 1b 35.7; 5m 35.7 K
Parsons Taxi Parsons W Va 1b 152.27; 15m 157.53 M
Queens Service Cab Montgomery Ala 1b 152.45; 20m 157.71 R
Girouxs Taxi Waterville Me 1b 152.45; 6m 157.71 M
M C Wilson Huntington Sta L I N Y 1b 152.39; 5m 157.65 M
Flushing Radio Taxi Serv Flushing N Y 1b 152.27; 10m 157.53 M
City Taxi Everett Wash 1b 152.45; 6m 157.71 M
City Cab Co Anacortes Wash 1b 152.39; 8m 157.65 M
Red Top Taxi Shenandoah Ia 1b 152.39; 6m 157.65 R
Steelton Taxi Co Steelton Pa 1b 152.39; 1m 157.65 R
Whitey's Taxi Franklin Square N Y 1b 152.39; 5m 157.65 L
Arthur Contoir Swanto Vt 1b 152.27; 1m 157.53 X
Madruga's Taxi Gloucester Mass 152.45; 10m 157.71 M
Mouston Cab Mouston Wis 1b 152.39; 6m 157.65 M
Grandview Cab Grandview Mo 1b 152.33; 10m 157.59 M
Burtis A Wheat Windon N Y 1v —; 2m — SS
Jamison Cab Co Shelby N C 1b 152.39; 10m 157.65 M
Bob's Taxi Serv Williamston N J 1b 152.33; 6m 157.59 M
Central Taxi Huntington N Y 1b 152.33; 5m 157.59 L
Howard LeRoy Kane Manistique Mich 1b 152.27; 1m 157.53 M
Picchis Taxi Penns Grove N J 1b 152.45; 5m 157.71 B
Auburn & Russ Taxi Auburn N J 1b 152.39; 10m 157.65 M
Rapid City Cab Rapid City S D 1b 152.39; 10m 157.65 M
Snyder Taxi Co Eggertsville N Y 1b 152.45; 12m 157.71 M
White & Black Taxi Du Quoin Ill 1b 157.65; 7m 152.39 M
Tacoma Yellow Cab Co 1324 Market St Tacoma Wash Ft Lewis Wash 1b 152.33 M
Deluxe Cab Marietta Ohio 1b 152.45; 6m 157.71 M
Air Force Base Cab Rantoul Ill 1b 153.33; 10m 151.59 M
Banks Taxi Serv Woodbury N J 152.27; 10m 157.53 R
Loucks Taxi Du Quoin Ill 1b 152.45; 8m 157.71 R
Manassas Taxi Manassas Va 1b —; 6m — G
Bailey's Cross Roads Cab Alexandria Va 1b 152.27; 8m 157.53 G
Logan Cab Serv New Orleans La 1b 452.65; 50m 452.65 L
Morris Cab Co Morris Minn 1b 152.33; 5m 157.59 M
City Cab Dickinson N D 1b 152.27; 3m 157.53 M
Reliable Taxi Mt Vernon N Y 1b 152.33; 12m 157.59 M
Deerfield Cab Co Deerfield Ill 1b 152.45; —m 153.45 —
Courtesy Taxi Co Baxley Ga 1b 152.27; 6m 157.53 M
Wheatley Hills Taxi Westbury N Y 1b 153.39; 5m 157.65 L
Smiley's Taxi Orangeburg S C 1b 152.33; 10m 157.59 G
Bell Taxi Co Boston Mass 1b 2.45; 25m 157.71 M
Scotties Taxi San Marcos Tex 1b 152.27; 10m 157.53 M
Al's Taxi Durango Colo 1b 152.45; 10m 157.71 L
Diamond Cabs Inc Tampa Fla 1b 152.33; 50m 157.59 M
Fred's Taxi Whitinsville Mass 1b 152.45; 3m 157.71 M
Checker Cab Co Wichita Kans 1b 152.33; 82m 157.59 G
Cooks Taxi Saratoga Spgs N Y 1b 152.39; 10m 157.65 M

