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JUNE 1944

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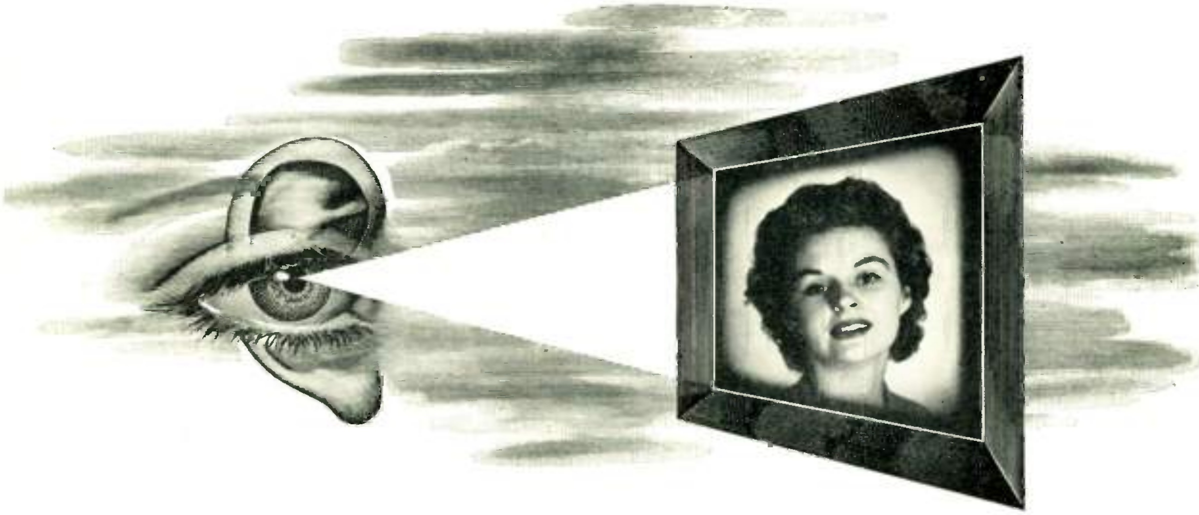

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The dollar sign is the answer. It completes the well-used television formula S + S, or Sight plus Sound, and it's a rather dramatic way of saying that television will bring profit to you.

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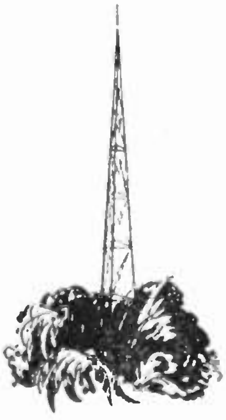
Instead of the silvery Seine — the murky Congo. Instead of well-tended fields and spotless villages — African jungle. Instead of a nation of Frenchmen — a handful of over-worked technicians and hundreds of African natives.

Yet here, three hundred miles up the Congo, is the true voice of France. Here at Brazzaville a gallant group of Free French brought in American equipment and erected one of the most powerful short-wave transmitters in the world. Every hour of the day, the voice of Free France thunders from Brazzaville, speaking in twenty different languages—spreading truth among the conquered peoples of the world—sending bulletins to the Free French fleet.

This tiny outpost is one of the most important voices of France —and Freedom—in the world.

H.R.O. receivers are standard equipment used exclusively in this station for monitoring and rebroadcasting. Brazzaville is the Voice of France, and these receivers are the Ears of Brazzaville.



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AMPHENOL—FRIEND OF YESTERDAY'S "HAMS"...

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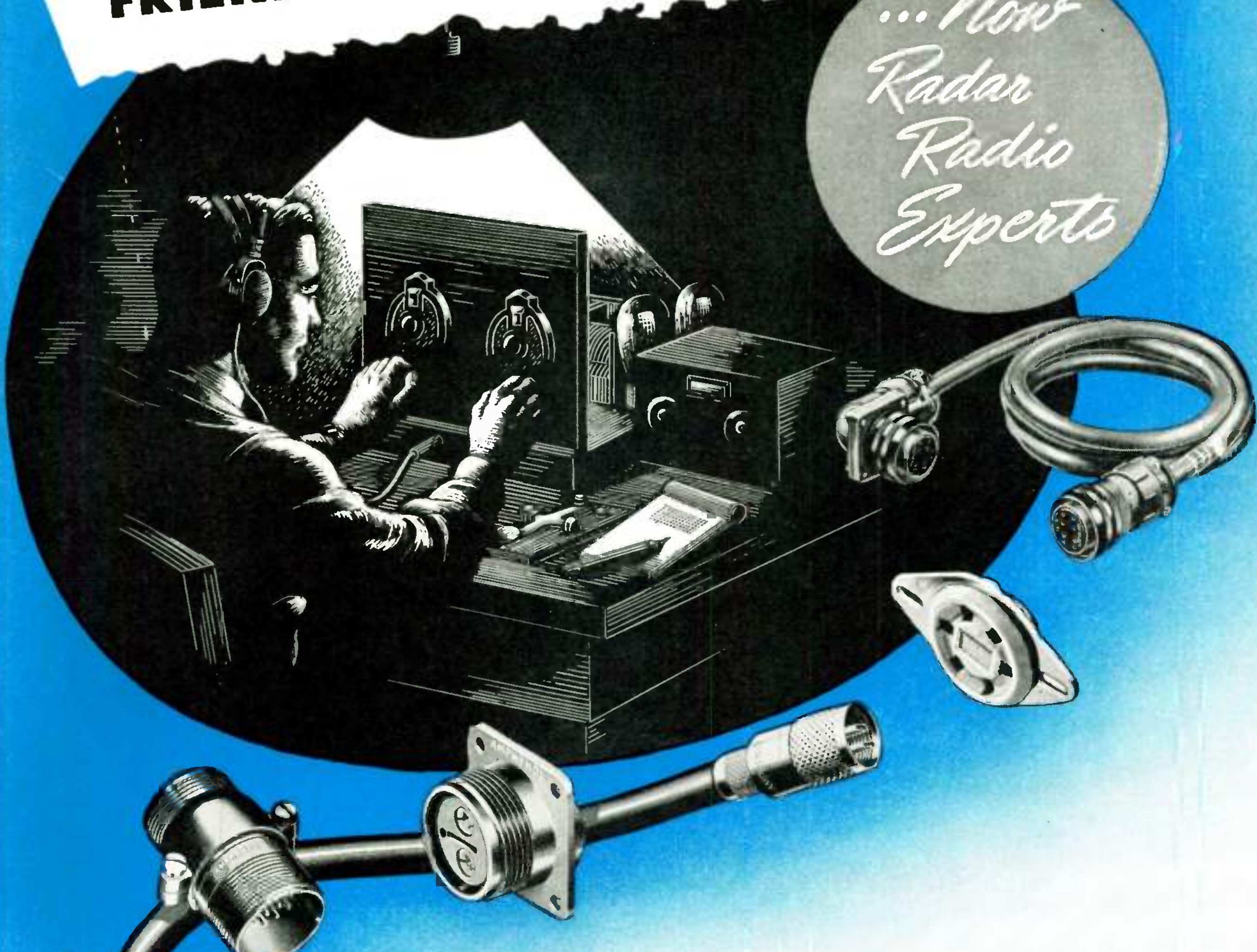

Back in the days when thousands of home basements sheltered embryo radio research laboratories, "Amphenol," stamped on a plug, socket or knob, meant a "good job." The "hams" learned the value of quality the *hard* way, and after the first disappointments saved their dimes and quarters to buy the better job identified by "Amphenol."

Now those "hams" are grown-up sergeants, ensigns, lieutenants, captains. They are communications officers, radio technicians, members of the secret radar fraternity, or concerned in some of the other wartime uses of electronics. Many of them are getting to foreign countries in person instead of by airwave. But wherever they are, "Amphenol" is with them—on cables, on wiring assemblies, connectors, sockets. To them Amphenol quality today has a new meaning, a more important personal dependability, in the electrical and electronics equipment they use in battle.

They will bring home their battle experience to the new radio sets, television, frequency modulation, the electronic and electrical developments to follow V-Day. Quality parts will be made by an equally war-seasoned and broadened Amphenol—a leader wherever electronic and electrical equipment are used.

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FM AND TELEVISION

FORMERLY: FM RADIO-ELECTRONICS

VOL. 4 | JUNE, 1944 | NO. 6

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MILTON B. SLEEPER, *Editor and Publisher*

WILLIAM T. MOHRMAN, *Advertising Manager*

GORDON CROTHERS, *Circulation Manager*

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The publishers will be pleased to receive articles, particularly those well illustrated with photos and drawings, concerning radio-electronic developments. Contributions will be neither acknowledged nor returned unless accompanied by adequate postage, packing, and directions, nor will FM Magazine be responsible for their safe handling in its office or in transit. Payments for contributions are made upon acceptance of final manuscripts.

THIS MONTH'S COVER

This lad is a talker on a baby flat-top, a part of the brains in a system of communications that has made his ship such a deadly weapon. If he could talk to us he might well say:

"We have radio engineers aboard who would have been deferred, too, if they had stayed at home. But because they left their jobs, you've kept yours. They were willing to put on the uniform. You weren't. If you read the papers, you know how well they're doing the job you didn't want.

"Sure, you're working hard, most of you, turning out some swell equipment. You're making money, too — much more than you've ever made before. Much more than we get.

"And that's all right with us. Only when we get back, we're going to ask: 'Did you buy all the Bonds you could while we were away?' And, boy, you'd better come up with the right answer!"

WHAT'S NEW THIS MONTH

2. Broadcasting Profits

1. On June 15th, first anniversary of operation under the FCC's much-contested Chain Broadcasting Regulations, Chairman Fly had this to say:

"Despite predictions of doom by network officials if the regulations became effective, broadcasting profits are higher now than ever before. Broadcasting stations as a whole earned 50% more, before income taxes, in 1943 than in 1942, and the networks profited similarly. Thus NBC, which in 1942 earned 137% on the value of its property, in 1943 earned a return, before income tax, of 190%. CBS went up from a 97% return in 1942 to a 158% return in 1943. The Blue Network went up from 8% to 149%, and the stockholders in the Mutual Network, on a combined basis, earned a return of 84% in 1943 as against 59% in 1942. Experience has now shown that the prophets of disaster were mistaken, and that the broadcasting industry can prosper as never before under our regulations."

Perhaps Chairman Fly is right. Perhaps the new setup under the network rules is responsible for these increased earnings, and perhaps the network officials who opposed them stood in their own light.

On the other hand, we are reminded that broadcasting revenue comes from the sale of time to advertisers, and that many accounts increased their 1943 appropriations substantially over 1942. Others bought radio advertising in 1943 who never used this medium before. The networks and some of the stations have been doing very smart promotional work.

Chairman Fly's statement is not supported by the figures he gave. They could be used to show that wartime conditions or more effective sales efforts have increased profits despite FCC regulations.

In either case, it is encouraging to find that the business of broadcasting shows such substantial gains. Data released by the FCC puts the "service income" of 796 stations at $46,481,379 for 1943. This figure is the total of broadcast revenue less broadcast expenses, but does not take account of Federal taxes. In 1942, the corresponding figure was $30,673,542.

Only 73 of the 796 standard broadcast stations reported a loss in 1943, compared to 171 in 1942, and 166 in 1941. The gain was well distributed, for 713 stations showed an increase in 1943 over 1942, while only 83 showed a decrease.

Sylvania Radio Tube "Firsts"

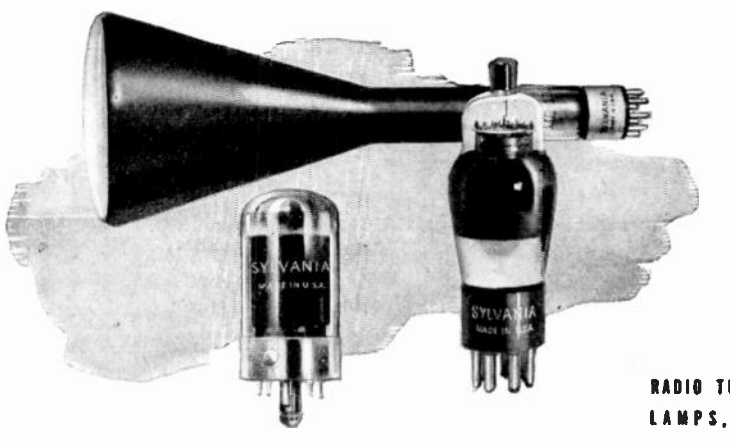
Sylvania was first to introduce a line of 1.4-volt tubes, which made the camera-type portable radio the rage of 1938 and later contributed to our military radio service.

Prior to this Sylvania development, the standard filament voltage for battery receivers was 2.0. This meant that two dry cells had to be connected in series to provide 3 volts. This power was reduced to 2.0 volts by means of a resistor, which dissipated one-third of the expensive voltage.

Sylvania 1.4-volt tubes operated, without resistor, on a single dry cell. Their low filament drain made it possible to build combination receivers that took their power from either a 110-volt power line or a single dry cell.

This development, which is typical of Sylvania's leadership in engineering of economical standardization, went to war in portable radio equipment for close-range military communication. On every front 1.4-volt tubes reduced by half, the battery weight that our boys have to carry.

Quality that Serves the War Shall Serve the Peace



RADIO DIVISION — EMPORIUM, PENNSYLVANIA

SYLVANIA
ELECTRIC PRODUCTS INC.

