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INDUSTRY NEWS

TV-AM-FM Set Production
Compiled from figures released by RTMA
Spot News Notes
Items and comments about people and companies

BROADCASTING

Low-Distortion FM-AM Tuner
Will Raymond

APPARATUS DESIGN

How Magnetic Amplifiers Work
Edgar V. Weir

COMMUNICATION

Duplex Signaling Unit for Microwaves
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Items of interest concerning Mobile Radio

FCC Organization Chart
Key FCC personnel as of January 1, 1952

Equipment for LCC Operation
Philip D. Hamlin

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ROY F. ALLISON, Editor

MILTON B. SLEEPER, Publisher

Addressee: ROY F. ALLISON, Editor

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Mobile Radio Applicant List

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THE FUTURE OF FM, AM, BROADCASTING, AND TELEVISION COMMUNICATION

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THERE is nothing particularly impressive about the production figures on home receivers, as compiled by RTMA. TV receivers were up by slightly less than 4,000, over the October figure. All other categories declined slightly. That is in contrast to production in November 1950, when all types of sets registered a high for the year to that date.

The range in TV units per month in 1951 was from a high of 874,000 in March to a low of 146,000 in August; home radio models from 988,000 in March to 184,000 in July; portables from 226,000 in June to 64,000 in November; and auto radios 605,000 in May to 206,000 in November.

Predictions by RTMA president McDaniel and officials of the leading set manufacturers indicate a substantial drop in the production of home sets in 1952, as factories shift to military equipment. Also, the January 1 report from the Director of Defense Mobilization specifies a reduction of 40% in steel and more than 60% in copper and aluminum allocated to consumer radio and TV sets. This reduction is referred to average consumption in the first two quarters of 1950.

With the rapidly increasing interest in FM tuners and high-fidelity installations for radio, record, and tape reproduction, the need is growing for data on the volume of sales of such equipment. At present, no significant market information is available. Various suggestions have been made concerning the formation of a new industry group, to be comprised of manufacturers of chassis, amplifiers, pickups, record players, tape recorders, and speakers. Such an association could perform a number of useful functions, including the preparation of production statistics. It seems, however, that it would be much more logical for such manufacturers to be grouped as a department of RTMA. Certainly, some sort of action is called for, since the total volume of audio equipment sales is now at a very substantial level.

Receiving tube sales in the first 10 months of 1951 were 10 million above the same period of 1950. Sales through October amounted to 314,932,807. Of these, 211,273,000 were shipped for use in new sets, and 78,940,807 for replacements. Sales to government agencies totalled 5,681,534, while 19,037,876 were exported. During the month of October, sales amounted to 34,137,519 tubes.

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

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January, 1952—formerly FM, and FM Radio-Electronics
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Carbon Mobil-Mikes also available for exact replacement in current Motorola, RCA, G.E. and similar equipment. You get full advantage of E-V design and performance features.

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Close-talking, carbon type. Assures clear speech transmission under high ambient noise in any weather or climate. Blast-proof, waterproof, shock-resistant. Model 205 lists at $33.00. Model 602 Differential Dynamic at $45.00 list. (*Patent No. 2,350,010)

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THIS MONTH'S COVER
The Southern Counties Gas Company of California uses this completely-equipped mobile service truck for maintenance of radio equipment at its widespread operating bases. Power for the test instruments is supplied by a portable gasoline-driven generator where outside AC power is not available.

A complete description of this installation, which is an outstanding example of fine systems engineering, will be found in 5 pages of this issue beginning on page 17. It is planned to devote comparable space in future issues to other notable systems-engineering projects, such as the New York Fire Department and Pennsylvania Turnpike installations.

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

Industrial Communication System:
The new edition of the Registry of Industrial Radio Systems, revised each year from F.C.C. file records, is now ready for mailing. It shows the names and addresses of licensees, operating frequencies, number of mobile stations, call letters, and make of equipment for all mobile, point-to-point, and relay systems operated by the public utility, pipeline, geological survey, special industrial, low-power industrial, relay press, motion picture, and forest products services.

An idea of the increased number of systems in this group can be gained from the fact that it has become necessary to increase the size of this Registry to 82 per copy. This may seem to be a lot for a book of less than 100 pages. The cost is not actually in the production of the Registry itself, but in the increased work of checking the data on each individual license in the file room at the F.C.C. Only in this way can we make the deletions, changes, and additions to assure the accuracy of each listing in the Registry. In the past, listings of common carrier and limited common carrier systems have been included with the industrial systems. Starting this year, however, they will be published in the Registry of Air- Ground Systems, to be released in May.

Donald K. de Neuf:
Appointed general manager of Rural Radio Network. As chief engineer, he supervised the installation of the original RRN stations, now expanded to a 13-station FM net. He succeeds Michael R. Hanna, who is taking part in the joint Cornell-CBS TV film project.

New RTMA Offices:
Radio & Television Manufacturers Association has moved to 777 Fourteenth Street, N.W., Washington, D.C. Telephone number is National 3902. Newly organized statistical department, taking over work previously handled by Haskins & Sells, will have separate quarters at the new address. This department will be under the direction of W. F. E. Long.

New Manufacturing Plants:
Electronic Instrument Company, Inc., has purchased a 6-story building at 81 Withers Street, Brooklyn 11, for enlarged offices and production facilities. Early in the spring Raytheon will occupy a building of 50,000 square feet, now under construction on Seysen Street, Watertown, Mass. About 400 workers will be employed here. Sales and administrative offices of International Rectifier Corporation have been moved to a new building at 1521 E. Grand Avenue, El Segunda, Calif. The Victoria Avenue plant in Los Angeles will be maintained for research and development.

Conference on Quality Components:
Government-industry conference on improving the quality of radio components will be held in Washington on May 5 to 7, sponsored by the RTMA, IRE, and AIEE, with the active support of Government military agencies and the Bureau of Standards. Details can be obtained from J. G. Reid, Jr., National Bureau of Standards, Washington, D.C.

RTMA Reliability Chart:
As a step toward increasing the reliability of military, commercial, and home radio equipment, RTMA has prepared, in conjunction with the Armed Services Electro Standards Agency, a 14-point outline of design requirements. Copies of

(Continued on page 7)
Gus W. Wallin:
Elected to the newly created position of vice president in charge of engineering at Webster-Chicago. For the past 11 years he has been in charge of military engineering at Motorola.

Characteristics of the Eye:
According to Dr. R. M. Bowie, of Sylvania, the peculiarities of the eye which aid TV in the creation of visual illusion are:
1. The eye’s acuity for contrast detail far exceeds that for chromaticity detail.
2. Its threshold of flicker perception is roughly a logarithmic function of brightness.
3. Its threshold of flicker perception is at lower frequency for large areas than for small areas.
4. It is much more insensitive to flicker in chromaticity than in brightness.

NARTB Convention:
Will be held at the Conrad Hilton (formerly Stevens) Hotel at Chicago, March 31 to April 2. Exact dates of the engineering sessions will be announced later. Further information can be obtained from Neal McNaughten, Director of Engineering, 1771 N Street, N. W., Washington 6, D. C.

Frank H. Edelman:
Former chief chemist at International Resistance has been appointed technical director of Electronic Devices, Inc., 429 19th Street, Brooklyn 15, N. Y.

Air Raid Horns:
A 3-horn unit, designed to operate on compressed air, has been announced by G. B. Bashaw Company, 1909 S. E. 25th Avenue, Portland 15, Ore. Bureau of Standards report shows signal strength of 100 db at 100 ft. with 25 lbs. pressure per square inch, and an air consumption of .5 cubic feet per second. Fundamental frequency is 300 cycles, with rich harmonics at 4,000 cycles. Single horn units are also available.

Dr. Allen B. Du Mont:
Looking ahead to 1952: “Entertainment is just a part of the function and place in our lives that television will play. . . . The inherent honesty of television will be put to work in earnest in the cause of good, clean government, and a return to

For best service—buy locally
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Your local RCA Tube Distributor can handle your tube requirements for communications in the fastest possible time—save you hours, even days of time and effort. He knows what tube reliability means in 2-way radio—is prepared to back up your operations with the finest transmitting and receiving types ever made . . . RCA!

Call him up. His friendly service is just around the corner from you.
SPOT NEWS NOTES
(Continued from page 7)

the fundamentals of the American enterprise system. . . . Already more than 150 business and industrial TV units are in operation around the Country. . . . Industry officials contend that television's commercial and professional uses will overshadow its role in bringing entertainment into the living room. By the end of 1934, our industry will be producing at the annual rate of $4.5 billion, equal to the peak in World War II. . . . In our organization, already 60% of our business is in defense work, with a military backlog of over $60 million. . . . We anticipate that our total sales, which were around $50 million in 1951, will reach a company high-water mark in 1952 of between $100 million to $125 million.”

P. H. Neville;
Elected president of Leece-Neville Company. Although only 37 years of age, he has previously served as vice president and secretary.

Importance of Research:
From the New England Letter, published by the First of Boston: “In a comparatively short period, this Country has been converted from a wilderness into a mighty industrial empire with living standards far superior to those of any major country in the history of civilization. . . . During the past three decades the number of firms engaged in industrial research has increased eightfold, while expenditures for research have increased fifteenfold. Total expenditures for research of all kinds, including the amount spent by colleges, foundations, and the Government, were roughly estimated to be in the neighborhood of $2 billion and represent a fivefold increase in a decade. While this seems like a large sum, it constitutes only about $2% of the gross national product. . . . As Arthur Dehon Little pointed out, ‘When wisely conceived, intelligently directed, and generously supported, research yields returns of an order of value out of proportion to its cost. It becomes the mainspring of progress.’”

TV Antenna Data in Spanish:
For the benefit of Latin American countries, a catalog on TV receiving antennas, printed in Spanish, has been prepared by La Pointe Plascomold Corporation. Windsor Locks, Conn. The title is: La Linea de Antenas de Television mas completa y Potente del mundo.

Paul Hines:
Appointed director of engineering for (Continued on page 9)

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No. 4: Registry of Aeronautical Services
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AIRDROME—FLYING SCHOOL
FLIGHT TEST—UTILITY

PRICE: No. 1, $2 postpaid
Nos. 2, 3, 4, $1 each, postpaid
Published by RADIOCOM, Inc.
Great Barrington, Mass.
SPOT NEWS NOTES
(Continued from page 8)

Workshop Associates, Needham Heights, Mass. He will be in charge of the new antenna laboratory now under construction at Natiek, and will supervise all engineering at the Needham plant. Previously he headed Raytheon's antenna group.

Monitoring Receivers:
There is a large and increasing demand from communication systems for monitor receivers of commercial design, to provide continuous tuning from 30 to 50 and 125 or 152 to 174 mc. There are models available to cover these ranges, but for commercial use higher sensitivity and selectivity is specified, at a price of $250 to $900.

More Service:
H. I. Rommes, director of operations for A. T. & T.'s long lines department: "During 1951, the Bell System added about 6,500 miles of TV channels, bringing the total to over 4,000." Priorities and material shortages permitting, A. T. & T. "plans and hopes during the year 1952 to add Miami, New Orleans, Houston, Dallas, Ft. Worth, San Antonio, Oklahoma City, and Tulsa to its network."

Saul Decker:
Advanced by CBS-Columbia to the post of chief television engineer. In this capacity, he will be responsible for the development and design of radio and TV sets produced by the CBS manufacturing subsidiary. He will report directly to Leopold M. Kay, vice president in charge of engineering.

TV for South America:
Another Du Mont Television has been shipped to South America. This one, sold through Federal Telephone & Radio, is equipped with a trailer carrying a 50-cycle, 10-kw. engine-driven generator, so that the TV unit can be used where power lines are not available.

High-Power Vibrators:
New bulletin describing power supply vibrators for aircraft and industrial equipment has been issued by James Vibrapower Company, 4036 Rockwell Street, Chicago 18. This series is intended for both new equipment and replacement use.

New Appointments:
David S. Rau has been elected vice president and chief engineer of RCA Communications, Inc. He has been with the company since graduation from Annapolis in 1922. Mr. Rau succeeds C. W. (Concluded on page 46)
A triumph in the art of transmitter design... made possible through the use of Eimac tetrodes.

Collins 300J 250-watt and 20V 1kw AM broadcast transmitters employing Eimac 4-125A and 4-250A power tetrodes.

In your own equipment... enjoy the advantages and economies made possible through the use of Eimac tetrodes. Write our Application Engineering Department for the latest information and technical data.

The Collins 300J 250-watt and 20V 1kw AM broadcast transmitters are a tribute to the art of transmitter design. Performance, circuit simplicity and economy of operation highlight the many features Collins Radio has incorporated in these modern transmitters.

Through the use of high-gain, long-life Eimac tetrodes, Collins has achieved considerable simplification in circuits associated with the modulator and power amplifier stages. These highly efficient tetrodes also permit the use of low drain receiver-type tubes in the driver stages. Spare tube inventory can be kept small and representing a minimum investment. As an example; the 300J employs only 16 tubes of but 7 types in the entire transmitter.
The New Low-Distortion

SR 51 FM-AM TUNER

DETAILS OF A TUNER THAT PROVIDES TRUE HIGH FIDELITY FM AND AM TOO — By WILL RAYMENT*

There is general agreement on the point that any tuner for use in a high-fidelity installation should include a sensitive, noise-free FM section. However, while remarkable FM performance has been achieved in many tuner designs, too little engineering effort has been expended on the AM sections.

Conventional receivers and tuners, even those in the higher price ranges, suffer from two serious defects which prevent the realization of optimum AM performance. In an effort to minimize noise and interference, the IF bandpass is made so narrow that audio reception is limited to well below 10,000 cycles. It is usually 5,000 cycles, or even less. Also, the second detector circuit introduces appreciable harmonic distortion, amounting typically to 25% at 100% carrier modulation. It should be emphasized again that this is true of even the best conventional AM receivers and, in most cases, of the AM sections of tuners.

On the other hand, there is much high-quality program material being broadcast by AM stations, for not all are limited to 5,000-cycle transmission. Many metropolitan stations are assigned 20-ke. channels, which permit transmission of 10,000-cycle audio. Then, too, some sections of the Country have ordinary 5,000-cycle AM service, but have only one FM station or none at all. Distortionless AM reproduction is important to people in such areas.