AUTO EMERGENCY

Veteran's Garage Norwalk Conn 1b 35.7 L
Maine Automobile Assoc Portland Me 1b 35.7 G
Bill & Jim Serv Ypsilanti Mich 35.7; 5m 35.7 M
Greenwood's Garage Baltimore Md 1b 35.7; 10m 35.7 M

HIGHWAY TRUCKS

Sam E Wood Inc Midland Tex 1b 35.82; 30m 35.82 M
Farmers Butane Gas Co Gatesville Tex 1b 35.78; 3m 35.78 L
Baker Oil Co Nashville N C 1b 35.78; 10m 35.78 M
Valley Butane Serv Fresno Calif 1b 35.90; 15m 35.90 G
Vapo Gas Box 432 Cocoa Fla 1b 35.74 C
Milbourne Fla 1b 35.74; 15m 35.74 C
Farmers Butane Gas Co Evant Tex 1b 35.78 L
Hamilton Tex 1b 35.78; 7m 35.78 L
Tart Coal & Oil Co Dunn N C 2b 35.74; 6m 35.74 M
Torg's TV Sales & Serv Elkhart Ind 1b 30-42 mc; 6m 30-42 mc G
Amis Butane Co Anthony N M 1b 35.78 L
Nr Elfrida Ariz 1b 35.78a L
Fabers Tex 1b 35.78; 25m 35.78 L
Harrison Oil Co Williamston N C 1b 35.9; 20m 35.9 M
Falwell Fast Freight Inc Box 937 Lynchburg Va Friendship N C 1b 35.86 M
Panola Butane Gas Serv Carthage Tex
Longview Tex 1b 35 mc band K
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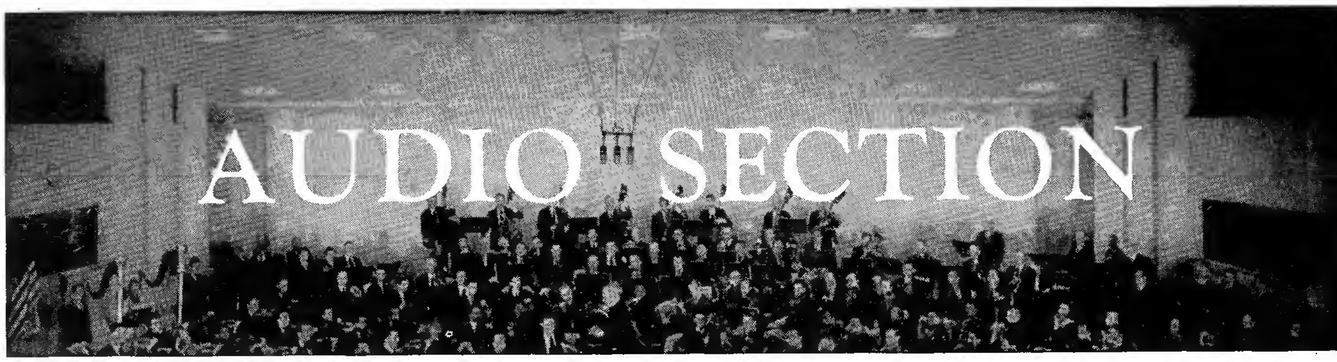

AN INTERMODULATION ANALYZER

DESIGN AND CONSTRUCTION DETAILS OF AN INTERMODULATION TEST UNIT THAT CAN BE BUILT AND CALIBRATED EASILY — *By* WILLIAM B. BERNARD*