RADIO TUBES, CATHODE RAY TUBES, ELECTRONIC DEVICES, FLUORESCENT LAMPS, FIXTURES AND ACCESSORIES, INCANDESCENT LAMPS

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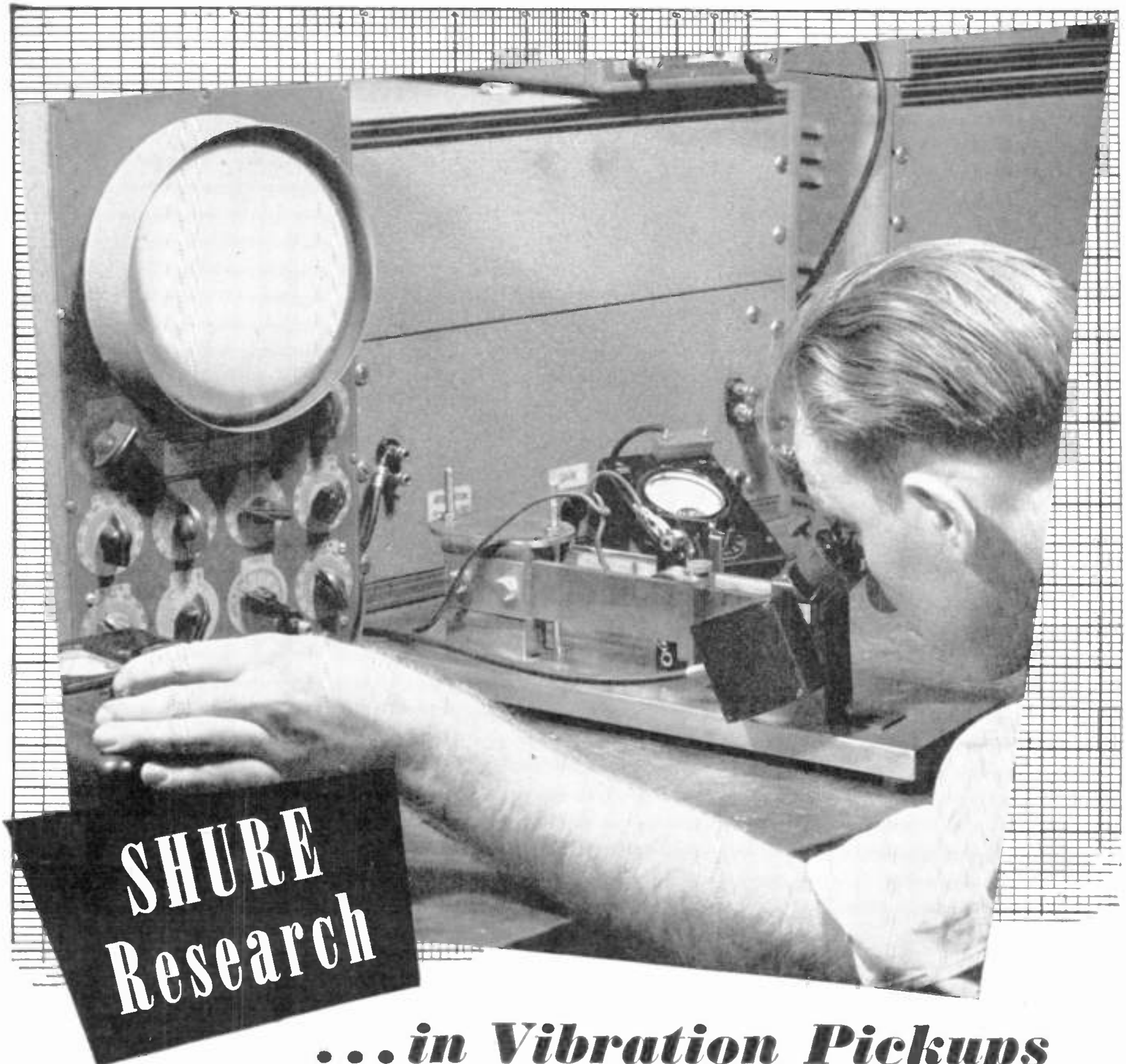

...in Vibration Pickups

Shure research has pioneered in the development of vibration measuring instruments. These instruments are important in the determination of leakages in water pipes, the vibration of machinery, buildings, electrical appliances. Among its many uses, vibration pickups have been successfully used in locating termite infested wooden members. Shure engineers have devised special vibration actuators and special standard pickups capable of measuring vibration accurately throughout the greater part of the audio frequency range. Another significant contribution is the development of integrating networks which permit the measurement of either acceleration, velocity or displacement with a single Vibration Pickup.

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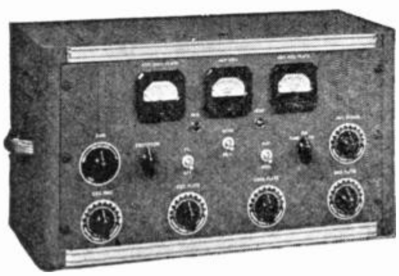

HARVEY UHX-25

A 25-Watt General Purpose Radio Telephone Transmitter

Available for operation between 1.5 M.C. and 30 M.C.

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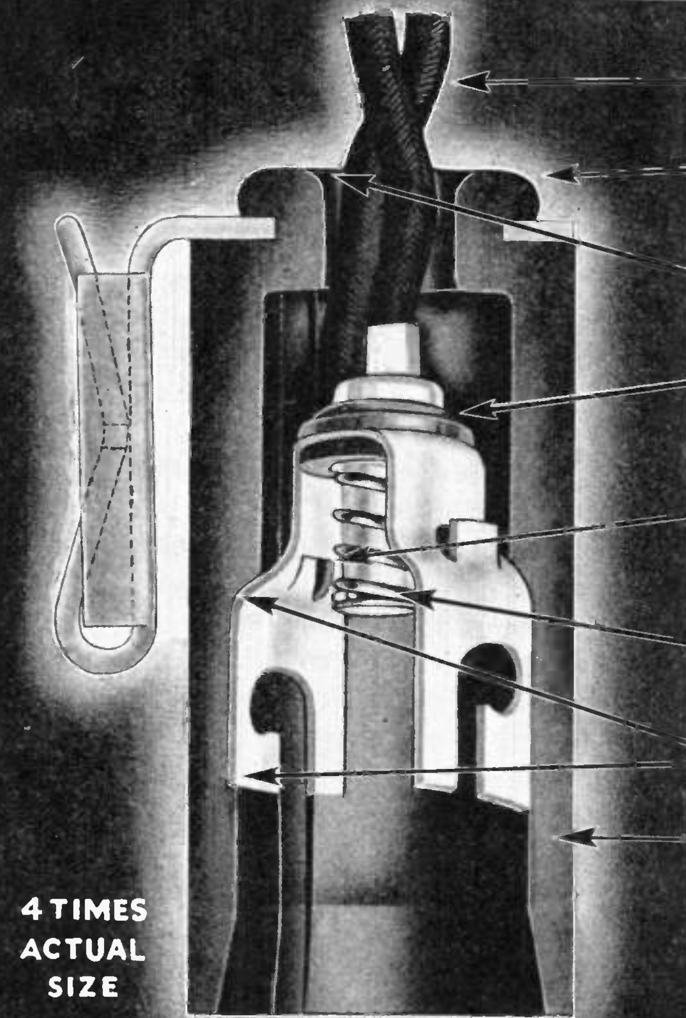
FOR I-F AND AUDIO AMPLIFICATION

a New and Superior DIAL LIGHT SOCKET



Tensile strength of leads and connections far in excess of requirements.

Tough, plastic shell molded around bracket providing a secure bond with mechanical strength far beyond any normal requirement.

Rounded edge will not cut or fray wire insulation.

Voltage Breakdown between contacts—1200 Volts. Voltage Breakdown to ground—5000 Volts.

Lug on contact fits in groove in shell so that contact cannot be turned or twisted when inserting lamp.

Center contact mounted so that it cannot protrude from shell and short on chassis when lamp is removed.

Plastic shell is recessed for contacts, which cannot be pushed or pulled out of position.

Stronger, tougher, heavy walled plastic shell.

A variety of different mounting bracket styles available, suitable for practically any mounting.

For Your Present and Post-War Production

Lenz Dial Light Sockets have always been known for their superior mechanical qualities and electrical characteristics.

Now these sockets are still further improved, with even greater mechanical strength. A stronger, tougher plastic shell is attached to the bracket with a new type of construction that provides a virtually unbreakable bond between shell and bracket. Its excellent electrical characteristics are maintained.

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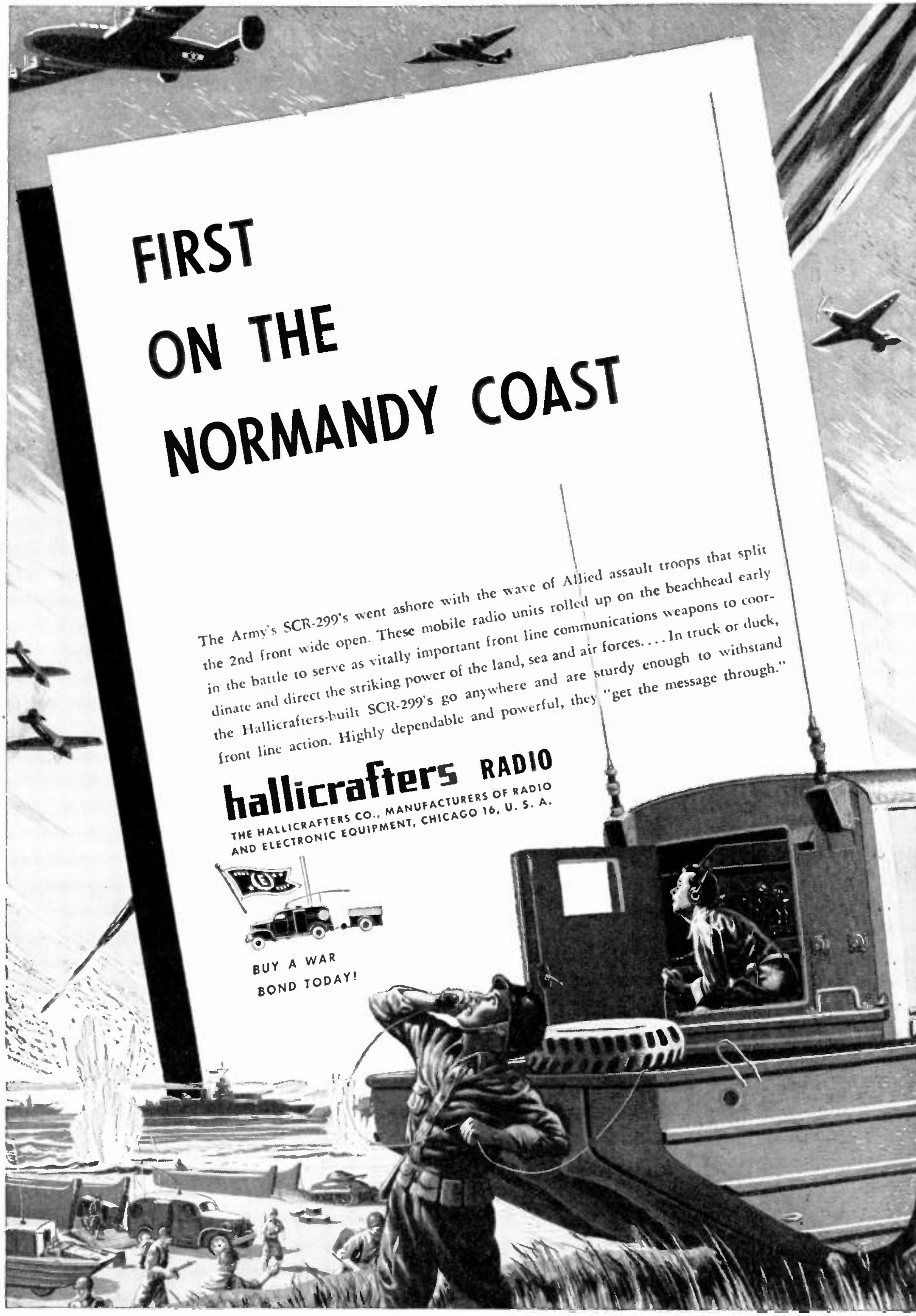
FIRST
ON THE
NORMANDY COAST
The Army's SCR-299's went ashore with the wave of Allied assault troops that split the 2nd front wide open. These mobile radio units rolled up on the beachhead early in the battle to serve as vitally important front line communications weapons to coordinate and direct the striking power of the land, sea and air forces. . . . In truck or duck, the Hallicrafters-built SCR-299's go anywhere and are sturdy enough to withstand front line action. Highly dependable and powerful, they "get the message through."
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THE HALLICRAFTERS CO., MANUFACTURERS OF RADIO AND ELECTRONIC EQUIPMENT, CHICAGO 16, U. S. A.
BUY A WAR BOND TODAY!

A WAR INDUSTRY LOOKS AHEAD TO PEACE

An Address Delivered at the Chicago Meeting of the Radio Manufacturers Association on June 7th

BY PAUL V. GALVIN*

TODAY we assemble for the third time at an annual membership gathering in full war production. It hardly seems that long ago since we ceased civilian set production. Many things have happened in such swift succession since then that in reality our civilian activity seems almost like a dim picture in our memory.

Our war production job is still our number one concern. The industry can be mighty proud of its war production job so far. We propose to keep at our war job with all our might to the very end, and conclude with an enviably fine record in serving our Armed Forces.

Founding of R.M.A. ★ It might be of interest to us all that, today, on the twentieth birthday of R.M.A., we go back into the past and briefly cover the origin of our Association. No doubt very few of us are familiar with the details, but we should be interested in knowing them.

On May 5, 1924, a handful of companies — nine in all — met at the Sherman Hotel in this city for the purpose of organizing an effort to oppose the first Federal excise tax on radio. They founded what they chose to call the "Associated Radio Manufacturers." This later was changed to the "Radio Manufacturers Association" incorporated under an Illinois charter. The nine companies were Howard Radio Company, Carter Radio Company, Rauland Manufacturing Company, Belden Manufacturing Company, Bremer-Tully Manufacturing Company, Trimm Manufacturing Company, Winkler-Reichmann Company, Sleeper Radio Company, and Herb Frost. Herb Frost was elected the first president and the first Board of Directors included J. MacStone, Phil Lenz, Austin Howard, Nick Carter, Norm Rauland, and Frank Reichmann. Others active in the organization included John Tully, Don MacGregor, Dick O'Connor, and Ed Riedel.

The founding fathers each contributed a loan of $50.00. The Directors each contributed a loan of $250.00. I am not familiar with the facts, but no doubt these gentlemen have long since charged off these loans on their income tax returns.

By the following year, the membership had increased to sixty. The membership has gone up and down with the fortunes of the industry, being up close to 300 prior to the break in 1929. It went down in the thirties, and today we have over 200 members which is the largest membership since the R.M.A. trade show era.

A study of the roster of membership over these years brings to mind all of the interesting names in radio manufacturing history — some have come and gone — many whose names glowed with great brilliancy across the entire horizon of the industry. Many have entered to find a place for themselves, and have grown and are still with us.

Status of the Industry ★ The radio manufacturing industry is just another one of those many chapters in American competitive economy where men with stout hearts, vision, technical ingenuity and merchandising capacity battle for the market for the purpose of building a business, in the spirit of competition and coöperation — a game where Mr. John Q. Public is the sole judge as to who remains in the play and who drops out.

The American radio manufacturing industry is a splendid example of the free enterprise system at work. We have no monopolistic cartel umbrella comfortably protecting our activities. We have no industry price control set-ups. We have no quota limitations on production. We have large and small companies competing for the same market — the little fellow many times licking the big fellow to a standstill. We have efficient mass production — a great array of specialist manufacturers, each doing his job in a highly efficient manner, serving his part of the broad pattern. We have scores of component manufacturers serving set manufacturers. We have stiff but fair competition, volume sales, low prices with small unit profit, high quality, and a tremendous value.

Conversion to Peace ★ When the war is over, we want to return to the American competitive economy at the earliest possible moment. We believe that some war controls will be necessary for a period after the war to assure orderly distribution of materials and goods, but these should be eliminated as soon as possible.

Looking back over the industry war record, we took our cue for action from President Roosevelt in the summer of 1940. Thereafter, though continuing our civilian business until the spring of 1942, we planned and coöperated in the orderly implementation of our industry into increased war production. Excellent planning and coöperation between the industry, the military services, and the War Production Board at that time permitted orderly transition from civilian to war production with practically no loss of time of our employees in our plants, and relatively small loss in obsolescence in inventory.

We have now been in high-gear war production for some time. Each firm has found its position in the broad scheme of things — we are in the groove and we are delivering.