It appears, therefore, that there is a real need for a tuner which can accommodate both FM and AM broadcast signals of any audio frequency range, and which can amplify and demodulate these transmissions with negligible distortion. The Sargent-Rayment model SR 51 FM-AM tuner, shown in Fig. 1, is designed to meet these simple but rigorous requirements, in addition to the other specifications of high-quality tuners.

AM Section:

The circuit of the SR 51 is shown in block form in Fig. 2. AM tuning is accomplished by ganged capacitors at the grid of the 6SK7 RF amplifier, the RF grid of the 6SA7 converter, and in the oscillator tank. The IF input transformer secondary is swamped by a 3-megohm resistor to obtain the necessary bandpass. Resistive loading of the IF output transformer is not necessary, however, since the primary is used in conjunction with the diode section of the 6SF7 to provide a DC control voltage for the 6E5 tuning eye and for AVC. The AVC is applied to the RF, converter, and IF stages.

Fig. 3 is a chart of detector distortion for various amounts of carrier modulation.

FIG. 1. FRONT VIEW OF THE SR 51 TUNER CHASSIS, SHOWING PANEL-MOUNTING BRACKETS

FIG. 2. A MODIFIED BLOCK DIAGRAM OF THE TUNER. NOTE THAT 2 OUTPUT JACKS ARE PROVIDED

*Engineer, Sargent-Rayment Company, 212 9th Street, Oakland 7, Calif.

January, 1952—formerly FM, and FM Radio-Electronics
tion. The center curve is for a diode detector operating under ideal conditions; that is, with no AC shunt impedance. With a load of 1 megohm, the harmonic distortion is increased tremendously, as shown by the top curve. At 100% carrier modulation, the distortion is increased from 5 to 23% for 400 cycles. Actually, since the detector in a conventional AM circuit ordinarily feeds an AF amplifier grid resistor, the AVC system and, in some cases, a tuning eye tube, the load may be appreciably less than 1 megohm.

However, AM detector loading is avoided completely in the SR 51 tuner. The IF output transformer secondary is coupled to the 6SN7 dual-triode detector in a unique circuit that introduces only 45% distortion at 100% carrier modulation. This is shown by the bottom curve, Fig. 3.

The audio signal is fed to a 10-kc filter, to eliminate adjacent-channel whistle, and then to the audio selector switch. Extremely sharp attenuation, 0 db at 9 kc and -47 db at 10 kc, is achieved by the use of a bridged-tee LCR filter circuit.

**FM Circuit Design:**

IF transformers and tubes have been developed to the point where stability can be maintained with gain such that the maximum useful sensitivity of an FM tuner is determined by the input circuit noise. Accordingly, the problem of increasing sensitivity is one of reducing the input noise figure. The approach to this problem employed in the SR 51 tuner has been so successful that an input of 5 microvolts produces 20-db quieting.

An input transformer feeds the grid of a 6C4 triode, used as an untuned input coupling tube. The output is impedance-coupled to the 6BA6 RF amplifier. Tank circuits at the grids of the RF amplifier, bypassing the bass, treble, and volume controls, and is intended for use with a recording amplifier. This is labeled out. The other output jack is for general use, since it follows the tone and volume controls.

Bass and treble controls are of the RC type, and are isolated by one half of a

![FIG. 3. SOME AM DETECTOR DISTORTION CURVES](image)

The 6BE6 mixer, and the 6J6 oscillator are capacitively gang-tuned. The remaining half of the 6J6 envelope is used as an AFC reactance tube.

Two stages of IF amplification, utilizing 6BA6's, follow the mixer and terminate in a 6AL5 ratio-detector circuit. Detector AM absorption is 70%. Outputs from the detector go to the audio selector switch through the deemphasis circuit, and also to the tuning eye and AFC tubes.

**Audio Controls:**

Three input jacks are provided on the chassis, so that audio from a TV tuner and a phonograph preamplifier or crystal pickup can be switched and controlled. Two output jacks are furnished. One is connected directly to the selector switch, 2-stage 6SN7 audio amplifier. Curves of boost and drop obtainable with these controls are given in Fig. 4. It can be seen that the maximum variation at midrange frequencies is 4 db, while the response at 40 cycles can be adjusted from -17 to -16 db, and at 10 kc. from -14 to -22 db.

**Installation:**

The SR 51 has other features intended to facilitate custom installations. As can be seen in Figs. 5 and 6, the chassis is provided with rubber mounting grommets on the base, as well as brackets for panelmounting. The dial escutcheon and plastic control-designation plate are removable, and can be fastened to the cabinet panel. A switched AC outlet is provided at the back of the chassis. Also, a power plug for a phono preamplifier is included.

Controls from left to right in Figs. 1 and 5 are on-off and volume control, treble control, selector switch, bass control, and tuning control. Dimensions are 14 ins. wide by 7 ins. high by 10 ins. deep. Power requirements are 85 watts at 110 to 125 volts.
HOW MAGNETIC AMPLIFIERS WORK

A CONCISE, NON-MATHEMATICAL DISCUSSION OF THE BASIC PRINCIPLES OF MAGNETIC AMPLIFIERS, AND OF THEIR APPLICATIONS — BY EDGAR V. WEIR

Progress in the development of the magnetic amplifier has been rapid during the past few years. There are indications that many of the disadvantages thought to be inherent in this device are being overcome or minimized, with the result that the range of applications for magnetic amplifiers is expanding constantly. At the present time, they are employed most extensively in military electronic apparatus and in servosystems. It is our firm belief, however, that eventually, they will be utilized in broadcast and audio applications, and in communications equipment where the factors of ruggedness and dependability are of paramount importance. This article is the most lucid and authoritative presentation of the basic principles of magnetic amplifiers we have seen. We believe that it will serve our readers admirably as an introduction to this relatively new branch of electrical science, with which many more of them will soon be concerned.

An amplifier is a controllable-impedance device which is inserted between a source of power and a load. That impedance may be resistive, inductive, or capacitive, and an amplifier can be designed which utilizes any of the three types of impedance as the variable element. The vacuum tube is, essentially, a variable resistive impedance. The magnetic amplifier, on the other hand, is an inductive-impedance device.

Fig. 1 explains the basic differences in the operation of vacuum-tube and magnetic amplifiers. The tube is represented as a variable resistance which regulates the flow of current into a load. In this case, the variations in impedance are achieved through the application of a control voltage to an element in the tube. A variable inductive impedance element is shown inserted between the source of power and the load for the magnetic amplifier. This element is represented at the top, Fig. 1, by an iron-core reactor with two windings. The inductive impedance of that reactor is varied by a small current flowing through the second, or control winding. This controllable reactor regulates the flow of current into the load through impedance control, in much the same manner as the vacuum tube, except that the variable impedance is inductive rather than resistive. The power source for the magnetic amplifier is, of necessity, AC. Its frequency is referred to as the carrier frequency. The load may be either AC or DC.

A magnetic amplifier is, by strict definition, merely one or more such reactors. Combinations of reactors or single compound reactors are employed normally, so that voltages induced in individual reactor control windings cancel out and feed back a minimum of voltage into the control circuit. Other circuit elements can be used with the reactors to provide feedback or to obtain desired response characteristics. In such cases, the entire assembly is referred to ordinarily as a magnetic amplifier.

Operating Conditions:
Reactors, as associated with magnetic amplifiers, may be non-saturating, saturating, or saturable. The terms refer, of course, to current conditions in the magnetic material used as the core of the reactor.

A non-saturating reactor is one in which the applied carrier voltage is low enough so that the flux changes occur only in the unsaturated region of the magnetization curve, Fig. 2. If a higher voltage of the same frequency is applied, then the flux changes demanded cannot be met entirely within the unsaturated region. The flux is carried above the knee, into the saturated region, for some parts of the applied waveform. The reactor then becomes a saturating reactor, and exceptionally high peak currents are reached during those periods when the flux has been forced over the knee. If the reactor constitutes only a part of a circuit, as in the case of a magnetic amplifier, it can be seen that the effective inductive impedance has been reduced during those periods. This results in more of the supply voltage being transferred to the load.

In a magnetic amplifier, that change in inductance is not effected through the application of a higher carrier voltage. Instead, an extra magnetizing force is applied through a control winding, which causes operation to occur around a new point on the magnetization curve and forces the flux changes to swing over the knee. Thus, the non-saturating reactor becomes a saturable reactor. It has been forced to operate into the saturated region by an external control. The instantaneous current that flows during the part of the carrier cycle when the reactor is saturated is limited at any instant, of course, by the load impedance and the instantaneous value of the source voltage. From a control standpoint, however, it is dependent upon the characteristic of the magnetic material used in the reactor.

If the material is such that its magnetization curve is essentially flat after
half the full saturation level. From a composition standpoint, the 4750 and Orthonol metals are practically the same. They have essentially the same saturation level. It is readily apparent, however, that the 4750 continues to absorb voltage at high current levels.

The magnetic characteristic determines also the minimum currents that flow in magnetic amplifier circuits. As long as voltage is applied to the reactor elements of a magnetic amplifier, some current flows. That current must be of such magnitude as to cause the magnetic material to experience the changes in flux level which are required for it to absorb voltage. This magnetizing current is of almost square-wave shape in the case of some materials, particularly Orthonol. In all cases, it is very small compared to the current that flows after saturation has been reached.

The maximum voltage level at which the reactor element can operate without passing more than just such a small magnetizing current depends upon the flux density at which the knee of the curve appears. For cores of the same size, then, the Orthonol material has the advantage over the others shown in Fig. 2. For that given core size, it is capable of controlling much more power, for example, than Mu Metal. It has a slight advantage in this regard over Permenorm 5000 Z. Orthonol has an advantage over that material in having a lower minimum.

The rectifier permits some small reverse current to leak through, which carries the flux back to a position such as is shown as Condition 1, Fig. 3B. Even then, however, that reactor could only absorb such a small portion of the half-cycle voltage as is to the left of the dotted line rising from point 1 in Fig. 3C. The dotted line running from point 1 on

![FIG. 3. BASIC FULL-WAVE MAGNETIC AMPLIFIER CIRCUIT. NOTE HOW CURRENT IN THE CONTROL WINDINGS DETERMINES FLOW OF AVERAGE LOAD CURRENT BY ESTABLISHING CORE FLUX LEVELS](image)

![FIG. 2. Hysteresis Characteristic Curves for Cores of Various Magnetic Materials](image)

current also. In other words, for high power-handling capacity, material which can be operated at high flux densities without reaching saturation is desirable. For applications where low minimum currents are desired, materials with very low magnetizing currents are to be preferred.

**Sensitivity:**

So far, no mention has been made of the influence of the magnetic material upon the sensitivity of the amplifier. Sensitivity is not dependent solely on the permeability of the core material. The shape of the magnetization curve is important also, as will be explained.

In Fig. 3A, a basic full-wave magnetic amplifier circuit is shown. This circuit has two reactor elements connected in parallel, each with a rectifier in series. Carrier voltages induced into the control windings cancel out. The rectifiers serve to switch the current flow from one reactor to the other on alternate half-cycles. This is known as the parallel self-saturating circuit. It is highly efficient and is used widely.

Normally, the reactors in this circuit are so designed that a flux swing from one knee to the other absorbs one half-cycle of the applied carrier voltage. If the rectifiers were not in the circuit, and the half-cycle is the outline of the load current that would flow.

If there is current flowing in the control windings, then the magnetizing force contributed by it will either add to or subtract from the effect of the rectifier leakage. If a current is flowing in such a direction as to cause the flux to drop to a level corresponding to point 2 during the off half-cycle of carrier voltage, then there will be sufficient flux change available for absorption of half the following half-cycle. The resulting current into the load is indicated as the dotted line rising from point 2 and going on through the half-cycle. Further negative control will carry the flux back to point 3, with the further reduction in output current resulting.

This indicates exactly how the control is applied to this type of magnetic amplifier. There are many variations which can be employed to compensate for the leakage of the rectifiers and to control feedback.

However, the basic principle, applying in general to all types of magnetic amplifiers, is that of establishing a flux level in advance of the operating half-cycle. This determines just how much of the operating half-cycle voltage can be absorbed by the reactor element. It controls the "firing point" of the reactor. Once the reactor reaches saturation on a particular operating half cycle, it continues to pass current through the half-cycle. To regain control during that period would require prohibitive amounts of control power.

It is now apparent how the shape of the hysteresis loop of the core material determines the sensitivity of the amplifier. The sensitivity varies according to

(Continued on page 40)

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Voice-Frequency Signaling Units for MICROWAVE SYSTEMS

INEXPENSIVE SIGNALING UNITS FOR FREQUENCY-DIVISION MULTIPLEX SYSTEMS—By J. K. KULANSKY

MICROWAVE communication systems are inherently flexible in application. Through multiplexing techniques, a single microwave carrier can be made to convey multi-channel telegraph, teletype, or facsimile information, and accommodate one or more voice channels as well. Signals can also be impressed on the carrier to provide remote supervisory control facilities; automatic fault alarm and future failure warning alarm indications; automatic transfer indication for standby equipment; extension of duplex telephone ringdown signaling; facilities for dial signaling, selective calling, and selective signaling of mobile units through repeaters; fail-safe alarm information and telemetering data.

Each of these functions, and many others, can be accomplished with one or more voice-frequency tones. However, full realization of such system potentialities has been limited in the past by the prohibitive cost of suitable voice-frequency signaling equipment. This limitation has now been removed. The Hammond type DSU duplex signaling unit, shown in Fig. 1, was developed specifically to meet requirements for a low-cost voice-frequency tone generating and receiving unit for narrow-band carrier or subcarrier channeling.

Operation of DSU Unit:
The duplex signaling unit consists of an externally-keyed, single-tone transmitter, a single-tone receiver which operates a control relay, and a built-in power supply. Transmitter and receiver operating frequencies are available in any combination from 2,000 to 6,025 cycles, thus permitting utilization of the units without requiring associated subcarrier equipment. Channels are spaced at 100-cycle intervals in the range from 2,000 to 3,500 cycles, and at 150-cycle intervals from 3,500 to 6,025 cycles.