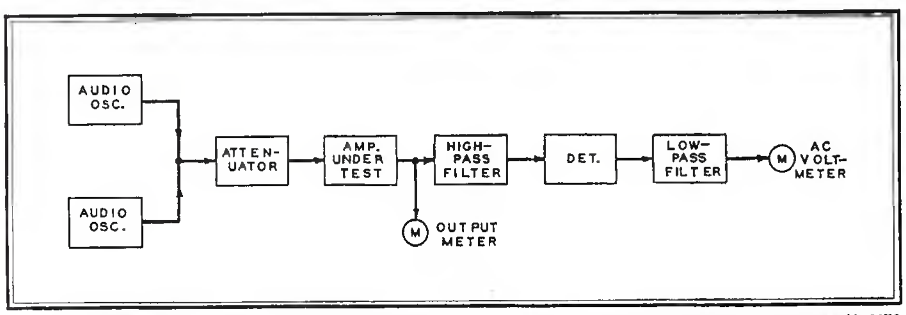

FIG. 1. DIAGRAM OF EQUIPMENT UNITS REQUIRED FOR MAKING INTERMODULATION MEASUREMENTS

THOSE who work with audio equipment find that on many occasions it would be desirable to measure accurately the results of their efforts. Much valuable information can be obtained with an audio oscillator, an AC voltmeter, and an oscilloscope. These instruments are adequate to determine frequency response and to find the output level at which severe distortion is evident. However, 10% second-harmonic distortion is not easily detectable on an oscilloscope. Even if it were, many oscilloscope deflection amplifiers have 10% or more second-harmonic distortion. It is obvious, therefore, that the observation of output wave forms on an oscilloscope can reveal distortion only when it is bad enough to be heard easily. A quantitative measure of distortion cannot be made readily without a harmonic analyzer or an intermodulation analyzer.

Measurement of the amount of intermodulation distortion produced by an amplifier or other audio device has become an accepted means of evaluating its performance. This method has several advantages over that of harmonic-distortion analysis. It imposes less severe requirements on the waveforms of the signal sources used, since a minor amount of low-order harmonic output from the signal generators has negligible effect upon IM measurements. Moreover, the intermodulation analyzer is ordinarily much simpler in construction than the harmonic analyzer. Finally, the results obtained by intermodulation testing are more meaningful, since the amplifier is operating under conditions representative of actual use, and the products of intermodulation are, in general, unpleasant and discordant, while those of harmonic distortion are not.

Intermodulation Testing:

Fig. 1 shows the basic intermodulation test setup. One oscillator provides a frequency in the vicinity of 50 cycles, and the other furnishes a high frequency, usually about 5,000 cycles. The low-frequency output is set at a level 12 db above that of the high-frequency signal, and both are fed into the device being tested. The resultant output is fed through a high-pass filter, which passes only the high-frequency signal, or carrier, and any high-frequency side bands which are produced by the intermodulation of the high and low frequencies. The output of the high-pass filter is then applied to a detector in order to recover the low-frequency signal which has been mixed with the high frequency by nonlinearity in the device under test. Any remaining vestiges of the carrier are removed by a low-pass filter. The output of the low-pass filter is then measured by an AC voltmeter. If a standard carrier level is established for the detector, the AC voltmeter can be calibrated directly in percentage of intermodulation.

It is convenient to combine the high-pass filter, detector, low-pass filter, and AC voltmeter in one unit. Such an assembly makes up an intermodulation analyzer. The instrument is made more versatile if an input voltage amplifier is

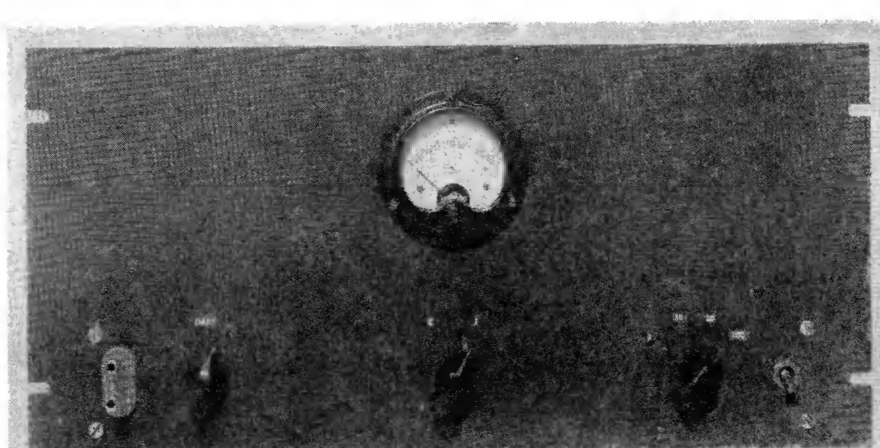

FIG. 2. FRONT PANEL CARRIES METER, GAIN CONTROL, CALIBRATE, RANGE, AND POWER SWITCHES

*Commander, USN. 123 Elwood Avenue, Norfolk 5, Virginia.

provided also, so that low-level signals can be checked.