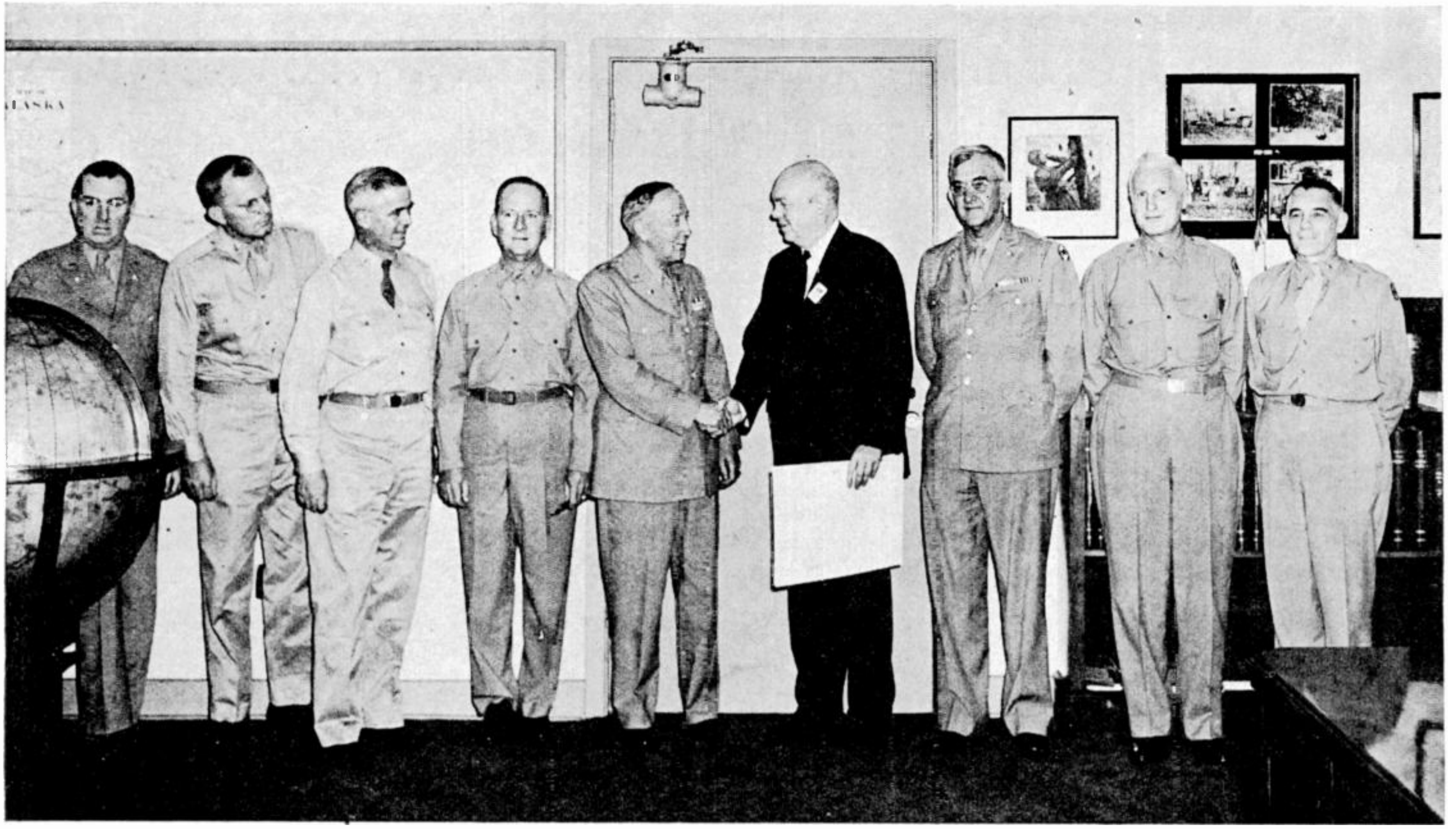
We all know that some day we will go back to civilian production, and when we resume civilian production we will then take on just as important a responsibility to our civilian economy as we now bear to our war economy. Up to now, the industry has done very little post-war planning. We have been too busy with our war job. I think we can again take our cue from President Roosevelt, who has made some recent public utterances pointing up post-war planning. I can see where we can do some work in this direction without being distracted from our war job.

When the German phase of the war is closed, the military people will no longer need all of our facilities or workers for war work. When that time arrives, we should be fully prepared to quickly turn to some civilian production to keep our people working. Our model designing should be all ready for production when we get the green light to go into civilian activity. Our merchandising plans should be fully prepared and ready for execution.

Although it does not seem likely that we will be shipping any civilian radio sets until some time in 1945, nevertheless, I think it is well in order that the industry, in conjunction with officials of WPB, work out an orderly program setting forth just how the WPB Limitation Order will be altered — after the German war has been concluded — permitting our re-entry into some civilian production while we are still continuing our military production requirement for the Japanese war. We all know this will result in some form of an allocation. It will be "X" numbers

(CONTINUED ON PAGE 61)

* Retiring president of the Radio Manufacturers Association, and president of Galvin Manufacturing Corporation, 4545 Augusta Boulevard, Chicago, Ill.



MAJOR GENERAL INGLES, CHIEF SIGNAL OFFICER, PRESENTS AWARD TO DR. ARMSTRONG. NAMES OF OTHER OFFICERS APPEAR BELOW

NEW SIGNAL CORPS AWARD TO FM INVENTOR

First "Certificate of Appreciation" Presented to Dr. Edwin H. Armstrong at Pentagon Ceremony

ANOTHER honor was added to the many that have been bestowed upon Major Edwin H. Armstrong when, on June 17, he received the first Certificate of Appreciation to be awarded by the Signal Corps.

This award was presented by Major General Harry C. Ingles, Chief Signal Officer of the U. S. Signal Corps, at a brief ceremony at the Pentagon Building. General Ingles said:

"Dr. Armstrong: It is with deep gratitude and respect that the Signal Corps presents to you this Certificate of Appreciation, and an appropriate emblem, in recognition of the important and unselfish services you have rendered the Army and the Nation during two wars.

"Those of us who have been associated with you through the years know how unsparingly you have contributed your talents and your time to the development of Signal Corps equipment which is now proving its superiority on every front. We recall that you perfected the superheterodyne receiver during the first World War and your more recent waiver of royalties on your Frequency Modulation patents is still fresh in our memories. In addition, you have undertaken vital contract development work for the Signal Corps and given generously of your knowledge and advice in the conduct of many experiments.

"Your patriotism and your accomplishments have been an inspiration to all of us, and I most sincerely wish for you many more years of devoted service to our Country."

The Signal Corps officers in the photograph above who took part in the ceremony were, from left to right, Colonel J. D. O'Connell, assistant to General Colton; Brigadier General Frank C. Meade, Director, Plans and Operations, Office of the Chief Signal Officer; Colonel W. Preston Corderman, C. O. Arlington Hall Station; Brigadier General Jerry V. Matejka, Chief Personnel and Training Section; Major General Harry C. Ingles, Chief Signal Officer; Major Edwin H. Armstrong; Major General Roger B. Colton, Chief, Engineering and Technical Section; Major General William H. Harrison, Chief, Procurement and Distribution Service; and Major General James A. Code, Assistant Chief Signal Officer.

Dr. Armstrong held the rank of Major in the A.E.F., and worked on the development of the superheterodyne in England and France. The immediate purpose of this work was to make available supersensitive equipment for listening in on German radio communications, particularly on the battle fronts.

So successful was the superheterodyne that messages from the German Fleet, indicating a change of position, were reported to the British Admiralty shortly before the Battle of Jutland. The report was discredited, however, because the Admiralty Office did not believe it possible to hear messages transmitted from one German ship to another. As subsequent events showed, the German Fleet had moved, and if that warning had been heeded, there would surely have been a different outcome to the Battle of Jutland.

The perfection of the superheterodyne came too late to be used widely in World

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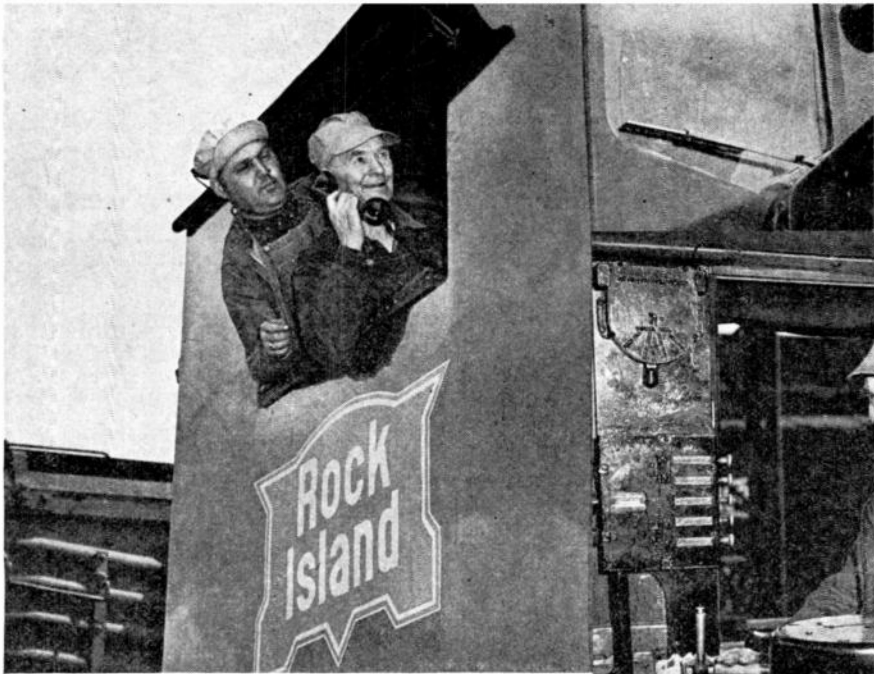

FIRST OF THE ROCK ISLAND'S 2-WAY FM INSTALLATIONS ARE FOR USE BETWEEN DISPATCHER'S OFFICE AND SWITCHING ENGINES. CONVENTIONAL METHOD IS TO SEND COURIERS ON FOOT TO DELIVER MESSAGES TO THE ENGINEERS

FM FOR RAILROADS HIGHLY SUCCESSFUL

Rock Island Road is Making First Installations on Diesel Switching Engines at Burr Oak Yards

MORE of what FCC Chairman Fly calls "policy conclusions under the cloak of technical observations" was expressed in a recent letter to the Kilgore Senate subcommittee on War Mobilization by W. R. Triem, general superintendent of telegraph of the Pennsylvania Railroad.

Denying that the two catastrophic railroad wrecks that occurred last year, resulting in the death of nearly 200 passengers, could have been avoided by the use of radio telephone communication, Mr. Triem said: "The railroads are charged with negligence for not using a method of communication which has not yet been developed to the point of practical usability, and the helpfulness of which, in the two selected cases, would have almost certainly been nil."

That is an amazing statement in view of the fact that in recent months the Pennsylvania has been very busy with a test installation of carrier current equipment [1] which was developed long before 1943, but did not give the performance of present-day FM radio equipment. The only apparent reason for trying to use something now that was found inadequate long ago is to becloud the issue of applying FM radio to railroad communications.

With the whole radio industry tied up tight on military production, no fair-minded person would criticise the railroads in general or the Pennsylvania in particular for not having installed radio communication prior to last fall.

The general use of radio by the railroads must be considered as a postwar project of considerable magnitude. Plans for installing complete radio communication on any road will require extensive preliminary study, followed by test installations before such systems can be put in operation. Supervisors and maintenance men must be trained, and crews instructed in the use of the equipment. This calls for new rules and regulations which can be drawn up only after the exhaustive consideration of all conditions and emergencies which may be encountered.

The development of Frequency Modulation, by which the use of radio is made possible and practical on the railroads, is too recent for it to have been put to use in this application.

However, Mr. Triem does lay himself open to the most severe criticism when he says that, in the two wrecks last year, the value of radio communication "would have almost certainly been nil."

It is not conceivable that the general superintendent of telegraph for one of the world's greatest railroads could be so intellectually limited as to believe that statement. On the other hand, the whole record of technical progress is a running account of eliminating men in positions of authority who stubbornly maintained the attitude: "I wouldn't believe it, even if it was so!"

And there are today certain railroad officials, particularly those concerned with communications and signaling, who, through personal prejudice or selfish reasoning, are prepared to resist the use of

(CONTINUED ON PAGE 27)

[1] *Not Radio*, *FM* Radio-Electronics, Page 24, March, 1944.

The original disclosure of

FREQUENCY MODULATION BROADCASTING

A Method of Reducing Disturbances in Radio Signaling By a System of Frequency Modulation

BY EDWIN H. ARMSTRONG*

PART I

IT IS the purpose of this paper to describe some recent developments in the art of transmitting and receiving intelligence by the modulation of the frequency of the transmitted wave. It is the further purpose of the paper to describe a new method of reducing interference in radio signaling and to show how these developments may be utilized to produce a very great reduction in the effects of the various disturbances to which radio signaling is subject.

Historical Notes ★ The subject of frequency modulation is a very old one. While there are some vague suggestions of an earlier date, it appears to have had its origin shortly after the invention of the Poulsen arc, when the inability to key the arc in accordance with the practice of the spark transmitter forced a new method of modulation into existence. The expedient of signaling (telegraphically) by altering the frequency of the transmitter and utilizing the selectivity of the receiver to separate the signaling wave from the idle wave led to the proposal to apply the principle to telephony. It was proposed to effect this at the transmitter by varying the wave length in accordance with the modulations of the voice, and the proposals ranged from the use of an electrostatic microphone associated with the oscillating circuit to the use of an inductance therein whose value could be controlled by some electromagnetic means. At the receiver it was proposed to cause the variations in frequency of the received wave to create amplitude variations by the use of mistuned receiving circuits so that as the incoming variable frequency current came closer into or receded farther from the resonant frequency of the receiver circuits, the amplitude of the currents therein would be correspondingly varied and so could be detected by the usual rectifying means. No practical success came from these proposals and amplitude modulation remained the accepted method of modulating the arc. The various arrangements which were tried will be found in the patent records of the times and subsequently in some of the leading textbooks.[1] The textbooks testify unanimously to the superiority of amplitude modulation.

Some time after the introduction of the vacuum tube oscillator attempts were again made to modulate the frequency and again the verdict of the art was rendered against the method. A new element however, had entered into the objective of the experiments. The quantitative relation between the width of the band of frequencies required in amplitude modulation and the frequency of the modulating current being now well understood, it was proposed to narrow this band by the use of frequency modulation in which the deviation of the frequency was to be held below some low limit; for example, a fraction of the highest frequency of the modulating current. By this means an economy in the use of the frequency spectrum was to be obtained. The fallacy of this was exposed by Carson [2] in 1922 in the first mathematical treatment of the problem, wherein it was shown that the width of the band required was at least double the value of the highest modulating frequency. The subject of frequency modulation seemed forever closed with Carson's final judgment, rendered after a thorough consideration of the matter, that "Consequently this method of modulation inherently distorts without any compensating advantages whatsoever."

Following Carson a number of years later the subject was again examined in a number of mathematical treatments by writers whose results concerning the width of the band which was required confirmed those arrived at by Carson, and whose conclusions, when any were expressed, were uniformly adverse to frequency modulation.