Fig. 2 is a block diagram of the unit. The transmitter is keyed by connecting terminals 1 and 2 on J1, the Jones plug visible at the right on the bottom view of the unit, Fig. 1. This permits conduction and operation of V1, the tone generator. The single-tone output of V1 is applied to an attenuator and then to V2, a buffer amplifier. From V2, the tone signal is coupled to output terminals on J1 through a 600-ohm line-bridging transformer with an impedance of 10,000 ohms. The audio output is adjustable from -25 to +5 dbm when a 600-ohm line is connected at terminals 3 and 4.

The tone generator harmonic content is 40 db down from the fundamental, and consists principally of third and other odd-order harmonics. Harmonic output at any one frequency is down considerably more than 40 db. This is an important requirement for the prevention of cross-talk between channels. Frequency stability is better than ±1 cycle with variations in input voltage from 105 to 125 volts, over the ambient temperature range of -30° to +60° C. This stability is maintained for the operating frequency range from 2,000 to 6,025 cycles.

A line bridging transformer is provided at the receiver input terminals also. This is followed by an input level control, which is adjustable for a maximum input sensitivity of -25 dbm.

The selective line amplifier, V3, follows the level control and feeds a multielement bandpass filter. The attenuation of this filter is such that the response of the receiver is down 20 db at the edges of the adjacent channels, and is more than 35 db down at the centers of the adjacent channels. Stability of the filter is comparable to that of the tone generator.

FIG. 2. BLOCK SCHEMATIC OF THE HAMMARLUND VOICE-FREQUENCY SIGNALING AND CONTROL UNIT

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Following the bandpass filter is a straight amplifier stage and a demodulator employing two IN54A crystal diodes. The rectified signals are fed to an RC shaping network, which provides uniform output pulses at preset operating speeds of 1 to 30 pps. Another crystal diode is utilized in a discharge circuit to provide rapid noise-voltage decay, thus preventing false operation of the control relay by extraneous noise.

Output pulses from the shaping network are applied to the grid of a DC amplifier, V₅, which has a high-speed relay as a plate load. Connections to the pressed-carrier modulation. By this means, individual voice-channels are heterodyned with subcarrier frequencies so as to place them in ascending order on the frequency scale above the first voice-channel. Normally, each voice-channel is allotted a band 3,000 or 3,800 cycles wide, corresponding to a frequency range of 300 to 3,300 or 3,300 cycles.

If a voice-channel can be restricted to the range from 300 to 2,500 cycles, as in Fig. 3, as many as 11 signaling channels can be accommodated in the space gained, utilizing DSU voice-frequency signaling equipment. These channels are extended. As shown in Fig. 5, the band from 3,025 to 6,025 cycles will accommodate 17 channels with maximum impulse speeds of 20 pps. A total of 33 signaling channels can then be obtained in the range above 2,000 cycles, with a low-grade service channel or nine 100-wpm telegraph channels below this frequency.

A unique method of adding signaling channels to an existing frequency-division system, by utilizing DSU units, is outlined in Fig. 6. Supervisory channels are added between the basic 300 to 3,300-cycle channel and the first carrier-derived voice-channel beginning at 4,700 cycles. Ten signaling channels are shown. The exact number that can be added depends, of course, on the frequency spacing between the basic voice-channel and the carrier-derived channel, and the adjacent cutoff characteristics of each. Since subcarrier channelizing equipment is not required for these signaling channels, they can be added at very little cost.

Another convenient means of adding signaling channels without associated subcarrier equipment is illustrated in Fig. 7. The basic voice-channel, terminating at 3,300 cycles, is retained. Then, 16 signaling channels, with maximum impulse speeds of 20 pps., are employed in the range from 3,775 to 6,025 cycles. Thus, they replace the first carrier-derived voice channel.

**Conclusion:**

It can be seen from the foregoing examples that, when suitable signaling units are available, voice-carrier signaling channels above 6,025 cycles will be useful and practical, since this type of equipment eliminates the need for subcarrier channelizing equipment for telemetering, supervisory control, and other signaling facilities.

Operating principles and equipment for obtaining carrier-derived voice channels in frequency-division microwave systems are similar to those employed in standard power-line carrier telephone systems. Thus, the data and suggestions given above are, in many ways, applicable to wire-lines and power-line carrier systems also.

**OSCILLOGRAPH BEAM INTENSIFICATION**

A new technique developed by J. H. Park of the National Bureau of Standards increases the writing speed of a high-voltage oscillograph to three-fourths the velocity of light. High intensification of the electron beam is obtained momentarily by superimposing a steeply-rising voltage pulse on the steady voltage applied to the discharge tube of (Continued on page 57)
GAS PIPELINE RADIO SYSTEM

INTELLIGENT SYSTEMS ENGINEERING PROVIDES VERSATILITY WITH MINIMUM EQUIPMENT IN GAS COMPANIES’ RADIO SYSTEM — By HARRY KEELING

DURING recent years, gas transmission and distribution companies have been making increasingly greater use of radio communication equipment to expedite system operations and to ensure uninterrupted service during times when floods, earthquakes, or other disasters break down wire telephone lines. The Southern Counties Gas Company of California and the Southern California Gas Company have been working together for the past ten years to develop a radio communication system which would provide the best possible service for both companies at minimum cost to each. Although the companies own and operate their own radio equipment independently, the separate installations are combined to make up an integrated system which results in maximum benefits for the individual companies without duplication of facilities. Provision has been made for channel-sharing and, in some cases, joint ownership and operation of certain facilities which are used by both. The technical design, preliminary planning, field surveys, and supervision of radio equipment maintenance for both gas companies are handled by the engineering staff of one. This is a much more economical arrangement than separate radio engineering groups maintained by each company.

Service Area:

These two gas companies serve more than 1,450,000 natural gas customers, and provide gas service to an estimated population of 5,200,000 in Southern California. In addition, about 1 million persons in the San Diego area depend upon the Southern Counties Gas Company for gas which is distributed by the San Diego Gas & Electric Company.

The Southern Counties and Southern California Gas Companies’ integrated pipe line system is spread out over a very large area. They maintain and operate 17,862 miles of pipe lines in Southern California. The total area served is better than 50,000 square miles. In addition to domestic and commercial customers who rely on natural gas as their sole fuel, many industrial organizations, hospitals, schools, government agencies, and military establishments depend upon these companies for gas.

The sources of natural gas that feed this pipe-line network are far apart. A 1,200-mile pipe line from Texas to the California border, and a 250-mile pipe line from that point to Los Angeles deliver a maximum daily gas volume of about 405 million cubic feet to the Los Angeles area. Other supply sources of natural gas are widely-scattered gas and oil fields and underground storage reservoirs in Central and Southern California.

Need for Radio Service:

Public telephone facilities or leased lines are adequate for normal communications. Since 1941, however, the gas companies have been using mobile radio communication equipment to conduct certain operations on their pipe lines which could not be handled satisfactorily in any other way, and for emergency point-to-point service when normal telephone communication is disrupted. Because of the large territory served by the combined gas companies, Fig. 1, it is not economical to equip every vehicle and every operating base with radio communication equipment, as is the practice of electric utilities and public safety organizations. This is explained by the fact that gas and water pipes are underground, where they are fairly well protected from the elements. An electric utility, on the other hand, is more likely to have frequent interruptions in service, since overhead wires can be broken by wind storms and traffic accidents. Although an electric utility may have several hundred minor service interruptions during a single year, a gas utility seldom has a break in service.

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IF FIG. 1. TOWERS INDICATE BASE-STATIONS. DASHED LINES SHOW PRESENT POINT-TO-POINT CIRCUITS

transmitters are located atop mile-high Mt. Wilson, providing useful service ranges well over 100 miles in some directions. Channels 4 and 5 were among the first television frequencies utilized in Southern California. The interference to television receivers caused by 72 to 76-cm. transmitters created a public-relations problem. In the early developmental stages of the gas companies’ communication system, it was anticipated that mountain-top repeaters would be used for primary coverage, and that they would be controlled by 72-cm. circuits. In order to eliminate the possibility of interference to television reception, however, microwave control circuits were selected finally as the most desirable choice in the Los Angeles area. Motorola.
microwave equipment, therefore, is used to control the relay station on Santiago Peak, 55 miles to the east. Early in 1949, the FCC announced that it would discourage the expansion of systems operating on 2992 mc., a frequency then in use by these gas companies. This announcement accentuated the need for a completely new system.

One of the first steps in the development of the new system was the design of a communication facility which would provide mobile radio communication for the newly constructed pipe line extending from Blythe, on the California-Arizona border, to Los Angeles. This Texas pipe line leg, Fig. 1, was considered to be of primary importance; accordingly, the communication system was developed there first. Future expansion was provided for, so that branches in the San Joaquin Valley and along the coast of Southern California northward to Goleta and Santa Maria would be included in the system eventually.

**Description of the System:**

The new radio communication system for the gas companies has been under development for the past two years, and is now almost completed. This system was designed to provide the following types of service:

1. Conventional mobile service between base stations at the principal operating headquarters and supervisors' vehicles, construction trucks, and patrol cars. This VHF system is operated simplex so that, where it is necessary, direct mobile-to-mobile or portable-to-mobile operation is possible for maintenance and repair work on pipe lines in remote areas.

2. Emergency point-to-point service, to provide communication between the principal operating headquarters of the companies during times when the normal wire-line communication system is inoperative. In all but a few cases, this service is provided through the VHF base-station transmitters.

3. Extended talk-back range for mobile units operating in remote areas, through the use of unattended mountain-top repeater stations. It is expected that, in the future, complete emergency point-to-point service over distances involving several hundred miles will be provided by these mountain-top repeaters.

In order to keep the overall system cost within the budget, it was necessary that the number of installations be held to a minimum. Also, it was anticipated that during times of disaster, when radio equipment was most seriously needed, commercial power or public telephone service might be inoperative. Therefore, gasoline-driven generators have been provided at all base stations. Where a remote transmitter is used, the generator is turned on automatically in the event of a control-circuit failure.

Motorola Quik-Call selective calling is used throughout the system. Many base stations situated throughout Southern California are installed at operating bases that do not have 24-hour working schedules. These stations have operators on duty during normal working hours, but

![FIG. 2. POINT-TO-POINT CIRCUITS ALONG THE TEXAS PIPE-LINE ROUTE. REPEATER STATIONS ARE EMPLOYED FOR EXTENDING MOBILE COVERAGE ALSO.](image)

![FIG. 3. MICROWAVE TRANSMITTER-RECEIVER AT THE CENTRAL HEADQUARTERS IN LOS ANGELES.](image)
found that satisfactory radio communication over the 240-mile distance between Los Angeles and Blythe could be accomplished through the use of two unattended repeater stations, in addition to the base station at Indio. A diagram of this system, showing frequencies employed, is given in Fig. 2. The first repeater station is located on Santiago Peak near Santa Ana, at an elevation of 5,000 ft., and is 53 miles airline from Los Angeles. As mentioned previously, a microwave link was selected as the most practical method of control of this station from Los Angeles. There were many other agencies already using Santiago Peak as a site for unattended base stations and repeaters, and commercial power was extended to the top of the mountain. However, wire communication circuits are still unavailable. All the radio equipment is controlled through radio circuits. Since Santiago Peak is located in Orange County, near the center of the combined gas companies territory, it is expected that it will be used in the future to provide emergency point-to-point service to networks running north along the coast and northeast to the San Joaquin Valley.

**Santiago Peak Relay Station:**

The Santiago Peak relay installation is unusual in many ways. A 6,500-mc. microwave link from the gas company headquarters in Los Angeles controls this station. Fig. 3 shows the microwave transmitter and antenna at the Los Angeles terminal. The Los Angeles dispatcher has full supervisory control over the point-to-point and land-to-mobile circuit from Los Angeles through the repeater.

Automatically-switched standby equipment is supplied at the Santiago Peak end of the circuit to provide absolute reliability. RF housings include two complete transmitter-demodulator units, one for regular operation and one for emergencies. Sensing circuits in the equipment act upon the failure of any tube or component, and initiate the automatic switchover to the standby gear. Thus, little or no actual outage of the control circuit is experienced. This automatic changeover feature is not utilized at the Los Angeles terminal, since an adequate maintenance staff is available on short notice. In Fig. 4, the microwave equipment is at the left of the building. The pole at the right carries the omnidirectional VHF antenna for mobile communication and the corner-reflector antenna beamed toward the base-station at Indio.

Provision for 3 voice channels has been made in the microwave system. This will permit future expansion of point-to-point facilities, so that this system can be tied in with the other two main divisions of the pipe-line system.

The microwave equipment employs a double-FM modulation system. Each input voice channel frequency-modulates a subcarrier transmitter on a frequency in the 190-kc. to 1-mc. range. The subcarrier transmitter outputs are combined and fed to the transmitter Klystron to modulate the FM carrier. Standard deviation of ±0.5 mc. is utilized for 100% modulation. Because of the direct line-of-sight path between the two terminals, it was unnecessary to use the tower reflectors normally associated with Motorola microwave equipment.

The relay-station transmitter, operating at 150 mc. with a normal power output of 60 watts to an omnidirectional antenna, is used for communication with mobile units operating within 80 to 100 miles of Los Angeles. However, this transmitter can be switched remotely to a directional antenna for emergency point-to-point service between Los Angeles and the Indio base-station. The antenna, a corner reflector, feeds a separate 150-mc. receiver equipped with selective calling control facilities.

Fig. 5 shows the 200-foot antenna tower at Indio. The 150-mc. antenna for mobile communication is located at the top on the left side of the tower. Below this is the 150-mc. corner reflector for point-to-point work with Los Angeles through the Santiago Peak repeater. The 72-mc. directional antenna for communication with Blythe through the Chuckwalla Peak repeater is at the top of the tower on the right.

Equipment at the Indio station is shown in Fig. 6. The 72-mc. rack is at the left, and the 150-mc. equipment is at the right.

The dispatcher at Indio can switch the Santiago transmitter to the Indio antenna, and, at the same time, raise the power from 60 watts to 250 watts. The operator at Los Angeles is then in direct communication with Indio, a distance of about 150 miles. In a similar way the Los Angeles operator, with supervisory controls, can switch the base-station transmitter on Santiago Peak from the omnidirectional to the beam antenna.