This article describes the construction of such a unit, shown in Fig. 2. The filters used are made up of inexpensive parts, easily obtained. No signal generators are included, in order to keep the design as simple as possible. Most everyone to whom an intermodulation analyzer would be useful is sure to have at least one audio oscillator. If only one oscillator is available, it can be used to provide the high-frequency signal, and a filament transformer can be employed to obtain a 60-cycle note from the power line.

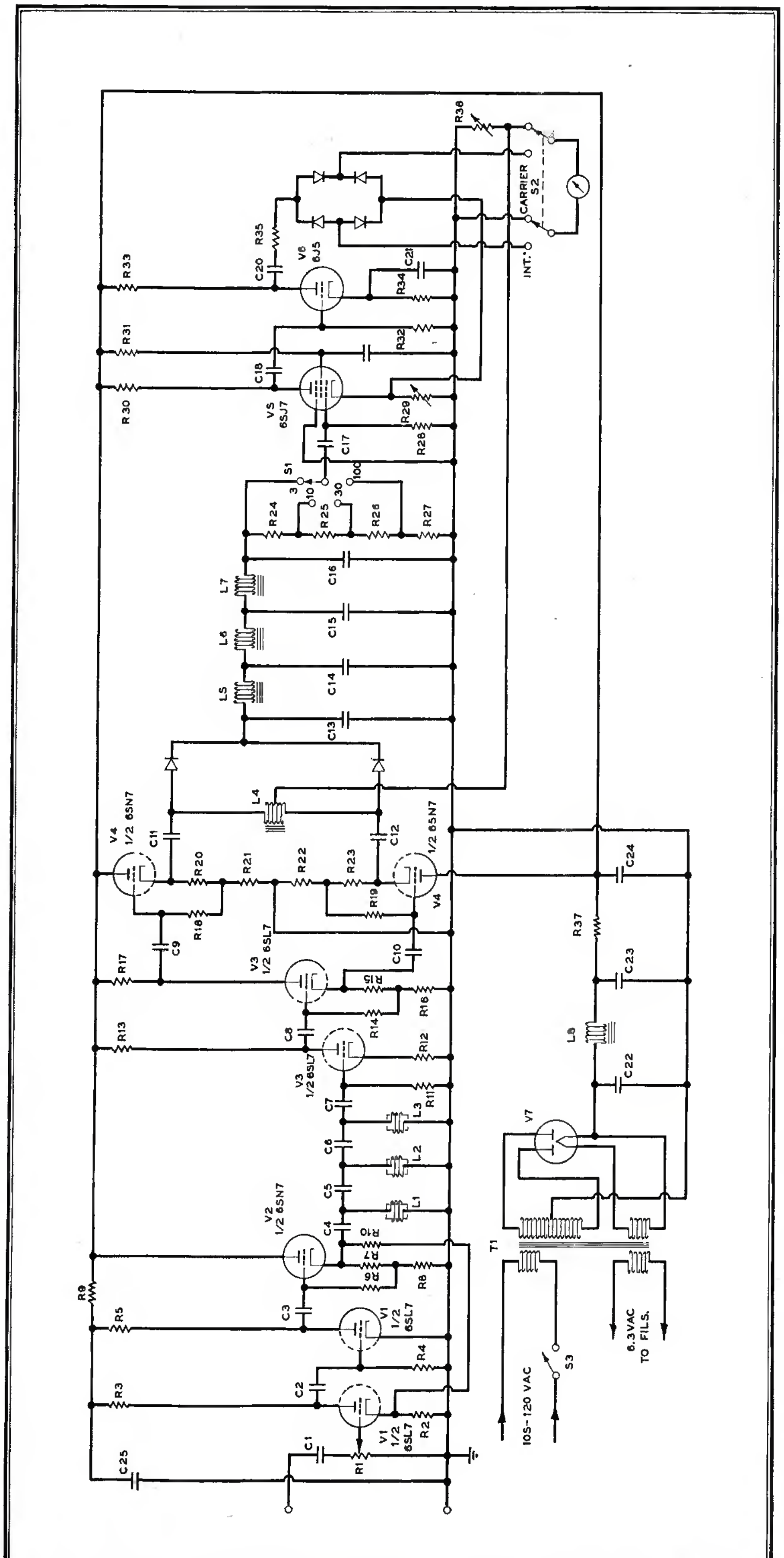

FIG. 3. CIRCUIT DIAGRAM OF THE IM TEST UNIT

Circuit of the Analyzer:

Since the analyzer circuits preceding the detector need pass only high frequencies, the input capacitor is very small. This capacitor, Fig. 3, aids the high-pass filter in discriminating against the low-frequency signal and, at the same time, protects the input amplifier against overload by the low-frequency component which is 12 db above the desired high-frequency signal. The input capacitor is followed by a .5-megohm potentiometer. This is required in order to set the input level to the amplifier for the desired carrier level. The preamplifier consists of a 6SL7 employed in a 2-stage voltage-amplifier circuit, and a 6SN7 operated as a cathode follower to match the low-impedance filter. Inverse feedback is provided from the output of the cathode follower to the cathode of the input amplifier, so as to reduce intermodulation in the preamplifier.

Circuit constants of the high-pass filter were calculated for a 1,000-cycle cutoff and 1,000 ohms impedance. The use of any but air-core chokes or the highest-quality iron-core inductors in this filter could result in intermodulation caused by nonlinear response of the inductors. By operating this filter at 1,000 ohms impedance, it is possible to employ standard 80-millihenry air-core RF chokes.