In 1929 Roder [3] confirmed the results of Carson and commented adversely on the use of frequency modulation.

In 1930 van der Pol [4] treated the subject and reduced his results to an excellent form for use by the engineer. He drew no conclusions regarding the utility of the method.

In 1931, in a mathematical treatment of amplitude, phase, and frequency modulation, taking into account the practical aspect of the increase of efficiency at the transmitter which is possible when the

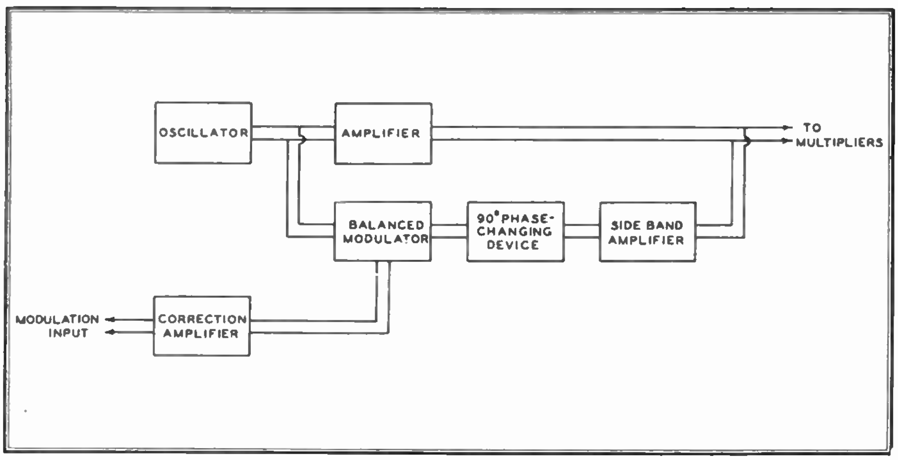

FIG. 1. BLOCK DIAGRAM OF THE PHASE SHIFT METHOD OF FREQUENCY MODULATION

* Department of Electrical Engineering, Columbia University, New York City. Presented before the New York meeting of the I.R.E., November 6, 1935. Reprinted from the *Proceedings of the Institute of Radio Engineers*, May, 1936, by permission. The diagrams have been redrawn for this presentation in *FM and Television*.

[1] Zenneck, "Lehrbuch der drahtlosen Telegraphy" (1912).
Eccles, "Wireless Telegraphy and Telephony" (1916).
Goldsmith, "Radio Telephony" (1918).

[2] "Notes on the theory of modulation," *Proc. I.R.E.*, vol. 10, pp. 57–82; February (1922).

[3] "Ueber Frequenzmodulation," *Telefunken-Zeitung* no. 53, p. 48 (1929).

[4] "Frequency modulation," *Proc. I.R.E.*, vol. 18, pp. 1194–1205; July (1930).

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frequency is modulated, Roder[5] concluded that the advantages gained over amplitude modulation at that point were lost in the receiver.

In 1932 Andrew[6] compared the effectiveness of receivers for frequency modulated signals with amplitude modulated ones and arrived at the conclusion that with the tuned circuit method of translating the variations in frequency into amplitude variations, the frequency modulated signal produced less than one tenth the power of one which was amplitude modulated.

While the consensus based on academic treatment of the problem is thus heavily against the use of frequency modulation it is to the field of practical application that one must go to realize the full extent of the difficulties peculiar to this type of signaling.

Problems Involved ★ The conditions which must be fulfilled to place a frequency modulation system upon a comparative basis with an amplitude modulated one are the following:

1. It is essential that the frequency deviation shall be about a fixed point. That is, during modulation there shall be a symmetrical change in frequency with respect to this point and over periods of time there shall be no drift from it.

[5] "Amplitude, phase, and frequency modulation," *Proc. I.R.E.*, vol. 19, pp. 2145–2176; December (1931).

[6] "The reception of frequency modulated radio signals," *Proc. I.R.E.*, vol. 20, pp. 835–840; May (1932).

2. The frequency deviation of the transmitted wave should be independent of the frequency of the modulating current and directly proportional to the amplitude of that current.

3. The receiving system must have such characteristics that it responds only to changes in frequency and that for the maximum change of frequency at the transmitter (full modulation) the selective characteristic of the system responsive to frequency changes shall be such that substantially complete modulation of the current therein will be produced.

4. The amplitude of the rectified or detected current should be directly proportional to the change in frequency of the transmitted wave and independent of the rate of change thereof.

5. All the foregoing operations should be carried out by the use of a periodic means.

The Transmitting System ★ An extensive experience with the various known methods of modulating the frequency convinced the writer as indeed it would anyone who has tried to work with this method of modulation at a high frequency that some new system must be evolved. During the course of this work there was evolved a method which, it is believed, is a complete solution of the transmitter problem. It consists in employing the modulating current to shift the phase of a current derived from a source of fixed phase and frequency by an amount which is directly proportional to the amplitude of the modulating current and inversely proportional to its frequency. The resulting phase shift is then put through a sufficient number of frequency multiplications to insure 100 per cent modulation for the highest frequency of the modulating current. By keeping the initial phase shift below thirty degrees substantial linearity can be obtained.

The means employed to produce the phase shift consisted of a source of fixed frequency, a balanced modulator excited by this source, and arrangements for selecting the side frequencies from the modulator output and combining them in the proper phase with an unmodulated current derived from the initial source. The phase relations which must exist where the combination of the modulated and unmodulated currents takes place are that at the moment the upper and lower side frequencies produced by the balanced modulator are in phase with each other, the phase of the current of the master oscillator frequency with which they are combined shall differ therefrom by ninety degrees.

The schematic and diagrammatic arrangements of the circuits may be visualized by reference to Figs. 1 and 2, and their operation understood from the following explanation. The master oscillator shown in these diagrams may be of the order of fifty to one hundred thousand or more cycles per second, depending upon the frequency of the modulating current. An electromotive force derived from this oscillator is applied in like phase to the grid of an amplifier and both grids of a balanced modulator. The plate circuits of the modulator tubes are made nonreactive for the frequency applied to their grids by balancing out the reactance of the transformer primaries as shown. The plate currents are therefore in phase with the electromotive force applied to the grid. The succeeding amplifier is coupled to the output transformer by a coil whose natural period is high compared to the frequency of the master oscillator and the electromotive force applied to the grid of this amplifier when the modulator tubes are unbalanced by a modulating voltage applied to the screen grids is therefore shifted in phase ninety degrees (or 270 degrees) with respect to the phase of the electromotive force applied to the grids of the balanced modulators. Hence it follows that the phase of the currents existing in the plate circuit of the amplifier of the output of the balanced modulator (at the peak of the modulation voltage) is either ninety degrees or 270 degrees apart from the phase of the current existing in the plate circuit of the amplifier of the unmodulated master oscillator current. Therefore the voltages which they develop across the common resistance

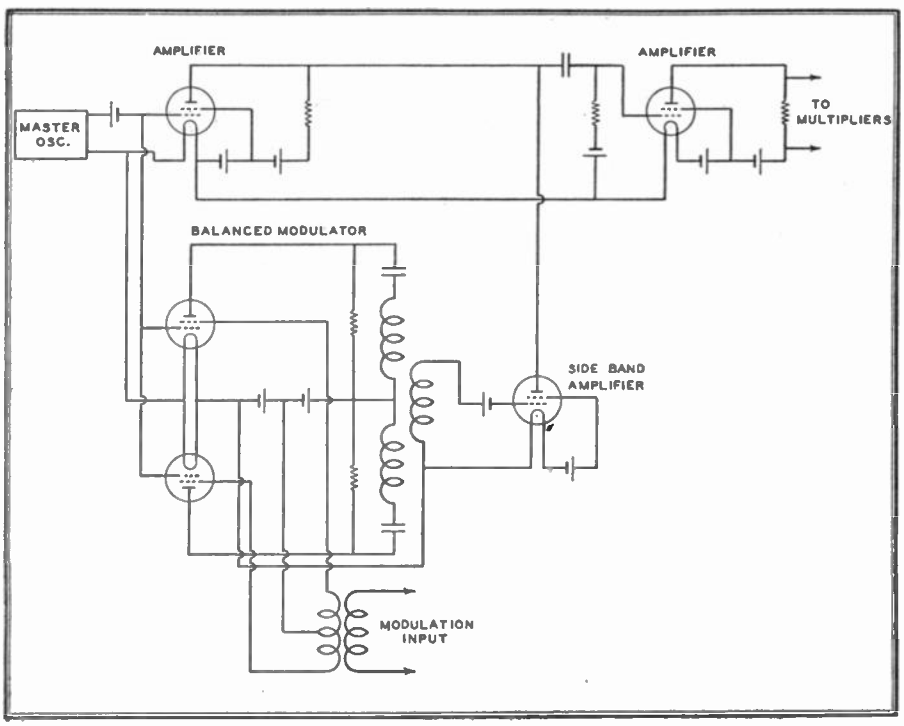


FIG. 2. SCHEMATIC DIAGRAM SHOWING THE ELEMENTS OF THE PHASE SHIFT CIRCUIT

load will be ninety degrees apart.

The resulting effect on the phase of the voltage developed across the resistance in the plate circuits of these two amplifiers when modulation is applied, compared to the phase of the voltage which would exist there in the absence of modulation will appear from Fig. 3. It will be observed from the vector diagrams that the phase of the voltage across the common resistance load is alternately advanced and retarded by the combination of the modulated and unmodulated components and that the maximum phase shift is given by an angle whose tangent is the sum of the peak values of the two side frequencies divided by the peak value of the unmodulated component. By keeping this angle sufficiently small (not greater than thirty degrees) it may be made substantially proportional to the amplitude of the two side frequencies and hence to the amplitude of the initial modulating current.[7] It will be observed that if the angle through which the phase is shifted be the same for all frequencies of modulation then the rate of increase or decrease of the angle will be proportional to the frequency of modulation and hence the deviation in frequency of the transmitted wave will be proportional to the frequency of the modulating current. In order to insure a frequency deviation which is independent of the modulation frequency it is necessary that, for a constant impressed modulating electromotive force, the angle through which the phase is shifted be made inversely proportional to the frequency of the modulating current. This is accomplished by making the amplification of the input amplifier inversely proportional to frequency by means of the correction network shown in Fig. 4. The network consists of a high resistance in series with a capacity whose impedance for the lowest frequency of modulation is relatively small with respect to the series resistance. The voltage developed across the capacity which excites the succeeding amplifier stage is therefore inversely proportional to frequency and hence it follows that the angle through which the current is advanced or retarded becomes directly proportional to the amplitude of the modulating current and inversely proportional to its frequency. The resulting phase shift must be multiplied a great many times before a frequency modulated current which can be usefully employed is produced. This will be clear from an examination of the requirements of a circuit over which it is desired to transmit a frequency range from thirty to 10,000 cycles. Since the lowest frequency is limited to a phase shift of thirty degrees it follows that for 10,000 cycles the phase shift will be but 0.09 degree. The minimum phase shift for 100 per cent modulation of the transmitted wave is roughly forty-five degrees. A frequency multiplication of 500 times is required, therefore, to produce a wave which is fully modulated [8] and capable of being effectively handled by the receiver in the presence of disturbing currents.

Under ordinary conditions this multiplication of frequency can be realized without loss of linearity by a series of doublers and triplers operated at saturation provided the correct linkage circuits between the tubes are employed. Where however the wide band frequency swing which will be described subsequently in this paper is employed unexpected difficulties arise. These also will be dealt with subsequently.

From the foregoing description it will be seen that this method of obtaining frequency modulation consists in producing initially phase modulation in which the phase shift is inversely proportional to the frequency of modulation and converting the phase modulated current into a frequency modulated one by successive multiplications of the phase shift. The frequency stability, of course, is the stability attainable by a crystal controlled oscillator and the symmetry of the deviation may be made substantially perfect by compensating such asymmetrical action in the system as may occur. With the method of phase shifting shown in Fig. 2 there is an asymmetry which is of importance when the frequency of modulation is high compared to the master oscillator frequency. It occurs in the plate transformer of the balanced modulator. The plate circuits of these tubes are substantially aperiodic and consequently the amplitudes of the upper and lower side frequencies are approximately equal and from this it follows that the electromotive forces induced in the secondary are directly proportional to the values of these frequencies. Where the master oscillator frequency is 50,000 cycles and a frequency of modulation of 10,000 cycles is applied, the upper side frequency may be fifty per cent greater than the lower. This inequality may be compensated by a resistance-capacity network introduced subsequent to the point at which the combination of carrier and side frequencies is effected but prior to any point at which loss of linearity of amplitude occurs. The level in the amplifiers ahead of the compensating network must be kept sufficiently low so that the operation of the system is linear. After the side frequencies are equalized amplitude linearity ceases to be of importance.

The performance of transmitters operating on this principle has been in complete accord with expectations. While the arrangements may seem complex and re-

At the November, 1935 meeting of the Institute of Radio Engineers in New York City, Major Edwin H. Armstrong delivered the paper which disclosed his "method of reducing disturbances in radio signaling by a system of Frequency Modulation."

Probably the most important contribution to the literature of the radio art, this paper is particularly remarkable because the passage of time has confirmed every statement made in this clear and simple presentation of the theory, application, and comparative performance of a completely new system of radio transmission and reception — and this despite the fact that the mathematical proof, developed previously, had shown the method employed successfully by Major Armstrong to be inoperable.

Since 1939, when Major Armstrong's station at Alpine, N. J., went on the air, his "system of Frequency Modulation" has revised the whole setup of radio broadcasting. It has also expanded enormously the use and usefulness of emergency communications by making the 2-way radio telephone practical. And as it has come into general use by our Armed Forces, the way has been paved for many new peacetime applications.

During the last five years the expansion of radio research, development, design, and production has drawn hundreds of new engineers into our industry. Very few of these men have read or even known of the existence of Major Armstrong's original paper, published nearly nine years ago in the I.R.E. Proceedings.

It has been suggested repeatedly that this paper should be re-published in FM AND TELEVISION for the benefit of the newcomers, and to refresh the memories of those who have forgotten the background of Frequency Modulation under the pressure of work on its application to present military and future peacetime use.

Of special interest is Major Armstrong's original data on the comparative performance of FM and AM when both were operated on the same frequency. The criticism is heard frequently today that comparisons of FM at ultra-high frequencies and AM at standard broadcast frequencies are altogether unfair, and that little difference would be found between FM and AM performance and on the same frequencies.

Although much has been written by others on FM vs. standard AM broadcasting, it should be noted that Major Armstrong's famous demonstrations in 1934-1935, between R.C.A's station on the Empire State Building and Harry Sadenwater's home in Haddonfield, N. J., 85 miles distant, employed FM and AM transmission and reception on the ultra-high frequencies. Details of these tests will be found in the second part of the paper, to appear in a forthcoming issue.

[7] For the large angular displacements there will be an appreciable change in amplitude of the combined currents at double the frequency of the modulating current. This variation in amplitude is not of primary importance and is removed subsequently by a limiting process.

[8] One in which the side frequencies are sufficiently large with respect to the carrier to make it possible to produce at the receiver 100 per cent modulation in amplitude, without the use of expedients which affect unfavorably the signal-to-noise ratio.