At the present time, it is planned to retain a manual relaying procedure at
the Los Angeles station in order to provide extended talk-back range from mobile units to the base stations in the general area of Santiago Peak. Experience has indicated that the omnidirectional antenna on the Peak provides dependable coverage and reception of mobile units operating within a 100-mile radius of the station. This coverage is solid, except in the few areas where the signal is cut off by intervening hills. Thus, any mobile unit within this range can have a message relayed to its base station through the Los Angeles dispatcher, and vice versa.

In the event that talk-back relay traffic becomes greater than is practical to handle manually through the Los Angeles office, future plans call for additional control circuits between the other base stations and Santiago Peak. This will provide the base stations with their own facilities for handling traffic through Santiago Peak to the mobile units they control.

Typical of these operating base stations is that at Brea-Olinda, shown in Figs. 7 and 8. Note the selective-calling control box at the left in Fig. 7, and the standard triple-skirt coaxial antenna, Fig. 8.

Chuckwalla Peak Relay:
Aside from the various base stations located in the Los Angeles County area, other important stations utilizing 250-watt transmitters are situated at Beaumont, Indio, and Blythe. The Blythe and Indio stations have 200-foot towers which provide them with adequate mobile coverage. In addition to the 250watt transmitters operating in the 150-mc. band, these stations have 72-mc. control equipment for point-to-point work through the Chuckwalla repeater, and for communication through the repeater with mobile units along the 100-mile distance between Blythe and Indio. Fig. 9 shows the Blythe Compressor Station tower installation, with the 150-mc omnidirectional antenna and the 72-mc. Yagi array beamed toward Chuckwalla Peak.

This unattended repeater station is located in the mountains near the community called Desert Center, approximately midway between the two base stations it serves. The Peak is situated in the midst of rugged desert terrain, which is listed as "inaccessible and unexplored" on Department of Interior maps. This desert country is characterized by extremes of temperature and weather, from snow in the winter to 120° F. in the summer, and a scarcity of roads and power lines.

Preliminary studies of aerial maps and photographs suggested the possibility of a suitable location for an unattended re-
peater station in this general vicinity. Several months of reconnaissance work in four-wheel drive vehicles and on foot were required to determine finally that Chuckwalla Peak was the most accessible and desirable location for a station. In order to reach the summit of this range, at an elevation of 3,750 feet it was necessary to construct a 3½-mile access road from the floor of the valley. The top of the peak was blasted level, Fig. 10, and two 100-foot steel towers were erected to support the antenna structures. Then, a concrete block building to house the radio equipment and two diesel generators was constructed. The building and tower structures have been designed to withstand 120 mph wind loads.

Inasmuch as the station was designed for unattended operation for relatively long periods of time, every effort has been made to make the equipment as trouble-free as possible. The two diesel power-generating units are so arranged that they run alternately on either 2½ or 5-day cycles. The engine cooling systems are designed to provide continuous operation for 90 days or more, in temperatures exceeding 120° F. Fuel storage facilities are adequate for uninterrupted 90-day runs. Complete supervisory control facilities have been provided so that the operator at Blythe or at Indio can shift the load from one engine to another, should the necessity arise. The engines are protected also by the usual high-temperature low-oil pressure cutouts and, if these safety devices should operate, the malfunctioning engine is shut down and the second diesel started automatically. At the same time, a 1,000-cycle note is placed on the VHF carrier so that operators at Blythe and Indio are notified immediately of the trouble.

The operators can crank either of the engines by radio, should the cycling procedure be interrupted for any cause. Also, they can control the operation of the 60-watt VHF transmitter for talking to mobile units along the pipe line beyond range of the Indio and Blythe base stations. Selective line switching units are provided so that either Blythe or Indio operators can turn off the mobile-frequency transmitter when talking point-to-point.

Fig. 11 shows the north antenna tower, which carries the mobile-frequency coaxial antenna and the two Yagi transmitting antennas directed at Blythe and Indio. These operate at 75.58 mc. The two receiving antenna arrays, operating at 72.18 mc., are mounted on the south tower, which can be seen at the right in Fig. 10.

At the base of the north tower, a bronze plaque is imbedded in the rock. The tablet was installed in memory of Lt. Art Shropshire, designer of the buildings on Chuckwalla Peak, who was recalled to active duty and died in Korea.

System Maintenance:

Most of the routine maintenance work on the radio system is handled by outside contractors. However, the Southern Counties Gas Company has complete test and repair facilities to provide emer-

(Concluded on page 30)
THE FCC has quite consistently followed the policy of encouraging the development of competitive radio services. It has been maintained, however, on various occasions, that the Commission should take into account the number of competing services that can be operated profitably in a given market.

Most recent case of this sort arose in Rome, N.Y., a city of 11,000 population, where Woodruff G. Evans has operated a limited common carrier system since April, 1948. Last January, he filed a protest against the granting of a license to Martin J. Nunz, who applied for authorization to operate a similar service in the same city.

Basis of the Evans protest was that since he had obtained only nine subscribers, and had not reached the break-even point in his operation, it would not be in the public interest to authorize another service to compete with him.

Fallacy of the Evans position is its assumption that 1) without competition he would be able to obtain a sufficient number of subscribers to assure an operating profit before using up his capital provided the FCC would protect him against competition, and 2) that the total number of subscribers that could be obtained in the Rome area by aggressive sales promotion would not be enough to support two common carrier services.

If only one frequency assignment were available in Rome, Mr. Evans would have it by right of pioneering in the common carrier service. Still, that privilege would carry the obligation to attract the largest number of subscribers by dint of active sales effort, for only in that way could his monopoly be justified.

On the other hand, with two assignments available, Mr. Evans must do the work of his own resources, and not Government protection, as the means for meeting competition. If the newcomer is less able than Mr. Evans, he will only spur the latter to secure his position by rendering still better service. If the newcomer is more able than Evans, he should certainly be given the opportunity to put his ability at the disposal of the community, and if he builds up a larger number of subscribers, it will be by virtue of providing more satisfactory service. Certainly, it would not be in the public interest to foster an inferior service by protecting it against competition from a company capable of rendering superior service!

Radio Location Service:

In a Report and Order announced on December 19, the FCC amended the Rules Governing Industrial Radio Services by adding Subpart M, effective February 1, 1952. Purpose is to facilitate the eventual establishment, on a regular basis, of an industrial radiolocation service to be used primarily in connection with geographical, geological, and geophysical activities. All stations licensed under the new Subpart M will be on a developmental basis only and, to encourage further development of radiolocation techniques, deviations from the Rules may be authorized.

Recognizing that there are areas commercially exploitable for oil at distances 10 to 70 miles or more off shore in the Gulf of Mexico, the Commission has assigned the band of 1,750 to 1,800 kc, for radiolocation use, with the provision that licensees in that band must assume responsibility for protecting the disaster service against interference. Use of this band will be limited to the assignment of 25 kc, of spectrum space to each licensee for all his stations. Assignments in this band will be protected to the extent of a 20-db ratio of desired to undesired signals, and frequency assignments will not be repeated at intervals of less than 300 miles.

In addition to the 1,750 to 1,800-kc. band, the use of frequencies in the following bands may be authorized for land and mobile radiopositioning stations, subject to the condition that harmful interference will not be caused to radio-navigation stations:

<table>
<thead>
<tr>
<th>Band</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,000 to 3,246 mc</td>
<td>3,100 to 3,400 mc</td>
</tr>
<tr>
<td>3,266 to 3,500</td>
<td>9,000 to 9,500</td>
</tr>
<tr>
<td>3,325 to 3,410</td>
<td>9,320 to 9,500</td>
</tr>
</tbody>
</table>

Speed-measuring devices may be authorized in the band from 2,450 to 2,500 mc, on condition that harmful interference is not caused to fixed and mobile communication services, and that harmful interference must be accepted from industrial, scientific, and medical equipment.

Frequencies listed above do not provide for voice communication. Wire lines or frequencies allocated to such services as petroleum, special industrial, or low-power industrial must be used for that purpose.

Louis G. Caldwell:

Comment contained in a letter from Jeremiah Courtyard: "Louis Caldwell, first General Counsel of the FCC, was the acknowledged dean of the radio bar in both broadcast and non-broadcast matters. In the latter field, he acted in a variety of capacities, including that of counsel for Aeronautical Radio, Inc., since its organization as the communication agency of the domestic airlines. The broadcast and non-broadcast fields have grown so much, and have become so complex, that Caldwell was probably the last lawyer to enjoy an intimate knowledge of and a wide practice in both fields.

"His friends were as many as his knowledge of the radio field was wide. A prolific writer, especially in his younger days, his passing leaves in all of us the advice he gave me, at one of the Aeronautical Radio functions, on his way of accomplishing the many extra-curricular labors he crammed into a life filled to overflowing with regular duties. He said: 'If you have a difficult article to write or a study you want to complete, give it fifteen minutes a day. Otherwise, the enormity of the job will lead to putting it off, and it will never be done.' His advice was always valued highly, and the many distinguished works Caldwell left behind testify to the fact that he was a man who practiced what he preached.

"It is truly regrettable that the rich experience acquired by many Government lawyers, in the course of their highly specialized practice before administrative agencies, has not been more completely reduced to writing. Anyone who has participated from the Government side in the last general allocation proceeding, for example, has a wealth of experience of a type that is all too often lost to the succeeding individuals within the Government. Then, too, the people who could enrich the field with their writings are precisely the busiest. For them, Caldwell's fifteen-minutes-a-day recipe is the answer. It may lead me to the preparation of a long- contemplated booklet for those who have continual dealings with administrative agencies, explaining when to see or write their Congressmen about matters pending in governmental departments; how to handle such appointments; when (equally important) not to see or write their Congressmen; when to see the staff dealing with the matter in question; when and when not to see the Commissioners of Government agencies; and discussing other questions that perplex those not versed in the administrative art."
System Engineering:
Added functions required of radio communication systems and the increasing need of conserving channels are creating new demands for the services of engineering consultants. A recent example is the microwave relay system now being completed for the New Jersey Turnpike Administration. Operating on 960 mc., the installation provides a voice channel for monitoring the entire system, another for dial-phone administrative calls, a party-line teletype, and two voice channels for communication by VHF with State Police cars and maintenance trucks. For the latter purpose, there are VHF base stations at five of the seven microwave relay points.

The basic engineering requirements and the operational details were established by the Paul Godley Company, working in conjunction with RCA's engineering products department which designed and manufactured the equipment, and the RCA Service Company which handled the installation.

From the administration headquarters at New Brunswick, it is possible to communicate with all patrol cars, maintenance trucks, and toll gates along the Turnpike. The dial phones and teletype link the police divisions with one another, and with the Trenton headquarters of the State Police. A switching arrangement at the Turnpike headquarters makes it possible to separate the system into two, three, or four sections. With end-to-end operation, a single one-party line is provided. If serious traffic congestion develops in one region, that section can be isolated from New Brunswick, leaving it free to handle local traffic without tying up calls over the remainder of the system. During such an emergency, messages exchanged in the isolated section can be monitored from headquarters, or the section can be cut back into the system by throwing a single switch. Cost of the complete system will be somewhat above $100,000, according to best estimates.

Amateur Civil Emergency Service:
The FCC announced on December 19 a proposed rule making for the Radio Amateur Civil Emergency Service. Comments related to this matter may be filed on or before February 15. Operation of this service will be limited to the present national emergency, as proclaimed on December 16, 1950, and authorizations may be terminated by the Commission at any time, without a hearing.

Purpose of this service is to provide for the organization of amateur-operated networks under the immediate direction of Civil Defense Radio Officers. The proposed Rules and plan of operation are set forth in great detail, occupying 17 mimeographed pages.

Under this plan, the following bands will be used by stations operated under the direct supervision of designated or responsible officials of the civil defense organization:

**CW TELEGRAPH, AM TELEPHONE, AM FACHMILE, NARROW-BAND FM TELEPHONE**
- 28.55 to 28.75 mc.
- 50.35 to 50.75 mc.
- 75.35 to 75.75 mc.

**CW TELEGRAPH, AF AM TELEGRAPH, AM TELEPHONE, AM FACHMILE, WIDE-BAND FM TELEPHONE**
- 145.17 to 145.71 mc.
- 146.79 to 147.33 mc.
- 225.00 to 225.65 mc.

In addition, the following bands will be used by all authorized stations:

**CW TELEGRAPH, AM TELEPHONE, AM FACHMILE, NARROW-BAND FM TELEPHONE**
- 1,800 to 1,825 kc.
- 1,875 to 1,900 kc.
- 1,900 to 1,925 kc.
- 1,975 to 2,000 kc.

**CW TELEGRAPH, FS TELEGRAPH, AM TELEPHONE, AM FACHMILE**
- 3,510 to 3,515 kc.

**CW TELEGRAPH, FS TELEGRAPH, AM TELEPHONE, AM FACHMILE**
- 3,990 to 4,000 kc.

Very stringent rules are proposed as to persons authorized to operate stations in this service, and for the operating requirements and procedures.

2-Way Radio in England:
"In the U. S., Business Radio is largely confined to taxi and car-hire services, and, as they have only four channels below 450 Mc/s, as many as 400 taxis operate in the same channel in some of the larger cities. In this country [England] any applicant — from bookmaker to builder, doctor to dairy farmer, and taxi-owner to towage company — is accommodated within one of the business radio bands."

This reference to radio communication systems is quoted from the December issue of England's leading radio engineering magazine, the Wireless World. It must have puzzled a considerable number of our subscribers in England who saw the latest FCC summary in Radio Communication last month, showing 10,000 public safety, 3,200 land transportation, and 1,000 industrial service transmitters, operating with more than 300,000 vehicles equipped with 2-way radio. Of these systems, taxi operation only accounts for some 15%. If any of our subscribers abroad are interested in checking over the use of 2-way FM radio for mobile, point-to-point, and relay service in the U. S., we'll be glad to send them copies of our Registries of Radio Systems on request, without charge.

In England, 71.5 to 72.8 mc., 76.7 to 78.0 mc., 85 to 88 mc., 156 to 184 mc., and 460 to 470 mc. are assigned to business radio service. In the first three bands, channels are 50 kc. wide, in contrast to our 40-ke. channels at those frequencies, and 100 kc. wide in the fourth band, as they are here. According to a report made to the House of Parliament at the end of last July, there were 392 fixed and 1,902 mobile transmitters used for business radio at that time. These figures do not include police and fire systems.