Following the high-pass filter, a 6SL7 is used as a voltage amplifier and phase inverter to feed a 6SN7 push-pull cathode follower circuit. No feedback, other than that provided by unbypassed cathode resistors, is used in this section of the circuit since only high frequencies are present. Therefore, a small amount of distortion has almost no effect on the operation of the instrument.

The push-pull cathode follower output is applied to a full-wave detector circuit, which employs two IN34 crystals. These crystals are isolated from the DC potential present at the driver cathodes by capacitors C11 and C12. The center-tapped inductance L4 provides a DC return path for the rectified current. Since L4 must be a high impedance only to high frequencies, a small replacement-type push-pull output transformer is suitable. The DC component of the detector current is metered, so that a

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IM ANALYZER

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standard carrier level can be maintained.

Following the detector, the signal is sent through a low-pass filter whose constants were calculated for a 100-cycle cutoff and 10,000 ohms characteristic impedance. Small iron-core chokes can be used in this filter, since the usual nonlinearities of such inductors have only second-order effects on the reading of the analyzer. The low-pass filter is terminated by the voltmeter voltage divider, tapped to permit direct readings of intermodulation in four ranges, 0-3, 0-10, 0-30, and 0-100%.

The voltmeter circuit utilizes a 6SJ7 pentode and a 6J5 triode, both employed as voltage amplifiers, followed by a rectifier for the meter. Current feedback is used to reduce the effect of tube and rectifier characteristics on the meter readings. The rectifier was constructed from a 50-milliampere selenium rectifier, taken apart carefully in order to avoid disturbing the active junctions. One junction was used for each leg of the bridge. Any low-resistance copper-oxide meter rectifier can be used for this purpose. The meter requires 1 milliampere for full scale deflection. It can be switched by S2, Fig. 3, so as to read either carrier strength or intermodulation.