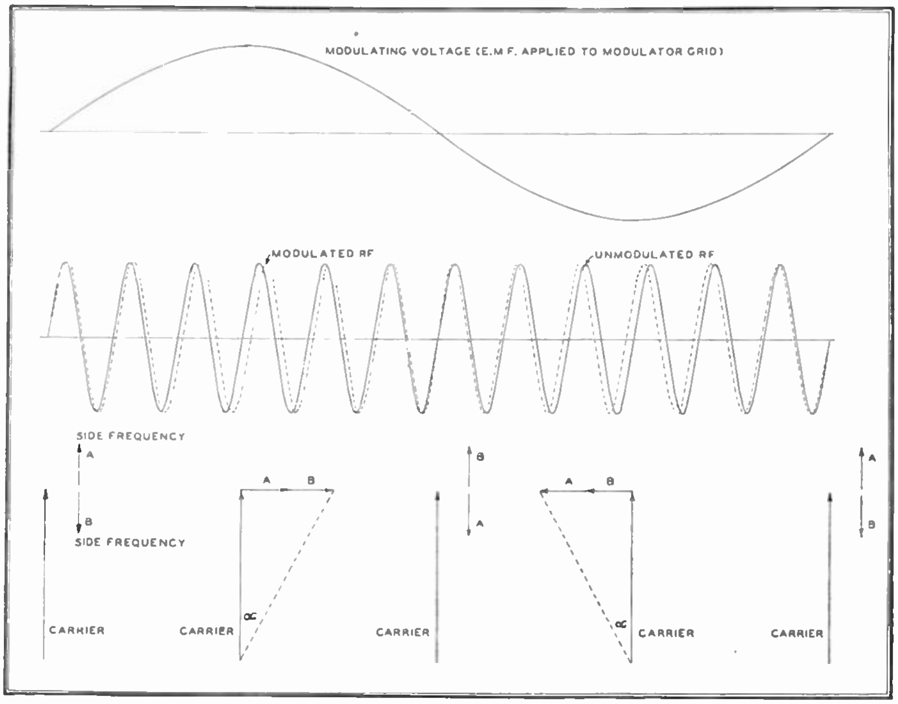


FIG. 3. PHASE OF THE VOLTAGE ACROSS COMMON RESISTANCE LOAD IS ADVANCED AND RETARDED

quire a large amount of apparatus the complexity is merely that of design, not of operation. The complete arrangement, up to the last few multiplier stages may be carried out most effectively with receiving type tubes, these last multiplier stages consisting of power type pentodes for raising the level to that necessary to excite the usual power amplifiers.

The Receiving System ★ The most difficult operation in the receiving system is the translation of the changes in the frequency of the received signal into a current which is a reproduction of the original modulating current. This is particularly true in the case of the transmission of high fidelity broadcasting. It is, of course, essential that the translation be made linearly to prevent the generation of harmonics but it must also be accomplished in such a manner that the signaling current is not placed at a disadvantage with respect to the various types of disturbances to which radio reception is subject. In the particular type of translation developed for this purpose which employs the method of causing the changes in frequency to effect changes in amplitude which are then rectified by linear detectors, it is essential that for the maximum deviation of the transmitted frequency there shall be a substantial amplitude modulation of the received wave. At first sight it might appear that 100 per cent or complete modulation would be the ideal, but there are objections to approaching this limit too closely. It will, however, be clear that where the translation is such that only a few per cent amplitude modulation results from the maximum deviation of the frequency of the transmitted wave the receiver is hopelessly handicapped with respect to amplitude disturbances. This is true because even when the level of the voltage applied to the conversion system is kept constant by a current limiting device or automatic volume control there still remain those intervals wherein the incoming disturbances arrive in the proper phase to neutralize the signaling current in the detector, effecting thereby substantially complete modulation of the rectified current or the intervals wherein the disturbing currents themselves effect greater amplitude changes than the signal itself by cross modulation of its frequency.

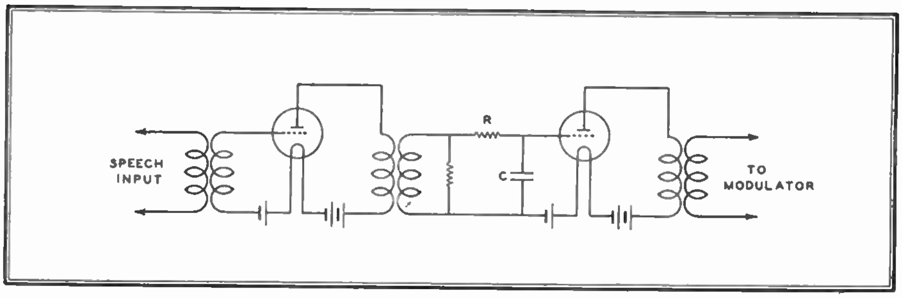


FIG. 4. NETWORK TO INSURE FREQUENCY DEVIATION INDEPENDENT OF MODULATION FREQUENCY

An arrangement in which linear conversion can be effected without handicapping the system with respect to amplitude disturbances is illustrated diagrammatically in Fig. 5. Two branch circuits each containing resistance, capacity, and inductance in series as shown are connected to the intermediate-frequency amplifier of a superheterodyne at some suitable frequency. One capacity and inductance combination is made nonreactive for one extreme of the frequency band which the signal current traverses and the other capacity and inductance combination is made nonreactive for the other end of the band. The resistances are chosen sufficiently high to maintain the current constant over the frequency range of the band; in fact, sufficiently high to make

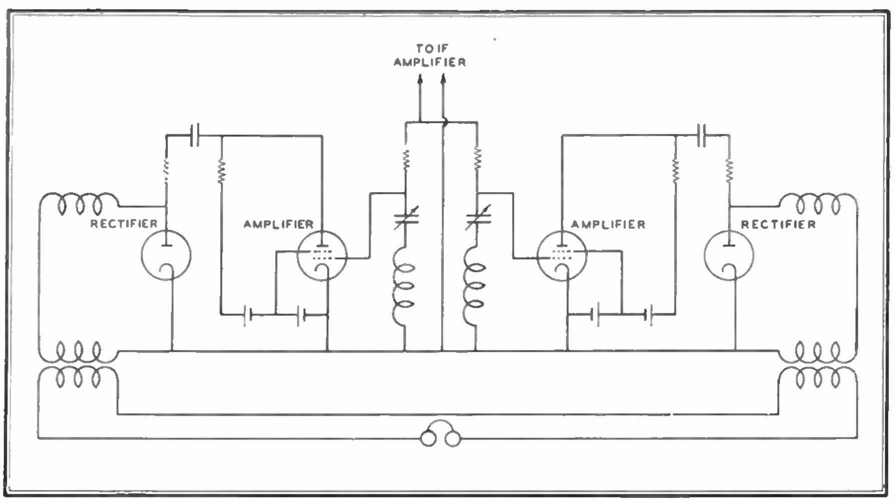


FIG. 5. LINEAR CONVERSION CIRCUIT FOR CONNECTION TO IF AMPLIFIER OF RECEIVER

each branch substantially aperiodic. The reactance characteristics taken across each capacity and inductance combination will be as illustrated in Fig. 6 by curves A and B. Since the resistances in series with the reactance combinations are sufficient to keep the current constant throughout the frequency band it follows that the voltages developed across each of the two combinations will be proportional to their reactances as is illustrated in curves A' and B'. The two voltages are applied respectively to the two equal aperiodic amplifiers, each of which is connected to a linear rectifier. The rectifiers are in series with equal output transformers whose secondaries are so poled that changes in the rectifier currents resulting from a change in the frequency of the received signal produce additive electromotive forces in their secondaries. Since amplifiers and rectifiers are linear the output currents will follow the amplitude variations created by the action of the capacity-inductance combinations. While the variation in reactance is not linear with respect to the change of frequency, particularly where the width of the band is a substantial percentage of the frequency at which the operation takes place, as a practical matter, by the proper choice of values together with shunts of high resistance or reactance these characteristics may be rendered sufficiently straight within the working range to meet the severest requirements of high fidelity broadcasting. The operation of the system is aperiodic and capable of effecting 100 per cent modulation if desired, this last depending on the separation of the two nonreactive points with respect to the frequency swing. Generally the setting of the nonreactive frequency points should be somewhat beyond the range through which the frequency is swung.

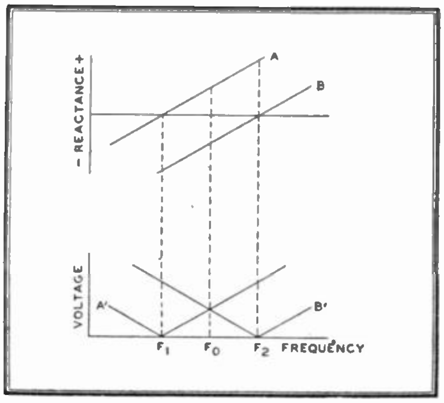


FIG. 6. REACTANCE CHARACTERISTICS ACROSS CAPACITY AND INDUCTANCE COMBINATIONS

There is shown in Fig. 7 an alternative arrangement of deriving the signal from the changes in frequency of the received wave which has certain advantages of symmetry over the method just described. In this arrangement a single capacity-inductance combination with the nonreactive point in the center of the frequency band is used and the rectifiers are polarized by a current of constant amplitude derived from the received current. In this way, by properly phasing the polarizing current, which is in effect a synchronous heterodyne, differential rectifying action can be obtained. In Fig. 7 the amplified output of the receiver is applied across the single series circuit consisting of resistance R, capacity C, and inductance L. The reactance of C and L are equal for the mid-frequency point of the band and the reactance curve is as illustrated in A of Fig. 8. At frequencies above the nonreactive point the combination acts as an inductance; at frequencies below the nonreactive point as a capacity and the phase of the voltage developed across the combination with respect to the current through it differs, therefore, by 180 degrees above and below the nonreactive point. Since the current through the circuit is maintained constant over the working range by the resistance R and since the resistance of the capacity C and inductance L may be made very low the electromotive force developed across C and L is of the form shown in curve B. This curve likewise represents the variation in voltage with variation in frequency which is applied to the grids of the amplifiers and eventually to the two rectifiers D_1 and D_2.

The heterodyning or polarizing voltage is obtained by taking the drop across the resistance R^1, amplifying it, changing its phase through ninety degrees and applying the amplified voltage to the screen grids of the amplifiers in opposite phase. The characteristic of this amplifying and phase changing system must be flat over the working range. Under these conditions the signaling and heterodyning voltages are exactly in phase in one rectifier and 180 degrees out of phase in the other, and hence for a variable signaling frequency the rectifying characteristics are as shown in curves C and D the detector outputs being cumulatively combined for frequency changes. Adjustment of the relative amplitudes of the signaling and polarizing voltages in the rectifier controls the degree of amplitude modulation produced from 100 per cent down to any desired value.

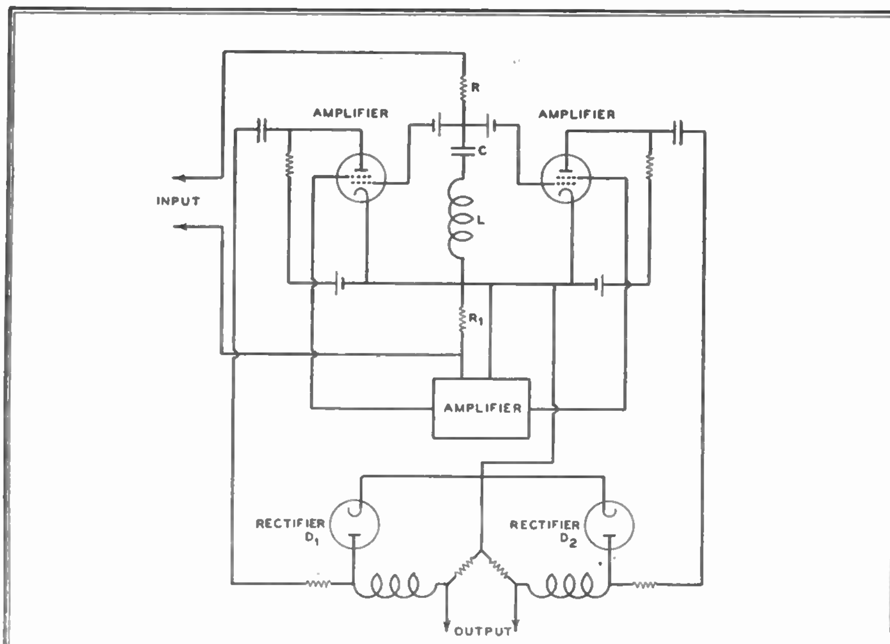


FIG. 7. ALTERNATE METHOD OF DERIVING SIGNAL FROM CHANGES IN FREQUENCY

Part II

With the foregoing description of the instrumentalities for transmitting and receiving frequency modulated waves it is now in order to consider the main object of the paper; the method of reducing disturbances and the practical results obtained by its use.

Method of Reducing Disturbances ★ The basis of the method consists in introducing into the transmitted wave a characteristic which cannot be reproduced in disturbances of natural origin and utilizing a receiving means which is substantially not responsive to the currents resulting from the ordinary types of disturbances and fully responsive only to the type of wave which has the special characteristic.

The method to be described utilizes a new principle in radio signaling the application of which furnishes an interesting conflict with one which has been a guide in the art for many years; i.e., the belief that the narrower the band of transmission the better the signal-to-noise ratio. That principle is not of general application. In the present method an opposite rule applies.

It appears that the origin of the belief that the energy of the disturbance created in a receiving system by random interference depended on the band width goes back almost to the beginning of radio. In the days of spark telegraphy it was observed that "loose coupling" of the conventional transmitter and receiver circuits produced a "sharper wave" and that interference from lightning discharges, the principal "static" of those days of insensitive and nonamplifying receivers was decreased. Further reduction in interference of this sort occurred when continuous-wave transmitters displaced the spark and when regeneration narrowed the band width of the receiving system. It was observed, however, that "excessive resonance" must not be employed either in telegraphic or more particularly in telephonic signaling or the keying and speech would become distorted. It was concluded in a qualitative way that there was a certain "selectivity" which gave the best results.

In 1925 the matter was placed on a quantitative basis by Carson [9] where in a mathematical treatment of the behavior of selective circuits when subjected to irregular and random interference (with particular reference to "static"), on the basis of certain assumptions, the proposition was established that "if the signaling system requires the transmission of the band of frequencies corresponding to the interval $\omega_2 - \omega_1$ and if the selective circuit is efficiently designed to this end, then the mean square interference current is proportional to the frequency band width $(\omega_2 - \omega_1)/2\pi$.

Hazeltine [10] pointed out that when a detector was added to such a system and a carrier of greater level than the interference currents was present, that for aural reception only those components of the interfering current lying within audible range of the carrier frequency were of importance and that Carson's theory should be supplemented by the use of a factor equal to the relative sensitivity of the ear at different frequencies.

With the discovery of shot effect and thermal agitation noises and the study of their effect on the limit of amplification quantitative relations akin to those enunciated by Carson with respect to static were found to exist.