An article on taxi radio which appeared in the December issue of the Wireless World describes the 12-watt fixed and mobile AM equipment manufactured by Pye Tele-communications, Ltd. Mobile units, working on 12 volts, draw 4.5 amperes for the receiver, 1.5 amperes for the transmitter tube heaters, and a total of 14 amperes during transmission. According to this article, taxi cabs "have to be fitted with loudspeakers in order that the driver's attention should not be distracted from his primary function of driving, which might well be the case if a calling device in the form of a buzzer or lamp were used and the driver required to search for and pick up a hand telephone set." Instead, "the microphone is carried by a horizontal swivelling arm attached to a vertical rod mounted on the glass partition which divides the driver's compartment from the luggage space. . . . He can speak into it without actually turning his head and taking his eyes off the road."

The press-to-talk switch is mounted "on an arm extending out from the instrument panel . . . just below the rim of the steering wheel. The knob of the switch projects outward . . . and by extending the first two fingers of the left hand it is quite easy to operate the switch without relaxing the grip on the wheel." That may be less complicated than it sounds, but our use of a hand mike or a telephone handset seems much simpler.

**INDUSTRIAL REGISTRY**
1952 Registry No. 1, listing complete information on systems operated by public utility, pipeline, geophysical survey, special and low-power industrial, relay press, motion picture, and forest products services, is now available at $5.00 per copy. Address: Register Editor, Radiocim, Inc., Gt. Barrington, Mass.
HAMMARLUND manufactures a complete line of economical and versatile equipment for remote control and data-transmission systems. This fast-acting electronic apparatus is based upon technically sound, time-tested designs. Hammarlund systems can be used with existing installations of any manufacturer, operating over wire or radio circuits, to provide safe, convenient, and reliable performance.

Among the applications of Hammarlund equipment are selective signalling, selective calling, fleet calling, control and selection of remote transmitters and receivers, remote on-off switching of industrial equipment, supervisory control, pipeline control, and telemetering. A few examples of Hammarlund Remote Control and Data-Transmission Units are illustrated here:

**THE HAMMARLUND Standard Duplex Signaling Unit**

The Hammarlund Model DSU — Duplex Signaling Unit consists of a tone generator and a receiver which operate at a predetermined frequency. Transmitted and received signals perform on-off switching, provide continuous indication of operating conditions, and automatic indication of wire-line or power-source failure at all points in the system.

A frequent application of this unit is its use in the form of a simple and inexpensive ringdown panel for communication circuits. One panel is used at each end of the circuit so that an operator at either end can signal the opposite end. This method eliminates the expense of monitor amplifiers, and relieves the individual operators of the annoyance of having to listen to all communications, since it is possible to signal only the operator who is wanted.

MANY TYPES of systems addition of selective calls of mobile services. The tem of selective calling for installations for privacy, ing standby periods, the s. When the dispatcher presses, only the speaker in the and transmitters in all on

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HAMMARLUND Multi-Gate are designed for those applications connecting wire or tone-operated remote control systems can be used. A frequent, simple app. System is its use to turn on
DATA TRANSMISSION EQUIPMENT

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EQUIPMENT FOR MCC OPERATION

HOW A TELEPHONE ANSWERING COMPANY USES EXISTING EQUIPMENT AND PERSONNEL TO ADD MCC SERVICE AT LITTLE COST — By PHILIP D. HAMLIN

Telephone answering today is big business. In its basic form, it is a simple process. Normally, a businessman is in his office not more than eight hours a day. Many of his customers, however, would like to contact him, place orders, or leave messages at other hours. They can be accommodated simply by having an extension from his office telephone installed at some other location, which is attended around the clock. Then, when his telephone rings, if there is no one in his office to answer it, the telephone answering service takes over, answering with the name of his firm and transmitting his business. Trained secretaries follow his instructions to the letter.

From this basic service have grown many additional ones, which can be handled with the facilities already installed for telephone-answering. For example, Sears, Roebuck Company employs this service on a nation-wide scale for taking telephoned catalog orders. Many emergency organizations are customers such as AAA and those who furnish local towing, commercial refrigerator, ambulance, and elevator and oil burner repair services. Not the least important is television repair service, which has become so vital to many users that not a moment’s delay will be tolerated. Broadcasting stations use the service for calls made in response to limited-offer advertising. All kinds of public opinion polls use it for sampling, although in this particular application it is utilized for making calls. There are many other applications, and new ones are being developed constantly.

One of the most recent developments in this field is mobile radiotelephone dispatching and message handling. At first glance, this would appear to be competitive with the telephone company. Actually, it is an entirely different kind of service, since the Bell System only provides facilities for direct two-way conversation.

This has tremendous appeal, but only to the man who is in no particular hurry. The reason is simply that there are only a few frequencies available for this common-carrier mobile radio telephone service. The number of parties required to share each frequency is sometimes enormous. Experience indicates that where 80 or more have shared a line, it is rarely possible to get immediate service. The average user, after getting a call through, makes no effort whatever to be brief; rather, he exchanges pleasantries with the other party, and wastes much of the air time. This tendency toward protracted conversation, in addition to the time consumed in reaching the operator and having her contact the land line, keeps the available frequencies crowded. Fifteen-minute waits are not at all unusual. Many users have discontinued the service because they found themselves home or at their destination before a mobile call could be completed.

The telephone answering service, on the other hand, handles messages through an operator who is trained in brevity and who has absolute control of the air time. If a customer wants a doctor in an emergency, he is not interested in exchanging pleasantries. He wants only to have his call conveyed to the doctor in the shortest possible time. He wants to know when the doctor will arrive and he may need very brief instructions on what to do while waiting. The same is true where trucks are dispatched for pickups or deliveries, or calls for servicemen are handled. The essential information can be capsulized and re-transmitted by the telephone answering service. The very impersonal aspect of this relaxing discourages redundancy. Also, a telephone answering organization can offer highly competitive rates because of the controlled air time.

The integration of mobile radio service with the regular telephone answering service presents an operating problem which has been solved by the equipment to be described. The economic success of adding radio communication is dependent entirely upon the utilization of existing facilities, particularly in the initial period of operation. All such systems begin with a central radio station and contracts for a few mobile units. It would be economic suicide to assign one operator to each of the three shifts, with nothing to do but respond to the calls of a few mobile units. Such operators have to be trained in the use of radio, in addition to secretarial skills. Obviously, the regular operators must be utilized, and this calls for a method of operation which will permit them to handle radio calls with almost the same habit patterns employed in telephone answering.

Switchboard Equipment:

The problem was presented to our development engineer, Mr. C. B. Ramsey. First, a study was made of the operating habits of switchboard personnel. The remote-control unit provided with the General Electric central-station equipment was then analyzed, and it was decided to use it as a basic unit upon which to build the control equipment. Accordingly, a new case about 20% larger than the original was designed. The standard remote-control unit was installed in the case, Fig. 1, together with the additional equipment necessary. A key switch marked LOCAL and switchboard was added. Its purpose is to switch

FIG. 1. MODIFIED GE REMOTE-CONTROL UNIT, USED AS SUPERVISORY MASTER-CONTROL EQUIPMENT
control between this supervisory equipment and the switchboard operator's unit. With the switch in the local position, operation is exactly the same as with the original GE remote-control unit, with the exception that channel A or B lighting is utilized to indicate transmitter standby condition. The red light at the center of the panel glows when the transmitter is keyed. When the key is in the switchboard position, however, the volume control, squelch control, and microphone key are disconnected, and the monitor speaker control is switched in automatically. This provides control of the speaker volume for both incoming and outgoing signals. All other necessary circuits are transferred to the switchboard operating unit.

At the switchboard position, shown in Fig. 2, a telephone-type drop relay is controlled by a circuit utilizing a 6AL5 rectifier and a G1613 thyatron relay tube. Upon receipt of an incoming call, part of the signal is rectified and applied to the thyatron. After a pre-set delay period, the relay drops, turning on an orange light and, if the operator chooses, ringing a buzzer also. The buzzer can be switched out at the operator's discretion.

When the operator goes on duty, she plugs her dual phone jack into the radio unit as shown in Fig. 2. The switch marked TELEPHONE-RADIO, when left in the TELEPHONE position, bypasses calls through the unit to the switchboard. The operator handles all switchboard calls as though the radio unit were not there. When the relay drops, indicating an incoming call, she plugs her patch cord into the drop relay jack at the top of the unit. The orange light and the buzzer are turned off automatically, and a white light to the left of the relay jack is turned on, indicating that she has answered the call. This is done so that similar units between every two operators, with identical lights, will indicate to the other operators that the call has been answered.

When the operator's patch cord is plugged into the drop relay jack, the relay is restored to its original closed condition. The operator then pulls the RADIO-TELEPHONE key forward to the RADIO position, and is thus connected to the radio circuit. The transmitter key is then operative. When the call is completed, the operator's patch cord is returned to its normal position, ready for another call. On this unit are squelch and volume controls also. These controls have no affect upon the setting of the controls at the standard remote position, when the supervisor wishes to take over.

Capacitive coupling between audio lines makes it possible for the land-line caller to hear the mobile unit's answer, although his call is not permitted to modulate the transmitter. Thus, a worried mother can call for a doctor through the operator, hear her question relayed to him, and then listen to his answer and instructions, while the answering service maintains rigid discipline and control of air time.

Each operation is displayed at the supervisory remote-control position by lights under appropriate wording on the panel. All relays and indicator lights are operated by heavily-filtered DC to prevent hum. The main switchboard unit has its own power supply, which can furnish power to five other auxiliary units. Eventually, it is planned to provide a unit between every two operators. Each unit will have two dual jacks, so that two operators can plug into one unit, and each will have her own TELEPHONE-RADIO key. In this way, incoming calls will be displayed to all operators. Any girl free at that moment will take the call. When she plugs her patch cord into the drop relay jack, all other operators will be notified by the flashing white light on each unit that the call is being handled.

The system as shown was custom-engineered for the Seattle Business Exchange, a telephone answering service. Some consideration has been given to production of the units for sale to other services with similar needs, but, at this writing, insufficient information is available to determine the degree to which such a unit can be standardized. Logging companies, oil companies, and others having their own telephone systems have indicated interest, but variations in switchboard equipment and requirements make custom building almost mandatory for these users. Further study will be devoted to this problem.

BLIND PROGRAM
QUALITY MONITORS

Broadcast stations of many European countries employ full-time program monitors, whose only task is to listen critically to the radiated programs. Experienced monitors can detect the slightest deviation from standard audio quality. This gives a continuous check on all the studio equipment, the modulator, and the transmitter, and is of practical value in reducing outage time as well as maintaining a high quality standard. However, the work is exhausting and difficult to undertake for long, uninterrupted periods. This article, reprinted from the Documentation and Information Bulletin of the European Broadcasting Union, describes the improved results obtained by employing blind persons as monitors.

The Nord West Deutscher Rundfunk, as part of its technical supervisory arrangements, has a department whose

(Continued on page 33)
A new Hallicrafters product—the "littlefone"—is now ready for thousands of important uses in hundreds of industries.

This light, rugged, dependable radio-phone will be offered through Hallicrafters distribution organization—by the men who know communications best.

USES OF "LITTLEFONE" CHALLENGE YOUR IMAGINATION!

There are literally thousands of industrial uses for the "littlefone" radio—anywhere where powerful, dependable, "on the move" contact is required.

AMONG THE MORE IMPORTANT PRESENT USES ARE:

RAILROADING

FREIGHT HANDLING

WAREHOUSE OPERATIONS

RANCHING & LARGE FARMS

MINING (Above & Below Ground)

PIPE LINE INSPECTION

ROAD BUILDING

SHIPPING (Dock Operations)

CONSTRUCTION

LUMBERING

World's Leading Manufacturer of Precision Radio and Television — Chicago 24
Two more good reasons why MICROPHONES are the Field-Proven Standard in Mobile Communications...

Subscribers to MCC Interstate network in northeastern U.S. are the Ray Nathan Oil Co. and Lane Refrigeration Co. Service trucks are equipped with 2-way radios for faster service to companies' Oil Burner and Refrigerator customers, respectively. Shure 100 Series Carbon Microphone is used for durability...high speech intelligibility.

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RAILROADING
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OIL
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it's always and reliably
SHURE BROTHERS, Inc.
225 West Huron Street
Chicago 10, Illinois
Cable Address: SHUREMICRO

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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.

WEIGHTY 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 are addressed to the Registry Editor.