The power supply is a conventional transformer-rectifier circuit, with a capacitor input filter consisting of one LC section and one RC section for the main supply, and an additional RC section for the preamplifier supply.

Dimensions of the chassis are 7 by 17 by 3 ins. The finished instrument is mounted behind a 19-in. rack panel 8¾ ins. high, which carries the meter movement. The high-pass and low-pass filters are shielded by mounting them separately in 2 by 2 by 4-in. boxes, Fig. 4, in order to reduce hum pickup by the filter inductors.

A parts list is given below:

CAPACITORS

All capacitors are 600-volt paper unless indicated otherwise.
C1 — 500 mmf., mica
C2, C3 — .02 mfd. C4, C7 — .15 mfd.
C5, C6 — .08 mfd. C8 — .005 mfd.
C9, C10 — .01 mfd.
C11, C12, C17, C18 — .1 mfd.
C13, C16 — .015 mfd., mica
C14, C15 — .03 mfd., mica
C19 — .25 mfd. C20 — .5 mfd.
C21 — 25 mfd., 25 volts, electrolytic
C22, C23, C24, C25 — 20 mfd., 450 volts, electrolytic

RESISTORS

All resistors are ½-watt carbon unless indicated otherwise.
R1 — .5 megohm, potentiometer
R2, R12 — 2,700 ohms R3, R13 — .1 megohm
R4 — 5.6 megohms R5 — .19 megohm
R6, R28, R32 — .47 megohm R7, R8 — 750 ohms
R9 — 22,000 ohms, 1 watt R10 — .22 megohm
R11 — 1,000 ohms R14, R31 — 1 megohm
R15, R25 — 2,200 ohms R16 — 47,000 ohms
R17 — 50,000 ohms R18, R19 — .33 megohm

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IM ANALYZER

(Continued from page 37)

R20, R23 — 1,500 ohms R21, R22 — 10,000 ohms
R24 — 8,200 ohms R26 — 820 ohms
R27 — 330 ohms R30 — .27 megohm
R29 — 750 ohms, wire wound potentiometer
R33 — 56,000 ohms R34 — 800 ohms
R35 — 22,000 ohms R37 — 1,200 ohms, 2 watts
R36 — 200 ohms, wire-wound potentiometer

TRANSFORMERS, CHOKES

T1 — 350-350 volts at 70 milliamperes, 5 volts at 2 amperes, 6.3 volts at 2.5 amperes
L1, L3 — RF choke, 80 millihenries, Meissner type 19-2709
L2 — RF choke, 80 millihenries, Meissner type 19-5596
L4 — Universal replacement-type push-pull output transformer
L5, L6, L7 — Filter choke, 4 henries, 30 milliamperes, Halldorson type C-9
L8 — Filter choke, 8 henries, 70 milliamperes.

MISCELLANEOUS

Chassis, 7 by 17 by 3 ins.
Rack panel, 8¾ by 19 ins.
Meter, 1-milliampere movement.
Switches, 1 DPDT, 1 SPST, 1 single-circuit 4-position wafer.
Double-contact input receptacle.
Low-resistance bridge rectifier.
2 shield cans, 2 by 2 by 4 ins.
7 octal tube sockets.
Two 6SL7, two 6SN7, one 6SJ7, one 6J5, one 5Y3G or equivalent.
2 IN34 crystal diodes.

Calibration Procedure:

The first step in calibrating the analyzer is that of adjusting the AC voltmeter. S2 is switched to the INTERMODULATON position, and a 60-cycle signal of .25 volts RMS amplitude is fed to the grid of V5. R29 is then adjusted until the meter reads full scale.

Next, the standard carrier level must be set up. This can be done by feeding two signals about 50 cycles apart to the input of the analyzer. These frequencies must be high enough so that they are not attenuated by the high-pass filter: frequencies of 5,000 and 5,050 cycles are suitable. One signal is set at a level 20 db above the other. The input potentiometer is adjusted until the meter reads 10% intermodulation. Then S2 is switched to CARRIER, and R36 is set to provide a half-scale reading on the meter. R29 and R36 are not used after this initial calibration. For this reason, they should not be mounted on the front panel. As Fig. 2 shows, the only front-panel controls are the gain control R1, which establishes the required carrier level in tests, the CARRIER-INTERMODULATION switch S2, the meter range control S1, and the power switch S3.