Johnson,[11] reporting the discovery of the electromotive force due to thermal agitation and considering the problem of reducing the noise in amplifiers caused thereby, points out that for this type of disturbance the theory indicates, as in the Carson theory, that the frequency range of the system should be made no greater than is essential for the proper transmission of the applied input voltage, that where a voltage of constant frequency and amplitude is used one may go to extremes in making the system selective and thereby proportionately reducing the noise, but that when the applied voltage varies

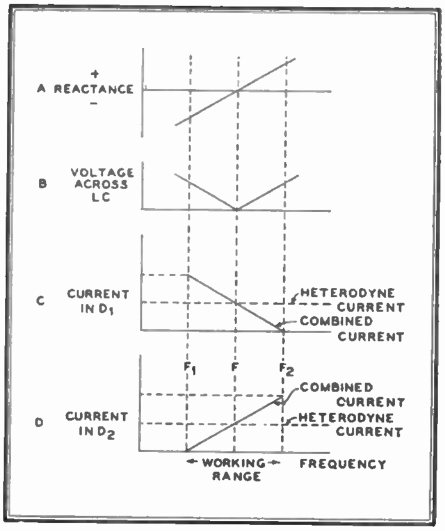


FIG. 8. CHARACTERISTICS OF FIG. 7 CIRCUIT

in frequency or amplitude the system must have a frequency range which takes care of these variations and the presence of a certain amount of noise must be accepted.

Ballantine [12] in a classical paper discussing the random interference created in radio receivers by shot and thermal effects obtained a complete expression for the noise output.[13]

Johnson and Llewellyn,[14] in a paper dealing generally with the limits to amplification, point out that in a properly designed amplifier the limit resides in thermal agitation in the input circuit to the amplifier, that the power of the disturbance in the output of the amplifier is proportional to its frequency range and that this, the only controllable factor in the noise equation, should be no greater than is needed for the transmission of the signal. A similar conclusion is reached in the case of a detector connected to the output of a radio-frequency amplifier and supplied with a signal carrier.

It is now of interest to consider what happens in a linear detector connected to the output of a wide band amplifier which amplifies uniformly the range from 300 to 500 kilocycles. Assume that the amplification be sufficiently great to raise the voltage due to thermal agitation and shot effect to a point ufficient to produce straight-line rectification and that no signal is being received. Under these conditions the frequencies from all parts of the spectrum between 300 and 500 kilocycles beat together to contribute in the output of the detector to the rough hissing tone with which the art is familiar. The spectrum of frequencies in the rectified output runs from some very low value which is due to adjacent components throughout the range beating with one another to the high value of 200 kilocycles caused by the interferences of the extremes of the band.

It is important to note that all parts of the 300- to 500-kilocycle spectrum contribute to the production in the detector output of those frequencies with which we are particularly interested — those lying within the audible range.

Assume now that an unmodulated signal carrier is received of, for example, 400 kilocycles and that its amplitude is greater than that of the disturbing currents. Under these circumstances an entirely new set of conditions arise. The presence of the 400-kilocycle current stops the rectification of the beats which occur between the various components of the spectrum within the 300- to 500-kilocycle band and forces all rectification to take place in conjunction with the 400-kilocycle carrier. Hence in the output of the rectifier there is produced a series of frequencies running from some low value up to 100 kilocycles. The lowest frequency is produced by those components of the spectrum which lie adjacent to the 400-kilocycle current, the highest by those frequencies [15,16] which lie at the extremity of

[9] J. R. Carson, "Selective circuits and static interference," *Bell Sys. Tech. Jour.*, vol. 4, p. 265 (1925).

[10] L. A. Hazeltine, Discussion on "The shielded neutrodyne receiver," *Proc. I.R.E.*, vol. 14, pp. 408, 409; June (1926).

[11] J. B. Johnson, "Thermal agitation of electricity in conductors," *Phys. Rev.*, vol. 32, no. 1, July (1926).

[12] Stuart Ballantine, "Fluctuation noise in radio receivers," *Proc. I.R.E.*, vol. 18, pp. 1377–1387; August (1930).

[13] Ballantine expressed his result as follows: "In a radio receiver employing a square-law detector and with a carrier voltage impressed upon the detector, the audio-frequency noise, as measured by an instrument indicating the average value of the square of the voltage (or current), is proportional to the area under the curve representing the square of the over-all trans-impedance (or of the transmission) from the radio-frequency branch in which the disturbance originates to the measuring instrument as a function of frequency and proportional to the square of the carrier voltage."

[14] J. B. Johnson and F. B. Llewellyn, "Limits to amplification," *Trans. A.I.E.E.*, vol. 53, no. 11, November (1934).

[15] It has been pointed out by Ballantine that it is improper to speak of the amplitude of a single component of definite frequency and that the proper unit is the noise per frequency interval. This is, of course, correct, but to facilitate the physical conception of what occurs in this system the liberty is taken of referring to the noise components as though they were of continuous sine wave form. The behavior of the system may be checked by actually introducing from a local generator such components.

[16] "Fluctuation noise in radio receivers," *Proc. I.R.E.*, vol. 18, pp. 1377–1387; August (1930).

the band; i.e., 300 and 500 kilocycles, respectively.

The characteristics of the rectifiers and the magnitude of some of the effects involved in the above-described action may be visualized by reference to the succeeding figures. The actual demodulation of the beats occurring between adjacent frequency components by the presence of the 400-kilocycle current is shown by the characteristic of Fig. 9, which illustrates what happens to the output voltage of a rectifier produced by beating together two equal currents of 350 and 351 kilocycles, respectively, when a 400-kilocycle current is introduced in the same rectifier and its amplitude progressively increased with respect to the amplitude of these two currents. The characteristic was obtained with the arrangement shown in Fig. 10, in which two oscillators of 350 and 351 kilocycles produced currents of equal strength in a linear rectifier, this rectifier consisting of a diode in series with 10,000 ohms resistance. The output of the rectifier is put through a low-pass filter, a voltage divider, and an amplifier.

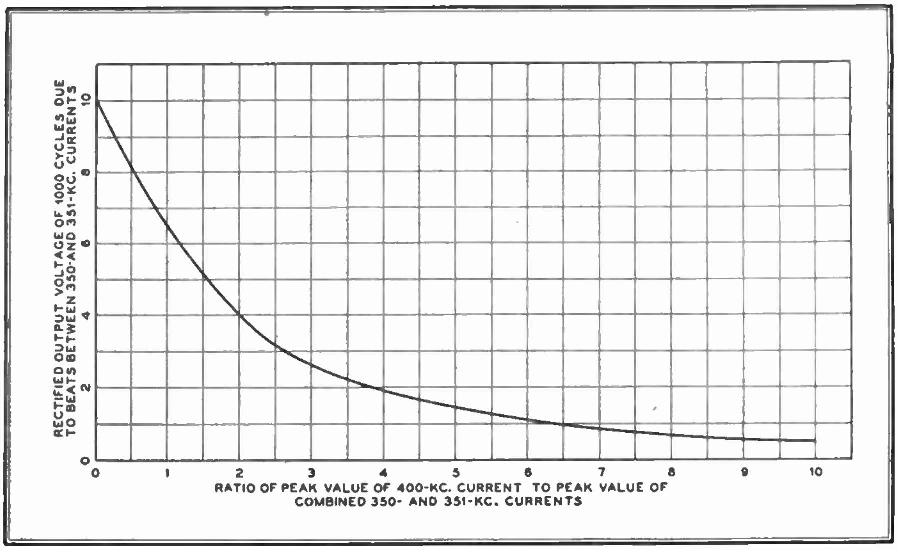


FIG. 9. EFFECT OF 400-KC. A CURRENT ON BEATS BETWEEN ADJACENT FREQUENCIES

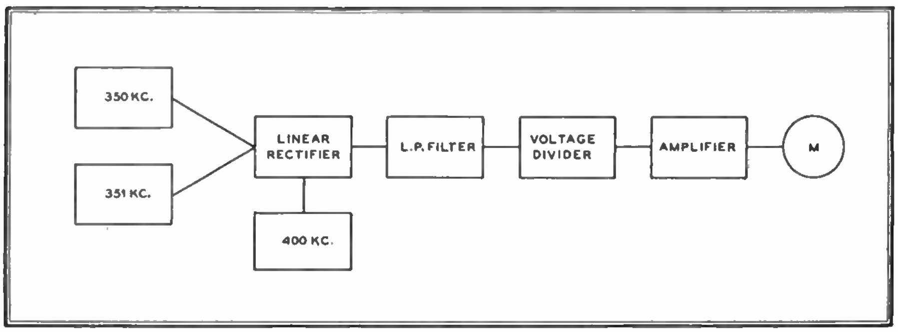


FIG. 10. BLOCK DIAGRAM OF TEST CIRCUIT USED TO OBTAIN CURVE SHOWN IN FIG. 9.

The 400-kilocycle current is introduced into the rectifier without disturbing the voltage relations of the other two oscillators and the effect on the rectified output voltage observed as the 400-kilocycle current is increased. The purpose of the low-pass filter is to prevent the indicating instrument from responding to the 49- or 50-kilocycle currents produced by the interaction of the 350- and 351-kilocycle currents with the current of 400 kilocycles. The linearity characteristic of the rectifier is shown in Fig. 11 where the voltage produced by the beats between a current of constant amplitude and one whose amplitude is raised from equality with, to many times the value of, the first current is plotted against the ratio of the two. The linearity of the rectifier is such that after the ratio of the current becomes two to one no further increase in rectifier output voltage results. In fact with the levels used in these measurements when the two currents are equal there is an efficiency of rectification of only about twenty per cent less than the maximum obtained.

It is important to note here that the only frequencies in the spectrum which contribute to the production of currents of audible frequency in the detector output circuit are those lying within audible range of the signal carrier. We may assume this range as roughly from 390 to 410 kilocycles. The frequencies lying beyond these limits beat against the 400-kilocycle carrier and of course are rectified by the detector but the rectified currents which are produced are of frequencies which lie beyond the audible range and produce therefore no effect which is apparent to the ear. It follows that if the signal carrier is somewhat greater in amplitude than the disturbing currents the signal-to-noise ratio for a receiver whose band of admittance covers twice the audible range will be the same as for one whose band width is many times that value. (There are, of course, certain second order effects, but they are of such minor importance that the ear cannot detect them.) The amplitude of the disturbances in the detector output, will vary in accordance as the components of the disturbing currents come into or out of phase with the signal carrier, the rectified or detector output current increasing above and decreasing below the level of the rectified carrier current by an amount proportional to the amplitude of the components of the 300–500-kilocycle band. The reasons for the independence of the

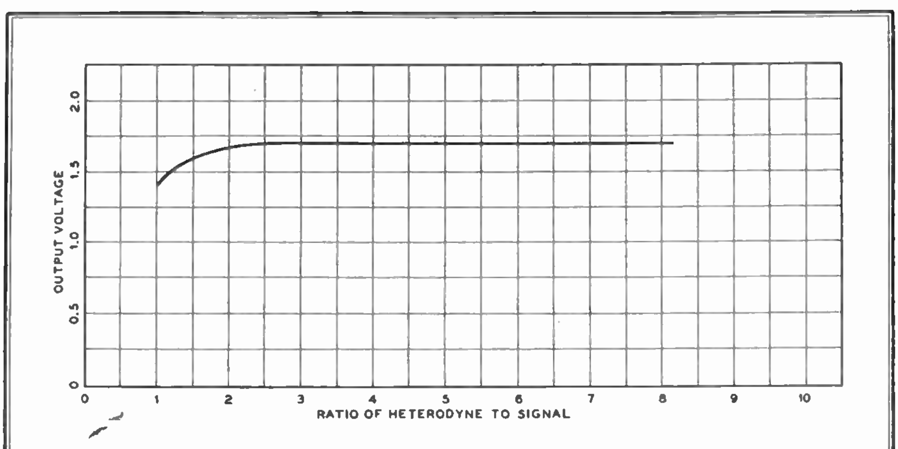


FIG. 11. CURVE SHOWING THE LINEARITY CHARACTERISTIC OF THE RECTIFIER

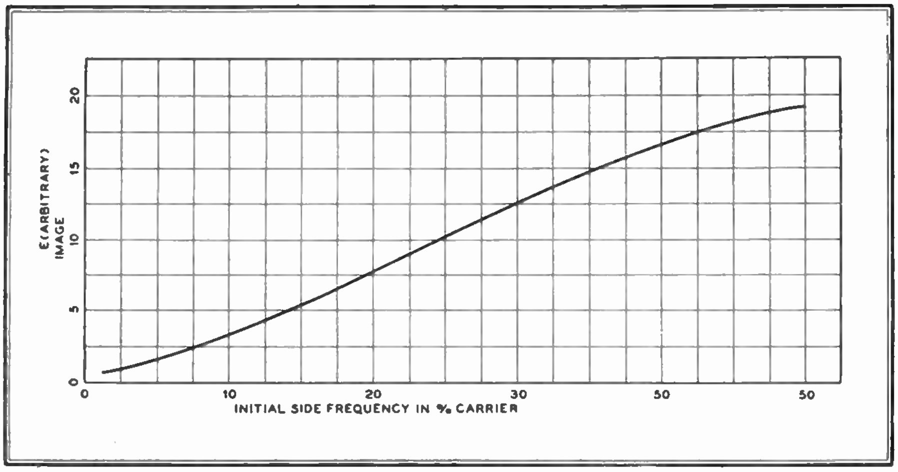


FIG. 12. RELATION BETWEEN AMPLITUDE OF THE ORIGINAL CURRENT AND THE IMAGE

signal-to-noise ratio of the band width under the circumstances which have been described should now be apparent. In any event, it can be readily demonstrated experimentally.

It is now in order to consider what happens when a current limiting device is introduced between the output of the amplifier and the detector input. (Assume signal level still above peak noise level.) Two effects will occur. One of the effects will be to suppress in the output circuit of the limiter all components of the disturbing currents which are in phase with, or opposite in phase to, the 400-kilocycle carrier. The other effect will be to permit the passage of all components of the disturbing currents which are in quadrature with the 400-kilocycle current.

Both the above effects are brought about by a curious process which takes place in the limiter. Each component within the band creates an image lying on the opposite side of the 400-kilocycle point whose frequency difference from the 400-kilocycle current is equal to the frequency difference between that current and the original component. The relative phase of the original current in question, the 400-kilocycle current and the image current is that of phase modulation — that is, at the instant when the original component and its image are in phase with each other, the 400-kilocycle current will be in quadrature with them both and at the instant that the 400-kilocycle current is in phase with one of these two frequencies, it will be out of phase with the other.

The relation (obtained experimentally) between the amplitudes of the original current and the image is illustrated by the curve of Fig. 12, which shows the relation between the amplitude of a 390-kilocycle current introduced into a limiter along with the 400-kilocycle current and the resulting 410-kilocycle image in terms of percentage amplitude of the 400-kilocycle current. It will be obvious from the curve that in the region which is of interest — that is, where the side frequencies are smaller than the mid-frequency — that the effect is substantially linear.