CODE LETTERS
The following letters indicate the type of facilities for which applications have been filed. Unless indicated otherwise, Fill operation is to the employer:
- A: All operation  a: Portable unit  b: Base station
- M: Mobile unit  r: Repeater or relay
- Make of equipment is indicated by one of these letters:
  - A: Allerlcopter  L: Lark
  - B: Belmont Raytheon  M: Matlock
  - C: Conoco  N: Gyn Radio Signal
  - D: Defiance  O: Formburn
  - E: W. Coast Electronics  P: Pacific
  - F: Federal Tel. & Radio  R: RCA
  - G: General Electric  S: Railway & S.
  - H: Harvey  T: Bandit
  - K: Kaiser

Graham County Sheriff Hill City Kans 1b 155.51; 155.51 M
Gram County Sheriff Croydon Iowa 1b 155.51; 155.51 M
Pound Town of, Wise Va Sm 39.51
Jim Hogg County Sheriff Hobsonville Tex 1b 39.51; 39.51 M
Benton County Sheriff Bentonville Ark 1b 39.51; 39.51 M
Hughson, City of, Ark Sm 39.51 M
Brown County Sheriff Wabasha Kans 1b 39.51, 39.51 M
Great Falls Police Box 3826 San Juan P.R. Insular Police
Ellicott, City of, N. Me Sm 39.51
Nevada County Chief of, Bismarck N.D 1b 42.26, 42.38 M
Fall River, City of, Ta 102 2p 39.26, 39.26 M
Osborne County Sheriff Osborne Kans 1b 39.51, 39.51 M
Waskeney, City of, Kans 1b 39.51, 39.51 M
Pancake, Village of, N Y 1b 39.51 M
N Augusta Town Council S C 1b 155.55, 155.55 M
Kans State of, Topeka Kans Norton Kans 1b 44.91
Leominore, City of, Calif 1b 155.51, 39.51 M
Agana Police Dept. Agana Guam
Tomah, City of, Wis 1b 39.34, 39.42 M
New Bern Sheriff's Office New Bern N.C 1b 39.10, 39.10 M
State of Cali, Sacramento Cali Los Angeles Calif 1b 42.34 G
Garden City, Town of, Ala 1b 155.01; 155.01 M
White City, Village of, Wis 1b 155.51, 1p 39.51, 39.51 M
St. Louis, City of, Mo 1b 155.51, 155.51 M
New Richmond, City of, Wis 1b 39.34, 39.42 M
Caldwell, City of, Police Dept 1b 159.09, 89m 159.09 M
Albee, City of, S C 1b 155.19, 155.19 M
Hollin Polly S S C 1b 155.19 M
Dux, City of, S C 1b 155.19 M
Alamo, State of, 1279 Under A St Paul Minn Dept
May Police 3b 42.82, 42.82 M
O'Tallain Fire Dept 3b 154.19, 154.19 M
Wakefield, Town of, Mass 1b 46.06, 46.06 L
Clay County, City of, Mo 1b 155.57, 155.57 G, 154.155.67 D
Sauk Center, City of, Minn 1b 155.76; 39.51 M
Alder County Sheriff Muncing Mich 1b 42.75, 42.58 M
Walwick, Borough of, N J 4b 37.10, 158.73 M
Avon, Borough of, N J 1b 156.21, 156.21 R

(Continued on page 3)
NEW APPLICATIONS
(Continued from page 30)

FIRE
Oreland Fire Co No 1 Oreland Pa
1b 154.13; 25m 154.13 P
Owosso, City of, Mich 2b 154.19; 10m 154.19 M
Pleasantview Fire, Protective Dist nr La Grange III 1b 154.25; 5m 154.25 M

FORESTRY
N Carolina, State of, Raleigh N C 1b 31.34, 31.46 L
Westport, Town of, Mass 1b 31.34; 6m 31.34 G
Georgia Forestry Comm Waycross Ga 6b 159.39 M
Kittery, Town of, Me 1b 45.14; 1m 45.14 L
Cleveland, City of, Ohio 1b 37.18 G
Maine Forestry Dept Augusta Me 1b 31.62 M
Alabama, State of, Montgomery Ala Dept of Conservation No A 1b 150.45 M
N H Forestry & Rec Dept Concord N H
West Boylston, Town of, Mass Forest Fire Warden 12m 32.4 M

HIGHWAY MAINTENANCE
West Va, State of, Beckley W Va Hwy & Constr Gypsy W Va 1b 37.98 R
Cahill State, Sacramento Calif Mt Lowe Calif 1b 47.02; 47.10 R; 1b 72.10 R
San Luis Obispo Calif 1b 75.78 R
Paso Robles Calif 1b 75.78 R
Indio Calif 1b 47.02 R
Cambria Calif 1b 47.02; 47.10 R
El Centro Calif 1b 75.78 R
Boulder Park Calif 1b 47.02; 47.10 R

SPECIAL EMERGENCY
Jackson, D & E Vtn Hosp Twin Falls Idaho 1b 47.00; 2m 47.00 M
Provincetown, Town of, Mass 6m 31.34 G
Mount Airy, E, Danville Va 5m 47.50 M
Miller, W T & Farmer, HT, Box 436 Richmond Va
Henrico Va 1b 47.50; 5m 47.50 M
Philadelphia, City of, Pa 3b 47.46, 47.54, 47.62 R
Colo, Elbert C, Kiowa Colo 1b 47.54; 1m 47.54 M
Florida Dept of, Statewide 1b 35.02 M
West, Dr Jas R 820 Seaberry Av Milford Del
1b 47.46; 1m 47.46 M
Grant, Dr W 3165 Tern St Cartersville Ga 1b 47.46; 1m 47.46 M
Moore & Lindsay, Drs Belvidere III 1b 47.58 M
Hoffert E J 1002 Franklin Av Fremont Ohio 1b 47.54; 2m 47.54 M
Henley, Dr Claud A Fairview Terr Jacksonville III 1b 47.54; 1m 47.54 M
Wells, Dr Robert J 605 Milton Benton Ill 1b 47.54; 3m 47.54 M
Brennan & Lackey, Drs 361 6th St Chino Calif 1b 47.66; 2m 47.66 M
Michigan, State of, Lansing Mich 1b 47.66; 2m 47.66 M
Ager, Robert J O'Neill Ne 1b 37.90 M
Dapper, Dr Robert R 1b 37.90 M
1b 159.51; 3m 159.51 G

POWER UTILITY
Ark Pr & Lt Co Pine Bluff Ark Smackover Ark 1b 37.70 L
Sunny Slope Water Co Pasadena Calif 1b 48.06; 8m 48.06 M
Gas Co Meridian Miss Lowndes Cty 1b 48.06 M
Amerada Petroleum Corp Tulsa Okla Lea N Mex
1b 33.18 G
Standard Oil & Gas Co Chicago III Corpus Christi Tex 1b 153.23 R
Owensboro-Clarksville Ky Webster Ky
1b 49.06; 10m 49.06 M
Central Maine Power Co Augusta Me Skowhegan Me 1b 47.98; m 47.98 M
Pacific Gas & Co San Francisco Calif Corcoran Calif 1b 153.71 L
Fresno Calif 1b 153.71 L
Dinuba Calif 1b 153.71 L
Niobrara Elec Mem Assn Hay Springs Neb 1b 47.78; 8m 47.78 M
Cenrtz Ariz Lt & Pr Phoenix Ariz 1r 956.75; 1q 956.75; 958.25 R
Mingus Mtn Ariz 1r 1.985 R
shaw Butte Ariz 1q 1.945; 1r 1.985 R
Abilene, City of, S C Dept of Water & Light 1b 47.70 M
Raff River EC Inc Malta Idaho 1q 74.50; 1b 48.06; 15m 48.06 G
Morton Pr & Lt Co Morton Texas 1b 37.66; 6m 37.66
Anahim, City of, Calif Dept of Pr & Wtr 1b 47.94; 6m 47.94 M
Durham, City of, N C Dept of Wtr 1b 47.94; 6m 47.94 M
Flat River EC Inc 1b 47.78 L
Coos-Curry EC Inc Box 456 Coquille Ore Gold Beach Ore 1b 36.72 M
N Cent Miss EAPA Olive Branch Miss 1b 48.30 R
Cumberland Valley EC Mercersburg Pa 1b 24.73; 2m 27.73; 20m 48.54 R
New MC EC Inc Neosho Mo 1b 158.13; 1m 158.13 M
Ohio Pr Co 606 2nd St SE Canton Ohio Dennison Ohio 1b 37.70 L

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PR-31

Tuneable 30-50 MC

PR-6

Tuneable 108-132 MC

AIRCRAFT

AR-1

Am Tuneable 108-132 MC

115 Volt AC-DC

SPECIAL INDUSTRIAL

Edgerton, Germershausen & Grt, Inc 160 Brookline Av Boston Mass 266 152.87; 32m 152.87 M
Black Rock Mining Corp Bishop Calif 1b 39 M
White Mtn Calif 1r 72.76; 1q 72.76 G
Cobb Caning Co Inc Cobb Wis 1b 43.95; 1m 43.95 M
W H Shields Constr Co Eugene Ore 1b 43.02; 1m 43.02 X

CONTINUED ON PAGE 32
**NEW APPLICATIONS**

(Continued from page 31)

Dayton Builders Concrete Co Dayton Ohio
1b 152.87; 1m 152.87 R
Taylor Bros Inc Evansville Ind 1m 43.06 M
Jas E Wright Jr Box 189 Indio Calif 1m 49.86 G
Claremont Constr Co Los Alamitos Calif
1b 49.86; 10m 49.86 G
San Angelo Tex 1b 49.98 G
Kermel Tex 1b 49.98 C
Hobbs N Mex 1b 49.98 G
McCartney Tex 1b 49.98 G
Manahans Tex 1b 49.98 G
Sundown Tex 1b 49.98 G
Post Tex 1b 49.98 G

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**MICROWAVE COMMUNICATIONS SECTION**

**RADIO CORPORATION of AMERICA**

ENGINEERING DEPARTMENTS. CAMDEN, N.J.

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RCA engineers are at your service for consultation on microwave systems. Write to Dept. 132-A for complete information.
NEW APPLICATIONS
(Continued from page 38)
OK Cab Co, Macom Ga 1b 152.53; 30m 157.59 L
Ace Cab Co, Inc, Arbutus Md
1b 152.27, 10m 157.53 LBM
1000 Cab Co, Williamston ND
1b 152.57, 10m 157.53 L
Mackey Taxi, Newton N J 1b 152.33; 1m 157.00 M
Veterans Cab, Pontiac Ill 1b 152.45, 6m 157.71 M
Rocket Cab Co, Encorsee, Mich 1b 152.39; 1m 157.65 M
Robin Hood Cab, New Orleans La
1b 152.55 L
"285 Taxi", Warren Ark 1b 157.30; 10m 157.53 M
City Cab & Storage Co, Columbus Ohio
1b 152.45, 25m 157.71 GX
Hurley's Cab, Paris Ky 1m 152.45 M
Trac Safety Cab Co, Virginia Minn
1b 157.53; 5m 152.27 M
City Cab Co, Jacksonville Ala
1b 152.33; 5m 157.59 M
Bus Station Cab, Co, Piedmont Ala
1b 157.65, 10m 152.39 M
City Taxi Co, Kearney Neb 1b 157.65; 10m 157.65 M
Sammy's Cabs, Iron Mountain Mich, Dickinson Mich
1b 152.27; 5m 157.53 R
Corner & Spring St Co, Eureka, Sora, Ark
1b 152.77; 27m 157.53 M
Shepard's Taxi Service, Franklin N H
1b 152.39; 1m 157.65 T
Earles Taxi, Dunellen, N J 1b 152.27, 1m 157.53 M
Century Cab, Hollywood Fla 1b 152.39; 15m 157.65 L
Suburban Cab Co, Harrisburg Pa
1b 152.33, 10m 157.59 L
Snyder's Cab, Fremont Ohio
1b 152.39; 6m 157.65 M
Rizzo, John J., Maspashusset N Y 1b 152.45 L
Black & Yellow Cab Inc, Riverdale Md
1b 152.45; 35m 157.59 L
Hennessy Taxi, serv., Elizabeth N J
1b 152.27; 10m 157.53 M
Independent Cab, Griswold, Ill
1b 152.33; 6m 157.59 M
Capitol Cab, Providence R I, 1b 152.45; 6m 157.71 M
Joliet Checker Cab, Joliet Ill
1b 152.45; 10m 157.71 M
ABC Taxi, Laredo, Tex 1b 152.27, 15m 157.53 M
Toms Taxi, Del Rio, Tex 1b 152.27, 15m 157.53 M
City & Safety Cab Co, Topeka Ks
1b 152.33, 12m 157.59 M
Friendly Cab Co, Lebanon Tenn
1b 152.45; 10m 157.71 R
Yellow Cab, Delano, Calif 1b 152.45; 10m 157.71 M

AUTO EMERGENCY
Cornwall, E M 402, 1st Av, Manassas Va
1b 47.58, 10m 47.58 M
The Automobile Club of Philadelphia, 235 23rd St
Philadelphia 3 Pa 1b 453.85; 25m 453.85 L
Mac's All Car Serv, Lansing Mich
1b 35.70, 6m 35.70 M
G & W Garage, Lawndale, Calif 1b 35.70, 3m 35.70 M
Daugherty's Super Service, Flushing N Y
1b 35.70, 6m 35.70 M
Carolina Motor Club, Charlotte N C
1b 35.70; 10m 35.70 M

BLIND MONITORS
(Continued from page 28)
task it is to monitor critically the radiated programmes. This programme
supervision locates and identifies any technical faults in the modulation chain
between microphone and transmitter, as well as in the transmitter itself. Over
and above its own work, this department makes everyone concerned with the pro-
grammes at the studio centres more painstaking. On account of its valuable
observations, which make it possible to attain the highest degree of reliability in operation, the department has come to play an important part in the activities of the NWDR, and an ever increasing interest in it is being shown by the other broadcasting organizations in the Western Zone of Germany as well as by foreign broadcasting authorities.
When this department came into being in 1948, the monitoring was done by
(Continued on page 34)

January, 1952—formerly FM, and FM Radio-Electronics 33
PIONEERS IN THE CORRECT USE OF ARMSTRONG FREQUENCY MODULATION

FM Receivers for All Broadcast Monitor and Network Services

BLIND MONITORS
(Continued from page 35)

engineers, as it was thought that only technically qualified personnel could do this task justice. It was, however, soon apparent that long hours of monitoring are extremely tiring and that, in the case of the less interesting transmissions, concentration soon fell off. In this way, momentary faults were often missed. In order to keep up the receptiveness of the monitors, their working hours were decreased, and among the additional staff which had to be engaged for this reason was a blind person. A comparison of faults registered soon showed that the blind operator was capable of a much higher degree of sustained concentration than were his seeing colleagues.

Since then the seeing monitors have been gradually replaced by blind personnel—particularly by war-blind. In this way it was developed the technical programme supervision department as it is today, where at present 12 blind persons are employed. Thus, the department has become socially one of the most important within the NWDR. The selection of the blind is made, in collaboration with the social welfare authorities, by means of a suitability test.

The monitoring rooms of the technical programme supervision department have been constructed with broadcast studio acoustics. In sound-proof cubicles, the blind sit in front of loud-speaker units which have a wide frequency range. Telephones connected with the broadcasting center and the transmitting station are placed conveniently on the table, as is also a blind-typewriter for registering faults. A switching panel makes it possible to compare the programme leaving the studio center with the same programme as received. The apparatus is maintained by a supervisory engineer who can, by glancing through the large windows in the sound-proofed doors, make sure of the correct functioning of the installation. He assists and advises the blind in all technical questions.