In actual operation of the instrument, the signal generators are set to the desired frequencies, 50 and 5,000 cycles for example, with the low frequency at a level 12 db. above the high frequency. When a pair of generators is used for the first time, it is a good idea to feed them into the analyzer to insure that there is no interaction between the generators that could initiate intermodulation in the output stages of one. After it has been determined that no sum or difference frequencies are present in the output of the generators, the instruments are ready for use. The outputs of the generators are fed into the amplifier being tested, and the output of the amplifier is set to the desired level and fed into the analyzer. S2 is switched to CARRIER, R1 is adjusted for the standard carrier-level reading, and the meter is then switched to read intermodulation percentage. It is, of course, good practice to start with the meter set at the highest IM range and to switch down to the range at which the meter reads in the proper part of the scale.

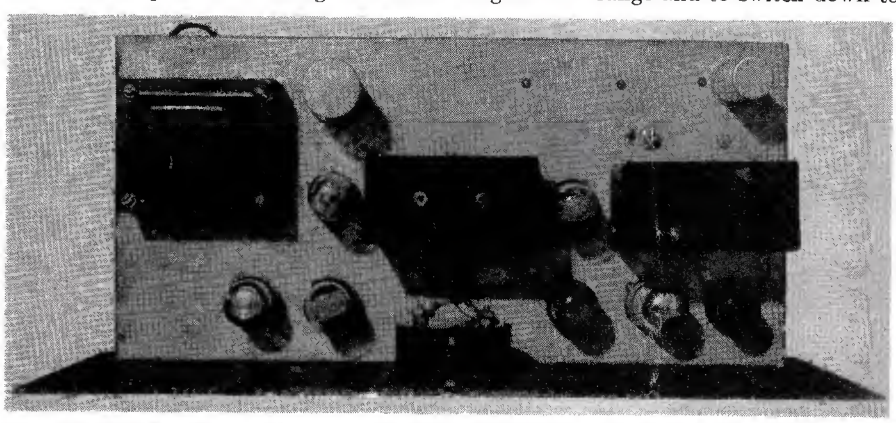

FIG. 4. TOP VIEW OF THE IM ANALYZER CHASSIS. FILTERS ARE ENCLOSED IN THE 2 SIMILAR CANS

Applications:

This instrument is very useful in the design, development, and testing of new amplifiers. Because many tube handbooks do not give distortion figures for resistance-coupled voltage amplifiers, many builders simply assume that the distortion of such amplifier stages will be negligible. However, a test of a number of 6SN7 halves with a .1-megohm plate load and a 2,700-ohm bypassed cathode resistor showed 5 to 9% IM with a signal of 1 volt impressed on the grid. This can be verified by the reader if he will study the figures given for harmonic distortion under similar conditions in the RC-coupled amplifier tables of the Sylvania handbook. Although harmonic and intermodulation distortion cannot be directly related, intermodulation figures are roughly 3 to 5 times the corresponding values of harmonic distortion.

It can be seen that it is wasteful of time and money to expend effort in reducing the distortion of an output stage if the earlier stages contribute more distortion! This early-stage distortion can be minimized greatly by designing the amplifier to provide a little extra gain, so that a separate feedback loop can be added around the stages ahead of the tone controls as well as those after the tone controls.

The applications of this instrument are not limited to testing amplifiers. Pickups and preamplifiers can be checked also by using special test records which provide the required pair of tones. Loudspeakers can contribute large amounts of IM distortion to the sound system. They can be checked by driving them with a known low-distortion amplifier and picking up the resultant output with a microphone. Checks of overall system distortion can be made by combining the last two tests.