With the above understanding of what takes place in the current limiter it is now in order to consider what happens when a selective system as illustrated in Fig. 13 is interposed between the limiter and the detector. (The band-pass filter is for the purpose of removing limiter harmonics.) A rough picture of what occurs may be had by considering a single component of the interference spectrum. Suppose this component to be at 390 kilocycles and that by the action already explained it has created its image at 410 kilocycles. These two frequencies are equal in amplitude and so phased with respect to each other and with respect to the 400-kilocycle carrier that no amplitude change results.

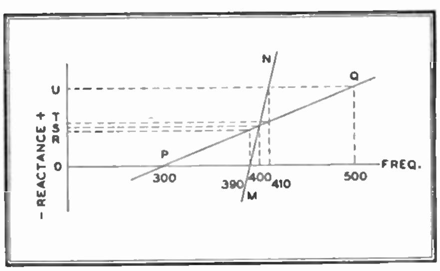


FIG. 14. CHARACTERISTIC OF SELECTIVE SYSTEM

Assume now that the selective system has the characteristic *MN* which as shown in Fig. 14 is designed to give complete modulation for a ten-kilocycle deviation of frequency. Since at 390 kilocycles the reactance across the capacity-inductance combination is zero and at 410 kilocycles double what it is at 400 kilocycles it follows that the 390-kilocycle component becomes equal to zero but the ratio of the 410-kilocycle component to the 400-kilocycle carrier is doubled; that is, it is twice as great as is the ratio in the circuits preceding the selective system. The change in amplitude, therefore, becomes proportional to *OU*. Therefore in combination with the 400-kilocycle carrier a variation in amplitude is produced which is substantially identical with that which would be obtained were the current limiter removed and the selective system replaced by an aperiodic coupling of such value that the same detector level were preserved.

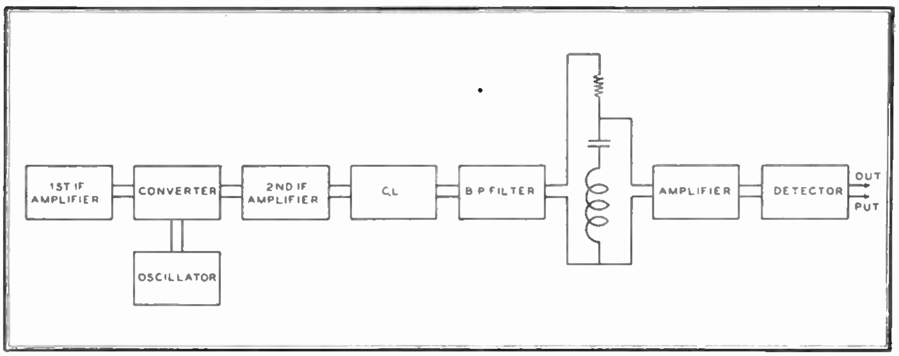


FIG. 13. SELECTIVE SYSTEM INTERPOSED BETWEEN THE LIMITER AND THE DETECTOR

Now consider what occurs when a selective system having the characteristic such as *PQ* and requiring a deviation of 100 kilocycles to produce full modulation is employed instead of one such as *MN*, where a ten-kilocycle deviation only is required. Assume the same conditions of interference as before. The 400-kilocycle voltage applied to the rectifier will be the same as before, but the *relative amplitudes of the 390- and 410-kilocycles voltage will only be slightly changed*. The 410-kilocycle voltage will be increased from a value which is proportional to *OS* to one which is proportional to *OT* and the 390-kilocycle voltage will be reduced from a value proportional to *OS* to one proportional to *OR*. The difference in value of the two frequencies will be proportional to the difference between *OS* and *OT* or *RT*, and the change in amplitude produced by their interaction with the 400-kilocycle current will be likewise proportional to

RT. The reduction in the amplitude of the disturbance as measured in the detector output by the use of a 200-kilocycle wide selective system as compared to the use of one only twenty kilocycles wide is therefore the ratio *RT/OU*. In this case it is ten per cent. The power ratio is the square of this or one per cent.

The above reasoning holds equally well if a balanced rectifying system is used where the characteristics of the selective system are as shown in Fig. 15. The output of the system insofar as voltages resulting from changes in frequency are concerned is the sum of outputs of the two sides of the balance.

It is of course clear that disturbing currents lying farther from the 400-kilocycle point than the ten-kilocycle limit will, by interaction with the 400-kilocycle current, produce larger values of rectified current than those lying within that band. *But the rectified currents produced in the detector output by those components of frequency which lie at a greater than audible frequency distance from the 400-kilocycle current will be beyond the audible range and hence will produce no disturbance which is audible.* (It is generally advisable to eliminate them from the audio amplifier by a low-pass filter to prevent some incidental rectification in the amplifier making their variations in amplitude audible.)

It remains only to consider what happens when the frequency of the 400-kilocycle current is varied in accordance with modulation at the transmitter. It is clear from Fig. 14 that when the selective system has the characteristic *MN* that a deviation of 10,000 cycles will produce complete modulation of the signal or a change in amplitude proportional to *OU*. Similarly, when the characteristic is according to the curve *PQ* it is clear that a 100,000-cycle deviation is required to produce complete modulation, which is likewise proportional to the same value *OU*. As the signal current is swung back and forth over the range of frequencies between 300 and 500 kilocycles the band of frequencies from which the audible interference is derived continually changes, the band progressively lying about ten kilocycles above and ten kilocycles below what we may call the instantaneous value of the frequency of the signal. The effect is illustrated by Fig. 16 and from this it will be seen that the amplitude of the disturbances in the output circuit of the rectifiers, which is proportional to the sum of *RT* and *R'T'* will be constant. This will be true where the ratio of the amplitude of the signal to the disturbing currents is sufficiently large — where this condition does not exist there are other effects which modify the results, but these will only be of importance at the limits of the practical working range.

Comparison of Noise Ratios ★ From the foregoing description it will be clear that as between two frequency modulation systems of different band widths the signal-to-noise power ratio in the rectified output will vary directly as the square of the

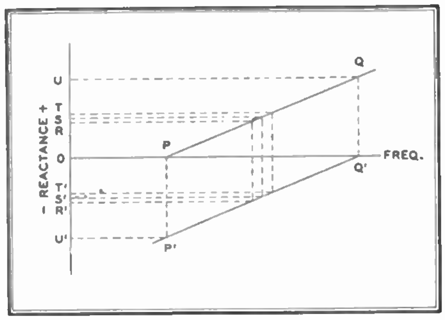


FIG. 15. CHARACTERISTICS OF SELECTIVE SYSTEM FOR USE WITH BALANCED RECTIFIER

band width (provided the noise voltage at the current limiter is less than the signaling voltage). Thus doubling the band width produces an improvement of 4 to 1 and increasing it tenfold an improvement of 100 to 1.

The comparison of relative noise ratios of amplitude and frequency modulation systems cannot be made on so simple a basis as there are a number of new factors which enter, particularly when the comparison is viewed from the very practical

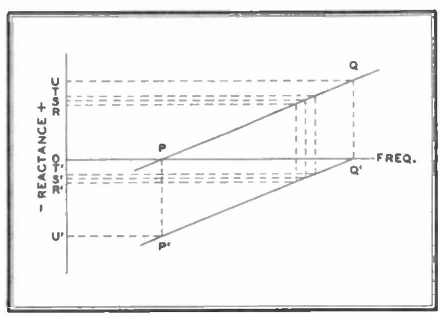


FIG. 16. INTERFERENCE IS DERIVED FROM CHANGING BAND OF FREQUENCIES

aspect of how much greater power must be used with an amplitude modulated transmitter than with a frequency modulated one. If the academic comparison be made between a frequency modulated system having a deviation of ten kilocycles and an amplitude modulated one of similar band width and the *same carrier* level (also same fidelity), it will be found that the signal-to-noise voltage ratio as measured by a root-mean-square meter will favor the frequency modulation system by about 1.7 to 1, and that the corresponding power ratio will be about 3 to 1. This improvement is due to the fact that in the frequency modulation receiver it is only those noise components which lie at the extremes of the band; viz., ten kilocycles away from the carrier which, by interaction with the carrier (when unmodulated) can produce the same amplitude of rectified current as will be produced by the corresponding noise component in the amplitude modulated receiver.

Those components which lie closer to the carrier than ten kilocycles will produce a smaller rectified voltage, the value of this depending on their relative distance from the carrier. Hence the distribution of energy in the rectified current will not be uniform with respect to frequency but will increase from zero at zero frequency up to a maximum at the limit of the width of the receiver, which is ten kilocycles in the present case. The root-mean-square value of the voltage under such a distribution is approximately 0.6 of the value produced with the uniform distribution of the amplitude receiver.

Similarly in comparing an amplitude modulation system arranged to receive ten-kilocycle modulations and having, of course, a band width of twenty kilocycles, with a 100-kilocycle deviation frequency modulation system (same carrier level and same fidelity) there will be an improvement in noise voltage ratio of

$$1.7 \times \frac{\text{deviation}}{\text{audio-frequency range}}$$

$$\text{or } 1.7 \times \frac{100}{10} = 17.$$

The above comparisons have been made on the basis of equal carrier. The practical basis of comparison between the two is that of half carrier for the amplitude modulation and full carrier for the frequency modulation system. This results in about the equivalent amount of power being drawn from the mains by the two systems. On this basis the voltage improvement becomes thirty-four and the signal-to-noise power ratio 1156. Where the signal level is sufficiently large with respect to the noise it has been found possible to realize improvements of this order.

The relative output signal-to-noise ratios of an amplitude modulation system fifteen kilocycles wide (7.5-kilocycle modulation frequency) and a frequency modulation system 150 kilocycles wide (75-kilocycle deviation) operating on forty-one megacycles have been compared on the basis of equal fidelity and half carrier for amplitude modulation. The characteristic of the selective system for converting frequency changes to amplitude changes, which was used, is shown in Fig. 17. The variation of the output signal-to-noise ratio with respect to the corresponding radio-frequency voltage ratio is illustrated in Fig. 18. The curves show that where the radio-frequency peak voltage of the noise measured at the current limiter is less than ten per cent of

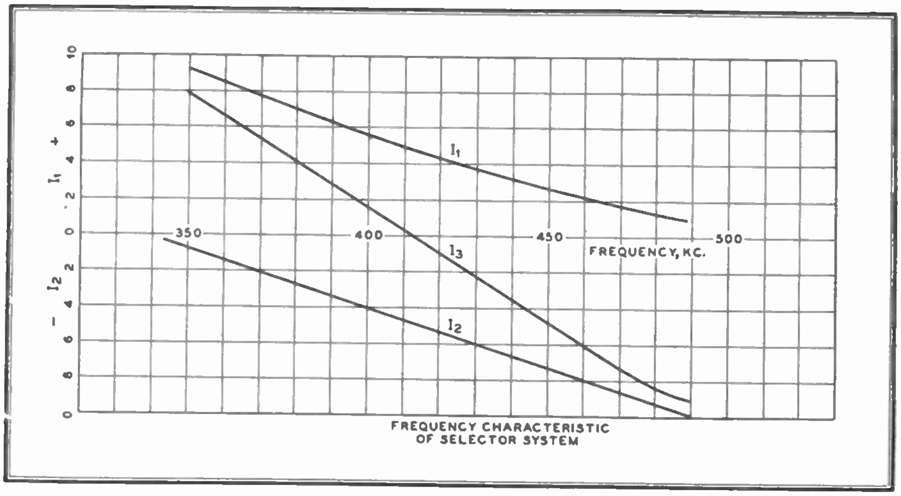


FIG. 17. GRAPH SHOWING THE CHARACTERISTIC OF SELECTIVE SYSTEM FOR CONVERTING CHANGES OF FREQUENCY INTO CHANGES OF AMPLITUDE

the signal peak voltage then the energy of the disturbance in the rectified output will be reduced by a factor which is approximately 1100 to 1. When the peak radio-frequency noise voltage is twenty-five per cent of the signal peak voltage then the energy of the disturbance in the rectified output has been reduced to about 700 to 1, and when it is fifty per cent the reduction of the disturbance drops below 500 to 1. Finally when the noise and signal peak voltages become substantially equal the improvement drops to some very low value. While it is unfortunate, of course, that the nature of the effect is such that the amount of noise reduction becomes less as the noise level rises with respect to the signal, nevertheless this failing is not nearly so important as it would appear. In the field of high fidelity broadcasting a signal-to-noise voltage ratio of at least 100 to 1 is required for satisfactory reception. It is just within those ranges of noise ratios which can be reduced to this low level that the system is most effective.

The arrangements employed in obtaining these characteristics and the precautions which must be observed may perhaps be of interest. As it was obviously impracticable to vary the power of a transmitter over the ranges required or to eliminate the fading factor except over short periods of time an expedient was adopted. This expedient consisted in tuning the receiver to the carrier of a distant station, determining levels and then substituting for the distant station a local signal generator, the distant station remaining shut down except as it was called upon to check specific points on the curve. Observations were taken only when the noise was due solely to thermal agitation and shot effect.

Fig. 19 shows the arrangement of apparatus. The receiver was a two-intermediate-frequency superheterodyne with provision for using either a narrow band second intermediate amplifier with the amplitude modulation system or a wide band amplifier with the frequency modulation system. The band width of the amplitude modulation system was fifteen kilocycles or twice the modulation frequency range. The band width of the frequency modulation receiver was 150 kilocycles or twice the frequency deviation. Provision was made for shifting from one intermediate amplifier to the other without disturbing the remainder of the system. The forty-one-megacycle circuits and the first intermediate amplifier circuits were wide enough to pass the frequency swing of 150 kilocycles. Identical detection systems were used, the frequency modulation detector being preceded by a selective system for translating changes in frequency into changes in amplitude. The output circuits of the detectors were arranged to be connected alternately to a 7500-cycle low-pass filter with a voltage divider across its output. An amplifier with a flat characteristic over the audible range and a root-mean-square meter connected through a high-pass, 500-cycle filter provided the visual indication.