In examining the reasons why the blind are so especially well suited for this newly-created occupation of broadcast monitor, it is relevant to hear a word from the monitor himself. Herr Erich Berlepsch says about his job: "I am of the opinion that monitoring in broadcasting is suitable work for a blind person, since he himself is particularly well-equipped for it. For myself, the most important things are that I am able to work independently and without any outside help, and perhaps even more that my blindness is of no importance in this work. This means much and doubtless

(Continued on page 35)
BLIND MONITORS
(Continued from page 34)
increases my — and my colleagues — liking for the job. Since in this job hearing is the most important thing, and since this has necessarily come to play a big role in my life, I feel myself more reliable in the execution of my work. Although it cannot be said that a blind person has better hearing than one who can see, it must be agreed that the hearing of the former is better-trained and sharper and, as a result of practice, a blind person is able to assimilate acoustic impressions more rapidly. An additional advantage in our job is that we are able to work undisturbed, since we have no visual distraction.

"Naturally, there are difficulties in our job. Although a materially safeguarded existence in the well-equipped rooms of the transmission supervisory department gives us an inner tranquility for carrying out our task well, it is very strenuous to do so for more than six hours. The constant sitting still in front of the loudspeaker is most certainly physical work, which can become a strain. Taken all round, I think I can say that although strenuous, the work can well be done by blind persons, both from mental and physical considerations, and over considerable periods."

Another blind monitor, Herr Jurgen Collarius, says in this connection: "Of the five senses, the eye and the ear are the most used. Of these two, the eye is preferred because it transmits impressions more quickly and accurately. A seeing person uses the eye even when the ear could replace it. Who among the sighted, for example, would think during the daytime of judging the speed of a passing car by the sound impression rather than the visual impression received, although he receives them both equally? In this case he permits himself so to speak, the luxury of neglecting the sound. On the other hand, a non-seeing person is forced to make full use of his ear, as he must try to replace the lack of one sense by the others. Therefore, one difference between the seeing and the non-seeing lies in the fact that the latter make complete use of every acoustical possibility, whereas the former do so only partially.

"A blind person, therefore, must have his ear receptive in every situation and at all times, as it forms his most important link with the outside world. He must differentiate quickly between the many sounds heard, and recognize their origins. This constant receptiveness, as well as analysis and recognition, requires the highest degree of concentration. This...
(Continued from page 36)
BLIND MONITORS
(Continued from page 85)
can be attained only through practice. A blind person must always try to increase this faculty in order to offset as much as possible the lack of sight. A seeing person is not obliged to do this, therefore he does not worry particularly about the practice and development of this faculty. On the contrary, he even finds the eye a hindrance, as its impressions always come into the foreground and distract him.

"Hearing thus trained and practiced, and the consequent facility of concentration, are the main requirements in the monitoring service. The constant use of both faculties in everyday life enables the sightless to give more detailed attention over long periods of monitoring. Excessive loudness and the intrusion of extraneous noises are bad for monitoring, and have a dulling effect since they are prejudicial to delicate impressions. The cubicles of the department are such that it would be possible to monitor for years without any deterioration of the work.

"In every type of work, he who does it must find a certain satisfaction. This grows out of the meaning and usefulness of the work for the worker himself and for the community. The individual identifies himself with the work he produces and establishes his social effectiveness according to its worth. Monitoring can be satisfying in this respect only if the monitor is made aware of the results of his work. Monitoring must not become purely routine work, and the observations must not serve only as statistics to be filed. The monitors’ experience must be made full use of, and they should be invited to express opinions. In no case must the technical programme supervision appear as a kind of radio police; this would have an unpleasant effect on collaboration with other departments. Monitoring gives the sightless the feeling of being a useful and complete member of the organization. The effect of this feeling forms the basis of his approach to life."

"In conclusion, it can be said that, whereas in general the lack of sight reduces the output of work, in the monitoring service it increases it."

Herr Gerhard Ziervogel, who was blinded in the war, says in a few sentences: "After working for nearly two years I still do my work with the same freshness and readiness. Because I am sightless, I have no distraction through external influences during my period of work, so that I can devote a greater degree of concentration to the broadcasts. By my new occupation I have become a full member of the working community."

(Concluded on page 37)
BLIND MONITORS
(Continued from page 36)
These observations by blind operators who have been doing this work for three years state the most essential facts of this new occupation for the blind.
Each department must, through the results of its work, justify its place in the organization. This is not very easy in the case of a supervisory department. The administration and programme staff had first to find the right approach to, and gain confidence in the ability of the monitors to do the work.
Carefully-kept statistics record, by means of graphs, the faults in the modulation chain to the transmitter and in the transmitter itself, and synopses of faults in programmes showed after a short while a tendency to decrease. In this way, a far-reaching stabilization in the operation of the modulation chain and the correct development of the service is being achieved. Thus, the technical programme supervisory department with its blind operators fulfills its task.

BEAM INTENSIFICATION
(Continued from page 16)
the oscillograph. The resultant increase in the intensity of the trace makes writing speeds up to 9,100 inches per microsecond easily visible. These high writing speeds are useful in studying rapidly-varying electrical surges, such as are caused by lightning discharges, and in learning more about the insulation breakdown the surges produce.
Insulation breakdown caused by lightning discharge often results in power outages and failure of electrical equipment. Thus, for development of insulation designs, as well as for routine tests on high-voltage components, most manufacturers of high-voltage equipment now employ surge generators to produce in the laboratory electrical surges having the same voltage and current magnitudes as those occurring on transmission lines as a result of natural lightning. During a thunderstorm, an electrical system may be subjected to surges rising to a million volts and a hundred thousand amperes for less than one microsecond.
For measurement of artificially-produced rapid changes in current or voltage, special high-voltage cold-cathode ray oscillographs are used, in which a cold-cathode discharge tube is the source of the electron beam. Part of the beam passes through a small hole in the center of the anode of the discharge tube into the main chamber of the oscillograph. Here the electrons pass through a beam
(Continued on page 38)

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"For further details, see "A Fifty-Fold Momentary Beam Intensification for a High-Voltage Cold-Cathode Oscillograph," by John H. Park, J. Research NBS 47, 87, (1951) RP 2231."
BEAM INTENSIFICATION
(Continued from page 37)

trap, focusing coils, and deflecting and sweep plates, finally striking a photographic film or fluorescent screen.

A pulse of increasing voltage applied to the sweep plates moves the electron beam horizontally across the film, providing a time axis. The voltage pulse to be studied, after being reduced in magnitude by a suitable divider, is applied to the deflection plates to deflect the beam at right angles to the time axis. This deflection, in combination with the sweep, leaves a trace on the film which is a plot of voltage against time for a particular surge. A corresponding plot of current against time can be obtained by using a shunt rather than the voltage divider.

In order to obtain a readable photographic record of the steeply-rising front of the surge, it is necessary to utilize a high-intensity electron beam for recording. Several methods have been used to increase the beam intensity, and thus the writing speed, of this type of oscillograph. For example, some research workers have used prefocusing coils around the discharge tube, and others have reshaped the electrodes or employed different gases in the discharge tube. None of these methods, however, has been entirely successful, and until now the normal writing speed of the instrument has been only about 200 ins. per microsecond. As part of a general program of basic instrumentation sponsored by the Office of Naval Research, the Office of Air Research, and the Atomic Energy Commission, the Bureau of Standards undertook to develop a more effective technique for intensifying the beam. A method has been found which increases the beam intensity over the steady-state value by as much as 50 times.

With this method, a momentary pulse having a peak value of about 2,000 volts is superimposed on the steady DC voltage, about 30 kv, applied normally to the discharge tube. The pulse must be of very short duration, down to about 5 microseconds, and it must produce a sudden increase in the voltage across the tube in ½ microsecond or less. This sudden change in voltage, even though it be only 2% of the steady voltage across the discharge tube, disrupts equilibrium conditions in the tube momentarily, and produces a greatly-intensified electron beam for about 2 microseconds.

The increased beam current lasts for such a short time that it does not increase appreciably the heat dissipation of the discharge tube, nor cause burning

(Concluded on page 59)
BEAM INTENSIFICATION

(Continued from page 38)

at the cathode. However, careful synchronization with the start of the sweep is required.

Application Methods:

Two principal means for applying the pulse have been developed and are being used. In one method, a current pulse is passed through a resistor inserted between the anode of the discharge tube and the ground-return lead. This causes a similar voltage pulse across the tube, which results in a sharp increase in the intensity of the electron beam. Alternatively, the cathode is connected to one terminal of a small high-voltage capacitor, and the other terminal is connected to ground through a resistor. Because of the steady direct-current voltage on the cathode, this capacitor is charged to 50 kv. When a current pulse is passed through the resistor, the cathode voltage is changed immediately by the IR drop through the resistor. This produces a very rapid change in the intensity of the beam.

A method of synchronizing the start of the beam intensification with the start of the sweep has been devised by NBS and used successfully with sweep speeds up to 60 ins. per microsecond. These fast sweeps were used to obtain records of the voltage oscillations occurring when the deflecting plates were short-circuited after being charged to a high voltage. Although this procedure deflected the electron beam from the top to the bottom of the film record in about the shortest time possible, a readable trace was recorded on the film. This trace was found to correspond to a writing speed of 9,100 ins. per microsecond, or three-fourths the velocity of light.

It is probable that writing speeds greater than the velocity of light could be obtained with this technique, if the deflecting system of the oscillograph were designed with that objective in mind. Since the current in the discharge tube is maintained at a steady low value except for the very short time required to obtain the record, the problems of beam adjustment and cathode life are of minor importance. In addition to its application with the high-voltage oscillograph, the new method should prove to be a useful tool for research in atomic physics, or wherever an electron beam of momentary high density is required.

PATTERN FOR TV PROFIT

Watch next month for the details of "Pattern for TV Profit," a series for management and engineering executives, to start in the March issue.

January, 1952—formerly FM, and FM Radio-Electronics
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These new instruments represent a high level of precision design and versatility of application at remarkably low cost. Major features that are common to all three instruments include:

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**PIPELINE RADIO**

(Continued from page 21)

Emergency maintenance for the equipment of both companies, and for special test work and installations. These repair facilities are based at the Company headquarters in Los Angeles.

Because of the steep grades and rough terrain on the approaches to the mountain top repeater stations, it has been necessary to obtain a 4-wheel drive station wagon for carrying supplies to these points on regular maintenance trips. This vehicle, shown in Fig. 12, is equipped with a 30-watt 2-way radio installation.

Fig. 13 is another view of the mobile field service truck, shown also on the front cover. The gasoline engine-driven generator is used to supply power for the test instruments when outside AC power is not available. The equipment on the truck includes a frequency monitor, a Motorola test set, a capacitor checker, a tube checker, a signal generator, multi-range volt-ohmeter, vacuum-tube voltmeter, tool boxes and spare parts. This truck is also radio-equipped.

Figs. 14 and 15 show the completely-equipped and shielded maintenance room at the Los Angeles headquarters. Here, receivers can be tested without interference from electrical disturbance within the building, and transmitters can be operated without interference to others on the same channel. The room is surrounded entirely by two insulated layers of fine screening.

**MAGNETIC AMPLIFIER**

(Continued from page 14)

the slope of the loop from point 1 to point 3, Fig. 3B. That slope is not necessarily related to the permeability of the material. As a rule, however, materials of high permeability do have desirable characteristics in that region. Generally, the high-permeability permalloy type materials are used for applications requiring high sensitivity.

The shape of that very important section of the hysteresis loop is affected by many factors. Eddy currents or other sometimes unpredictable factors may cause bumps on the curve which destroy linearity of control or even cause amplifier instability. Normally, these troubles can be avoided by judicious selection of the core material and by heat treatment. For high-frequency work, cores of extremely thin materials are required. Such cores are now available commercially in thicknesses down to only one-eighth of one mil, or .000125 in.

**Factors of Response:**

The magnetic amplifier described cannot

*(Concluded from page 41)*
give instantaneous response to step changes in voltage applied to the control circuit. Some delay is caused by inductive lag in the control circuit, and by damping effected by other coupled circuits. Then, too, there is an inherent response lag, because the flux level must be set during the half-cycle prior to the conductive half-cycle. The delay associated with the L/R figure of the control circuit can be improved by adding series resistance. That is a waste of power, however. The best approach is to use as much positive feedback as is possible, and to minimize the number of turns required in the control windings.

For a typical simple magnetic amplifier, a delay of about 300 cycles of the carrier frequency can be expected for 68% response with a power gain of 1 million. That figure can be improved significantly by the use of rate circuits in feedback networks. Because of a logarithmic delay-gain relationship, it is advantageous to employ several low-gain stages, rather than a single high-gain stage. For example, a gain of 1 million can be achieved in two stages with a resulting over-all response of only a few cycles of the carrier frequency. Also, since this delay is an inverse function of the carrier frequency, it is advantageous to employ a higher carrier frequency. Ten cycles of a 60-cycle carrier consume over 150 milliseconds. With a 10-kc. carrier, they take up only 1 millisecond. These are approaches employed which make possible the application of magnetic amplifiers to high-performance servo and other regulatory systems.

Conclusion:

The magnetic amplifier is not, at the present time, useful for all amplifier and control problems. However, it has become extremely valuable in many applications, and it is being put to new uses every day.

Present categories of application include instrument amplifiers, servo amplifiers, motor speed controls, voltage regulators, lighting intensity controls, battery charging controls, mechanical rectifiers and contact converters, computers, memory or information-storage systems, and special-purpose audio and video amplifiers. The magnetic amplifier is especially valuable in military applications, where long life and reliability are required under operating conditions of tremendous shock and vibration. It is in this field that the device is now finding widest acceptance. It is difficult to predict to what extent it will be useful in communication systems, but work is already being done in that field.
DESIGN OF CROSSOVER NETWORKS

PART 1 — PURPOSE OF CROSSOVER NETWORKS — TYPICAL CIRCUITS — CHARTS OF COMPONENT VALUES — OPTIMUM CROSSOVER POINTS — By SOL WHITE

UNDOUBTEDLY, the crossover network is responsible for more arguments and confusion among designers and users of high fidelity equipment than any other system component. While a great deal has been written on the subject, much of the available information consists of loosely formed opinions and conclusions which tend only to add to the confusion. This article is intended to provide practical, helpful data on the subject, with capsule appraisals of the various factors involved in the selection of optimum circuit constants, as well as design charts which have been simplified as much as possible. The material presented here is the result of extensive objective and subjective research by University engineers.