The analyzer can be useful also for maintenance work. One amplifier with a pair of 6L6's in the output stage showed 8% IM at rated output. By substituting a properly-balanced pair of tubes, the IM for the same output was reduced to 2%.

After working with one of these instruments, the reader will feel well repaid for the time and money that went into its construction, and will wonder how he managed to work without one.

EUROPEAN SOURCES FOR RADIO COMPONENTS

A considerable variety of components and materials, currently in short supply in this Country, can be obtained now from Italian and German suppliers. Included among such items are resistors, selenium rectifiers, and enameled resistance wire in fine sizes.

Among the firms visited by a survey team sent abroad by the Defense Production Administration, twelve companies, seven of them in Western Germany, are particularly recommended as potential suppliers to US companies.

The complete report of the survey team, and the list of European manufacturers and their products can be inspected at Room 2314, Temporary Building T, 14th and Constitution Avenue, N.W., or Room 4H4, GAO Building, 443 G Street, N.W., Washington, D. C.

Another source of information on Italian radio products is John Geloso, S. P. A., Viale Brenta, 29, Milano, Italy. Mr. Geloso is producing a very complete line of high-quality audio equipment, recorders, and radio receivers. Letters addressed to him can be written in English.

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"PRINCIPLES OF RADIO," sixth edition, by Keith Henney and Glen A. Richardson. John Wiley & Sons. 655 pages, $5.50.

Like many other basic radio textbooks, this one is intended primarily for self-study applications. At this point the similarity ends. Unlike most, this does not ignore or slide over important details in an effort to achieve simplicity and intelligibility to the student. The examples are concrete and practical, and enough information is provided so that the reader can understand *why* the examples are solved in a specific way, not just *how* they are solved. In our opinion, this principle is the basis of good education.

The book begins with fundamental concepts of electricity, following up with DC circuits, and then guides the student in logical steps through AC circuit theory, components, and design practise. A feeling of confidence is obtained upon reading this material. Heartily recommended.

"MICROPHONES," the first of a series of engineering training manuals by the staff of the British Broadcasting Corporation. Illiffe & Sons, Great Britain. 114 pages, price $3.25.

This book is intended to fill a gap in technical literature that has long been apparent. It does so very well, covering in detail the requirements for, operation of, and design considerations for microphones. Chapters are provided on basic operating principles of various microphones; analyses of sound waves, electro-acoustics, and diaphragm operation; and descriptions of typical studio microphones. A very complete appendix is devoted to mathematical design equations, proofs, and analogies. Should be invaluable to broadcast station engineers, as well as those engaged in design and development work on microphones.

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MAY 5-7, QUALITY ELECTRONICS CONFERENCE
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MAY 12-14, AIRBORNE ELECTRONICS CONFERENCE
Hotel Biltmore, Dayton, Ohio

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Rice Hotel, Houston, Texas

MAY 19-22, RADIO PARTS SHOW
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AUGUST 27-29, WESTERN ELECTRONIC SHOW & CONVENTION
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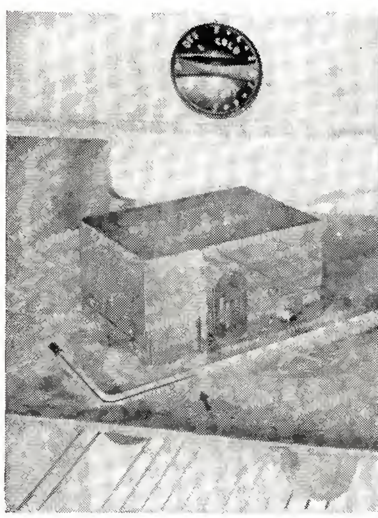

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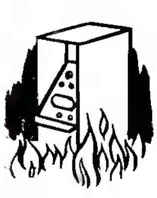

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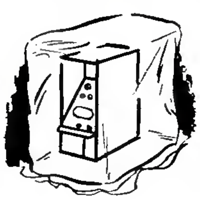

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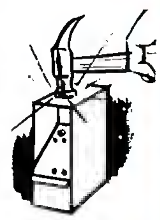

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