Functions of Crossover Networks:

When two or more speakers are employed in a reproducing system, it is advantageous to feed to each speaker only those frequencies which it is designed to reproduce. Of course, speakers designed to handle various ranges could be simply connected in parallel, with no attempt made to limit the frequency range fed to each speaker. Such a practice may produce results acceptable to non-critical listeners, but the performance would be inferior by far to what can be obtained from the same speakers operated with a suitable dividing or crossover network. The advantages obtained by channelling the various frequency ranges to the proper speakers are summarized as follows:

1. Elimination of double sound-sources, with their attendant frequency cancellations. Such dead spots are caused by differences in path lengths between the listener's ear and two speakers which reproduce the same frequencies.
2. An increase of about 3 db in acoustic output, since high-frequency power is not dissipated as heat in the woofer voice coil, and low-frequency power is not wasted in the tweeter driver.
3. Prevention of damage to the tweeter diaphragm from excessive low-frequency power.
4. Greatly reduced intermodulation.
5. Prevention of cone breakup at high signal levels. Since the first breakup occurs at about 2 kc, cleaner high-level reproduction is obtained if frequencies in this region and above are diverted from a cone speaker to a tweeter.
6. An impression of spatial sound generation when the sources of lows and...
cutoff rates given above are valid only for amplifiers with constant output voltage. When the networks are used with amplifiers having poor regulation, the attenuation rates are decreased.

These circuits are of parallel constant-resistance networks. The series configuration is not shown, in order to avoid confusion and because the series circuits have a disadvantage explained later.

Networks having cutoff slopes greater than 12 db per octave may have certain theoretical advantages. On the basis of listening tests, however, their complication and expense are not warranted, since perceptible distortion may be produced by them.

Single-Element Networks:
A chart for determining the values of L and C for the single-filter-element network, Fig. 1, is given in Fig. 1. Selection is made on the basis that the reactance of C1 is equal to that of the tweeter voice-coil at its crossover frequency, and the reactance of L1 is equal to that of the woofer at its crossover frequency.

In the case of a 2-way system, these frequencies are the same. If both voice-coils are of the same impedance, then the input impedance of the network is equal to that of one speaker. But if the tweeter impedance is not the same as that of the woofer, then the input impedance is equal roughly to the average of the two voice coil impedances, and the network should be connected to the amplifier output tap closest to this mean value.

When a 3-way system is planned, the value of L1 is found for the woofer impedance at the low crossover frequency. Then, C1 and L2 are found for the tweeter and mid-range speaker impedances, respectively, at the high crossover frequency. Finally, C2 is found for an impedance halfway between that of the tweeter and the mid-range speaker, at the low crossover frequency. The input impedance of the network is then the mean between the woofer impedance and the value used for calculation of C2.

Fig. 4 can be used to find the values of L and C in the following way: First, find the diagonal lines corresponding to the desired crossover frequency and the voice-coil impedance concerned. Where these lines intersect on the chart, read the value of L corresponding to the height of the intersection, at the left side of the chart, or the value of C corresponding to the horizontal location of the intersection, at the bottom of the chart.

Two examples should make this procedure quite clear. Suppose that a 4-ohm
SPOT NEWS NOTES

(Continued from page 9)

Latimer, who began his career with the Marconi Company in 1916, joining RCA when it was formed in 1919. Mr. Latimer has now been appointed vice president and chief technical consultant of RCA Communications.

Standard Ceramic Parts:

A 52-page catalog, detailing over 500 standard steatite parts, has been issued by Stupakoff Ceramic & Mfg. Company, Latrobe, Pa. Dimension drawings are given of coil forms, bushings, separators, standoffs, insulators, and similar items. A 9-page section on standards and testing is included.

Color-Code Chart:

A very elaborate wall chart is offered to engineers by the Centralab Division of Globe-Union, Inc., Milwaukee, Wisc. It shows the standard coding for transformers, battery cables, antenna and ground leads, telephone switchboard cable, RTMA and JAN mica, paper, and ceramic capacitors, resistors, speakers, and radio and TV chassis.

FM SET PROMOTION

Final plans for the pilot run of the FM receiver promotion campaign in North Carolina, jointly sponsored by RTMA and NARTB, were approved on December 27.

Promotional material prepared for this event includes 4-color window and counter displays, a set of 16 transcribed spot announcements, detailed plan books, and brochures for distributors and dealers. RTMA and NARTB will supply news releases to the local papers, and will carry a mail campaign directed to officials of schools and civic organizations, county agents, and clergymen.

E. Z. Jones of WBBB, pioneer FM broadcaster in Burlington, N. C., and chairman of the FM promotion committee for his state, said that the North Carolina stations will carry 10 or more industry spots each day without charge, that free mention will be made of dealers who conduct FM demonstrations, that the stations will offer special FM program features, and will supply dealers and newspapers with advertising pieces and program logs. This was confirmed by Earl Gluck, WSOO Charlotte.

Similar test campaigns will be started in Wisconsin on February 4, and in Washington, D. C., on March 1. Additional information can be obtained from John H. Smith, Jr., FM director of the National Association of Radio and Television Broadcasters, 1771 N Street, N. W., Washington 6, D. C.
G. A. Crossover Networks for Multiple Speaker Systems

By a judicious selection of associated components, the three coil sizes on which G.A. has standardized enable our customers to secure low-cost crossover networks which will operate at 14 different crossover frequencies! For the experimenter, that means a wide range of choice without having to break the bank to buy dozens of coils. For the man who wants to install his system once and for all, it means money saved, because G.A. saves money by making only three coil sizes (10.2, 5.1, and 1.4 Mh) — and it passes on those savings direct to its customers. Where else can you buy a big 10.2 Mh air-core choke, of No. 17 wire, for only $10.00? Here are the combinations possible with G.A. networks:

**RAPID ATTENUATION NETWORKS**

12 db drop per octave. These networks use two inductance coils.

<table>
<thead>
<tr>
<th>Impedance of low frequency Crossover Frequency Number</th>
<th>Order by 3 C0ils</th>
<th>Price Only</th>
<th>Complete*</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 ohms</td>
<td>2,000</td>
<td>$7.00</td>
<td>$11.50</td>
</tr>
<tr>
<td>1,100</td>
<td>2,700</td>
<td>$12.00</td>
<td>$20.00</td>
</tr>
<tr>
<td>700</td>
<td>3,300</td>
<td>$12.00</td>
<td>$25.00</td>
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<tr>
<td>350</td>
<td>4,100</td>
<td>$12.00</td>
<td>$30.00</td>
</tr>
<tr>
<td>175</td>
<td>5,100</td>
<td>$20.00</td>
<td>$40.00</td>
</tr>
<tr>
<td>8 ohms</td>
<td>1,100</td>
<td>$12.00</td>
<td>$20.00</td>
</tr>
<tr>
<td>550</td>
<td>2,100</td>
<td>$12.00</td>
<td>$24.00</td>
</tr>
<tr>
<td>350</td>
<td>3,300</td>
<td>$12.00</td>
<td>$25.00</td>
</tr>
<tr>
<td>175</td>
<td>4,100</td>
<td>$20.00</td>
<td>$30.00</td>
</tr>
<tr>
<td>85</td>
<td>5,100</td>
<td>$20.00</td>
<td>$40.00</td>
</tr>
</tbody>
</table>

**SLOW ATTENUATION NETWORKS**

4 to 6 db drop per octave. These networks use one inductance coil.

<table>
<thead>
<tr>
<th>Impedance of low frequency Crossover Frequency Number Only</th>
<th>Order by 1 Cell</th>
<th>Price Only</th>
<th>Complete*</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 ohms</td>
<td>1,600</td>
<td>$3.50</td>
<td>$5.50</td>
</tr>
<tr>
<td>500</td>
<td>2,200</td>
<td>$6.00</td>
<td>$10.00</td>
</tr>
<tr>
<td>250</td>
<td>2,700</td>
<td>$9.00</td>
<td>$15.50</td>
</tr>
<tr>
<td>8 ohms</td>
<td>800</td>
<td>$3.50</td>
<td>$5.00</td>
</tr>
<tr>
<td>250</td>
<td>1,100</td>
<td>$6.00</td>
<td>$10.00</td>
</tr>
<tr>
<td>125</td>
<td>2,200</td>
<td>$10.00</td>
<td>$15.50</td>
</tr>
<tr>
<td>85</td>
<td>2,700</td>
<td>$12.00</td>
<td>$20.00</td>
</tr>
</tbody>
</table>

* Complete networks include necessary capacitors and level controls. Be sure to indicate whether you want just the coils or the complete network.

We recommend buying the complete network since, in some cases, as much as 640 mfd. of capacitance is required.

If you want to use three speakers with crossover points at 350 and 1,100 cycles, for example, just order two of the networks listed above (for an 8-ohm system, with rapid crossover attenuation, it would be No. 6 and No. 8).

As most everyone has found out by now, G.A. is headquarters for crossover networks. As far as we know, we're the only organization stocking networks specifically designed for use with Air-Couplers.

The standard 350-cycle network is our No. 4 or 8. The slow attenuation network described in the May, 1951 issue of Radio Communication is our No. 17 or 19. To get a rapid attenuation network operating at 175 cycles, recommended for the corner or Triplex Air-Coupler, order our Nos. 5, 9, or 13.

**Air-Couplers**

We now have the new design, Dual Air-Coupler, described in Radio Communication for October and in the Winter issue of High-Fidelity, in stock and ready for immediate shipment.

And... big news... they are available either in knock-down form, ready for you to screw and glue together, or... completely assembled! Nothing for you to do but attach a 12-in. speaker to the back panel. Take your pick!

**KNOCK-DOWN DUAL AIR-COUPLER... only $34.50**

We've made a large production run on those, so we can keep the price down to the same low figure. Made out of solid 3/16-in. fir plywood, all pieces carefully and accurately cut.

**COMPLETELY ASSEMBLED DUAL AIR-COUPLER**

Only $47.50

If you haven't the time, tools, or inclination to lay out the parts, drill the screw holes, and put the kit together, then here it is, completely finished in a truly professional manner and ready to put into immediate service.

**Miscellaneous:** We continue to carry in stock...

Altex 400A-12-in. speakers, a beast buy under any circumstances, a must for Air-Couplers only $46.50; Peerless 5-3200 output transformers, $26.00; Peerless R-560A power transformers, $16.00; Peerless C-455A power chokes, $10.00 — a new supply of the English KE-66 tubes (specified for Williamsom amplifiers) has just been received; they're only $4.95 each. There's no exact U. S. equivalent.
NEW BOOKS


A truly comprehensive treatment of wave propagation above 30 mc, so written as to be invaluable as a reference book as well as a text. Subject matter is grouped in 9 independent sections, as follows: 1) Fundamental concepts and relations of currents and electromagnetic fields, 2) Space electromagnetic fields of elementary electric and magnetic dipoles, 3) Fundamental methods (of computation) used in electromagnetic theory, 4) Propagation characteristics, 5) Transmission lines and radiation, 6) Unobstructed space radiation, 7) Space radiation in the presence of electromagnetic obstructions, 8) Electromagnetic diffraction, and 9) Wave guides and cavities.

Despite (or perhaps, because of) the author’s 37 years of experience in this field, the text is written in an intense, positive manner that can be inspired only by tremendous enthusiasm and great authority. The reader profits therefrom.


Serving only as an introduction to the fundamental concepts of electricity and radio, but as a very good one, Mr. Seroggie’s book is lucidly and entertainingly written. Since no previous technical knowledge whatever is assumed of the reader, the book begins with the most elementary principles of electricity and radio, continues with the theory of tubes, transmitters, receivers, antennas, and power supplies, and ends with an introduction to transmission-line theory.

The fifth edition has been rewritten completely, with over 200 new illustrations. Of special value to the beginner is a section on symbols and graphs.


This book should be of genuine value to television servicemen, since it is estimated that from 85 to 90% of TV service work can be done in the customer’s home, and the margin of profit is greater than for shop work repair. Methods are described for diagnosing and rectifying typical troubles using only a VTVM, a capacitor test probe, and common sense. Four sections cover television receiver operation and layout, getting acquainted with strange receivers, judging set performance, and adjustment techniques without the use of instruments.
The importance of a completely moisture-proof electrical connector can scarcely be exaggerated. But in addition to this important characteristic, there are a host of other exclusive features that make Bendix Scinflex connectors outstanding for dependable performance. For example, the use of Scinflex dielectric material, an exclusive Bendix development of outstanding stability, increases resistance to flash over and creepage. In temperature extremes, from $-67^\circ F$ to $+275^\circ F$, performance is remarkable. Dielectric strength is never less than 300 volts per mil. If you want more for your money in electrical connectors, be sure to specify Bendix Scinflex. Our sales department will be glad to furnish complete information on request.

**PLUS**
- Pressure Tight
- Radio Quiet
- Single-piece Inserts
- Vibration-proof
- Light Weight
- High Insulation Resistance
- Easy Assembly and Disassembly
- Fewer Parts than any other Connector
- No additional solder required
Motorola microwave systems are in and working!

Including the world's first 1000-mile private operating system

Here is Experience that you can rely on!

Facing a healthy new demand for more serviceable and flexible communication facilities, responsible management turns to Microwave for the extension of communication facilities.

Use the Motorola Microwave circuit for telephone, teletype, telemetering, remote switching and general supervisory control applications.

Motorola is experienced in shaping the systems-design to meet the customers day-in-day-out operational problems.

More than 20,000 installations in the past ten years have proved the reliability of Motorola 2-way radio – and now more than 25,000 miles of Motorola Microwave operating circuits have proved the unquestioned reliability of Motorola Microwave Communications.

Make your new plant truly new all the way with Motorola Microwave.

Write for free booklet “The Motorola Microwave Story” and incidentally a Motorola engineer is ready to assist you with generous and thoroughly competent information.

Partial List of Microwave Systems

Aeronautical Radio Incorporated
State of California
Pan American Pipeline Co.
Shell Pipeline
Panhandle Eastern Pipeline Co.
Texas Illinois Natural Gas Pipeline Co.
Mid-Valley Pipeline Co.
Brazos River Electric Transmission Cooperative
City of Dayton, Ohio
Michigan State Police

Remember! Experience Counts
Especially in Microwave