The standard signal was introduced into the input of the two branches of the second intermediate-frequency stage at

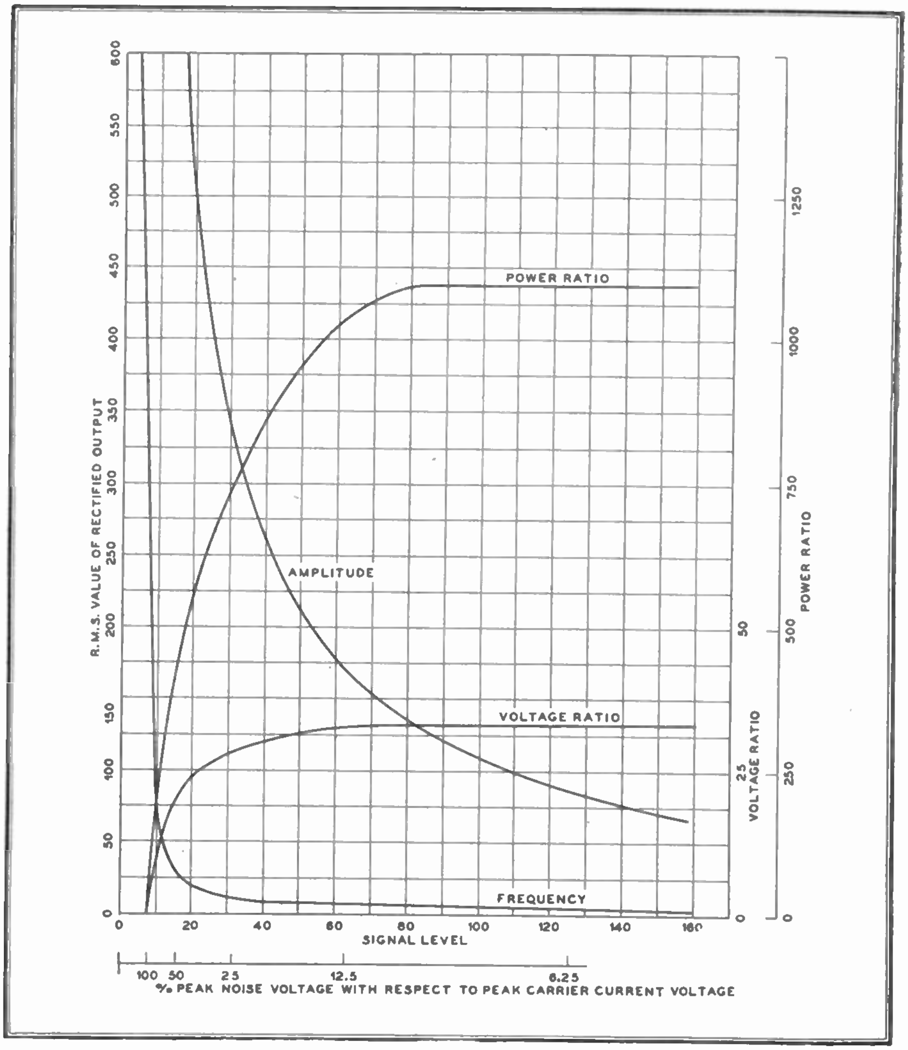


FIG. 18. CURVES SHOWING NOISE-REDUCING PERFORMANCE CHARACTERISTICS

400 kilocycles. As long as the receiver is linear between the antenna and the point at which the standard signal is introduced it is immaterial whether the signal be of forty-one megacycles, six megacycles, or 400 kilocycles. This has been checked experimentally but 400 kilocycles was chosen on account of the greater accuracy of the signal generator on low frequencies.

The relative noise levels to be compared varied over such ranges that lack of linearity had to be guarded against and readings were made by bringing the output meter to the same point on the scale each time by adjustment of the voltage divider, and obtaining the relative voltages directly from the divider.

Two other precautions are essential. The absolute value of the noise voltage band passed by the amplifiers of the frequency modulation part of the system there exists in the detector output rectified currents of frequencies up to seventy-five kilocycles. The amplitude of these higher frequencies is much greater than those lying within the audible range. The average detector output transformer will readily pass a substantial part of these superaudible frequencies which then register their effect upon the output meter although they in no way contribute to the audible disturbance.

The procedure which was followed in making the measurements we are considering consisted in tuning the receiver to the distant transmitter and adjusting the two detector levels to the same value for the respective carrier levels to be compared at any signal level by adjusting the voltage introduced by the signal generator to any fraction of that of the distant signal, bringing the level in the amplitude modulation detector up to the same original value by adjustment of the amplification of the second intermediate amplifier (the frequency modulation detector stays at its point of reference because of the current limiter) and comparing the two output voltages. The level of the detector in the amplitude modulation receiver was of course set with the half carrier value of the signal generator and the output voltage measured at that level. The output voltage of the frequency modulation system was measured when twice that voltage was applied.

It is important to keep in mind just

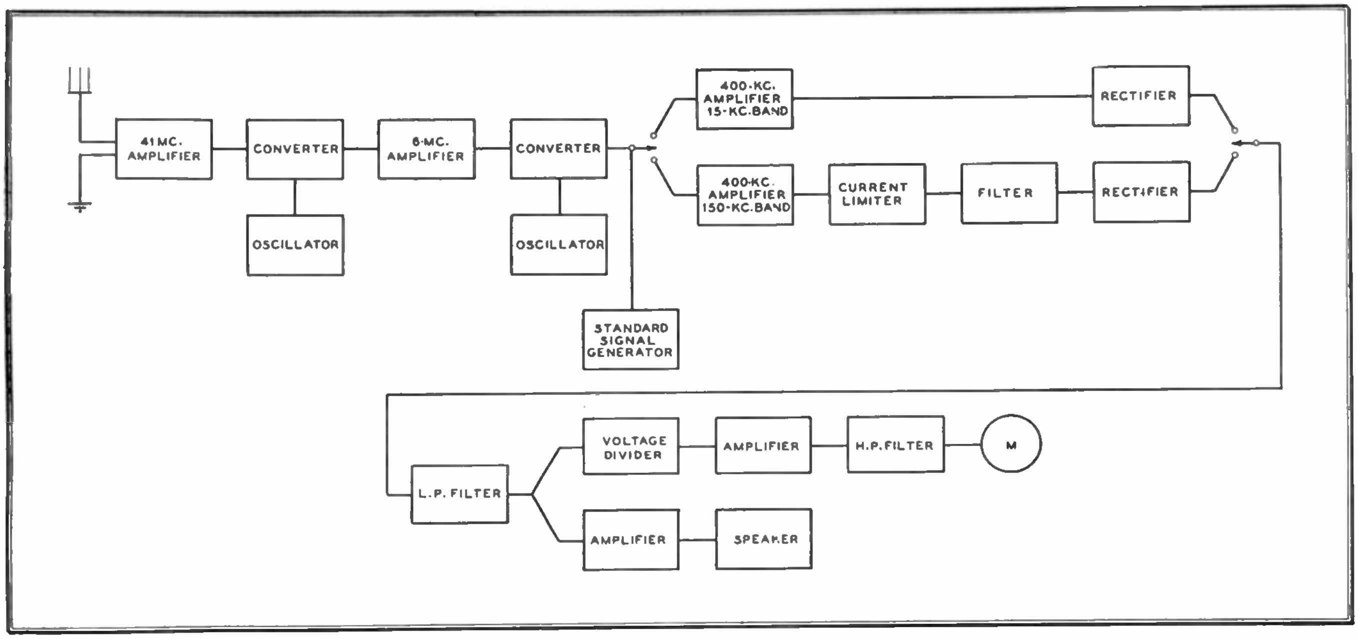


FIG. 19. BLOCK DIAGRAM OF ARRANGEMENT OF APPARATUS FOR OBTAINING PERFORMANCE CHARACTERISTICS

on the frequency modulation system becomes very low for high signal levels. If the voltages due to thermal agitation and shot effect are to be measured rather than those due to the power supply system the output meter must be protected by a high-pass filter of high attenuation for the frequencies produced by the power system. The cutoff point should be kept as low as possible since because of the difference in the distribution of energy in the rectified outputs of frequency and amplitude modulation receivers already referred to there is a certain error introduced by this filter which is small if the band width excluded by the filter is small but which can become appreciable if too much of the low-frequency part of the modulation frequency range be suppressed.

A second precaution is the use of a low-pass filter to cut off frequencies above the modulation range. Because of the wide employed. This was done by cutting the carrier in half at the transmitter when the amplitude modulation detector level was being set and using full carrier for the adjustment of the frequency modulation detector. Each system was then modulated seventy-five per cent and output voltages checked against each other. If they were equal the modulation was removed and the relative noise voltages measured for the respective carrier levels. This gave the first point on the curve. The transmitter was then shut down and a local carrier introduced which gave the same level in the 400-kilocycle intermediate amplifier circuits as the half carrier distant signal. This level was directly ascertainable from the rectified detector current in the amplitude modulation system. From this point on the procedure was entirely within the control of the receiving station. The noise ratios could be what quantities have been measured and what the curves show. The results are a comparison between the relative noise levels in the two systems (root-mean-square values) *when they are unmodulated.* In both an amplitude and in a frequency modulation receiver the noise during modulation may be greater than that obtained without modulation. In the frequency modulation receiver two principal sources may contribute to this increase, one of which is of importance only where the band for which the receiver is designed is narrow, the other of which is common to all band widths. If the total band width of the receiver is twenty kilocycles and if the deviation is, for example, ten kilocycles, then as the carrier frequency swings off to one side of the band, it approaches close to the limit of the filtering system of the receiver. Since the sides of the filter are normally much steeper than the selective system employed to convert the changes in frequency into amplitude variations and since the frequency of the signaling current will have approached to within the range of good audibility of the side of the filter a considerable increase in both audibility and amplitude of the disturbance may occur, caused by the sides of the filter acting as the translating device. This effect is obviously not of importance where a wider frequency swing is employed.

The other source of noise which may occur when the signal frequency swings over the full range is found in systems of all band widths. It was first observed on an unmodulated signal when it was noted that swinging the intermediate frequency from the mid-point to one side or the other by adjustment of the frequency of the first heterodyne produced an increase in the amplitude and a change in the character of the noise. The effect was noted on a balanced detector system and at first it was attributed to the destruction of the amplitude balance as one detector current became greater than the other. Subsequently when it was noted that the increase in the noise was produced by the detector with the smaller current and that the effect was most pronounced when the signal level was relatively low, the explanation became apparent. As long as the signal frequency was set at the mid-point of the band its level in the detector was sufficiently large to prevent the production of audible beats between the noise components lying respectively at the two ends of the band where the reactance of the selective systems is a maximum.

When however the signal frequency moves over to one side of the band the amplitude of the voltage applied to one of the detectors progressively decreases, approaching zero as the frequency coincides with the zero reactance point of the selective system. The demodulating effect of the signaling current therefore disappears and the noise components throughout the band, particularly those at the other side of it, are therefore free to beat with each other. The noise produced is the characteristic one obtained when the high-frequency currents caused by thermal agitation and shot effect are rectified in a detector without presence of a carrier. The effect is not of any great importance on the ordinary working levels for simplex operation, although it may become so in multiplex operation. It indicates, however, that where the signal-to-noise level is low, complete modulation of the received signal by the conversion system is not desirable and that an adjustment of the degree of modulation for various relative noise levels is advantageous.

In the course of a long series of comparisons between the two systems a physiological effect of considerable importance was noted. It was observed that while a root-mean-square meter might show the same reading for two sources of noise, one derived from an amplitude modulation, and the other from a frequency modulation receiver (both of the same fidelity) that the disturbance perceived by the ear was more annoying on the amplitude modulation system. The reason for this is the difference in the distribution of the noise voltage with respect to frequency in the rectified output currents of the two systems, the distribution being substantially uniform in the amplitude system but proportional to frequency in the frequency modulation system. Hence in the latter there is a marked absence of those frequencies which lie in the range to which the ear is the most sensitive. With most observers this difference results in their appraising a disturbance produced in the speaker by an amplitude modulation system as the equivalent of one produced therein by a frequency modulation system of about 1.5 times the root-mean-square voltage although of course the factor varies considerably with the frequency range under consideration and the characteristic of the individual's aural system.

On account of this difference in distribution of energy the correct method of procedure in making the comparison is that given in the article by Ballantine,[16] but lack of facilities for such determinations made necessary the use of a root-mean-square meter for the simultaneous measurement of the entire noise frequency range. The increase in noise voltage per frequency interval with the frequency may be readily demonstrated by means of the ordinary harmonic analyzer of the type now so generally used for the measurement of distortion. Because of the extremely narrow frequency interval of these instruments it is not possible to obtain sufficient integration to produce stable meter readings and apparatus having a wider frequency interval than the crystal filter type of analyzer must be used. The observation of the action of one of these analyzers will furnish convincing proof that peak voltmeter methods must not be used in comparing the rectified output currents in frequency and amplitude modulation receivers.

All the measurements which have been heretofore discussed were taken under conditions in which the disturbing currents had their origin in either thermal agitation or shot effect, as the irregularity of atmospheric disturbances or those due to automobile ignition systems were too irregular to permit reproducible results. The curves apply generally to other types of disturbances provided the disturbing voltage is not greater than that of the signal. When that occurs a different situation exists and will be considered in detail later.

There are numerous second order effects produced, but as they are of no great importance consideration of them will not be undertaken in the present paper.

(The second and concluding part of Major Armstrong's paper, detailing results of transmission tests, will appear in the July issue.)

FM FOR RAILROADS

(CONTINUED FROM PAGE 13)

FM in the face of any proof of its usefulness as a measure of public safety.

No, radio wasn't ready for the railroads when it was so badly needed last year, but woe betide the road that has another such wreck, after radio equipment becomes available for this service, if the officials have continued to stand against it.

That is hardly liable to happen, however, for it is certain that ICC regulations will be adopted to require the use of radio communication by the railroads. As soon as the exhaustive study necessary can be completed, and coördinated with engineering information and FCC planning,[2] such regulations can be expected.

Meanwhile, much preparatory planning is being done by some of the railroads and radio manufacturers. This is in line with Chairman Fly's policy of which he said: "Today, we do not have enough radio materials to immediately meet all military needs and supply any substantial demands from the public. Fortunately, materials are available and will continue to be available for research and experimentation. This again gives us great opportunity to move forward scientifically while we are commercially stalemated by the War. During this time is our easiest and best opportunity to advance the art." (*FM* and T., *May 1944, pg. 15.*)

Meanwhile, on June 5th, J. D. Farrington, chief executive of the Rock Island lines, together with other Company officials, were inaugurating the use of the exact kind of FM radio equipment which, Mr. Triem to the contrary, would have averted the wreck of the Congressional Limited and, in somewhat modified form, would have been equally effective in halting the Tamiami Champion.

"Hello," said Mr. Farrington. "Is this engine 700?" And back came the voice of the Rock Island's superintendent of telegraph, "Hello, Mr. Farrington. Yes, this is engine 700. This is Charley Ellis speaking."

(CONCLUDED ON PAGE 63)

[2] FCC railroad hearing has been set for Sept. 13. Since May 1st, 30 applications have been filed by railroads.

SPOT NEWS NOTES

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

FM Anniversary: July 18, 1944, marks the 5th year since the first FM broadcasting station went on the air. This was Major Armstrong's own station at Alpine, N. J. From that start, the number of FM stations now operating and those for which construction permits have been applied has now passed the 250 mark. First FM tests over a considerable distance were started on June 9, 1934, from the Empire State Building to Westhampton Beach, Long Island, approximately 70 miles.

New York City: FCC has granted modification of the construction permit for Metropolitan Television's station W2XNT. New date set for completion is December 31st.

Stockholders: In Press Wireless are listed in a recent publication from that Company as: Chicago Daily News, Chicago Tribune, Christian Science Publishing Society, N. Y. Times, N. Y. Tribune, Los Angeles Times-Mirror, San Francisco Chronicle, United Press, Associated Press, King features, and North American Newspaper Alliance. Headquarters of the last four are in New York City. In this coöperative enterprise, no one publisher can own more than one-sixth of the total number of shares. (History of this Company was told in *FM*, August, 1943).

FM Station Goes Commercial: FCC has granted commercial status and new call KMBC-FM to developmental station W9XER which has been operated by the Midland Broadcasting Company, Kansas City, Mo. Head of this concern is Arthur B. Church, member of the FMBI board of directors. KMBC-FM, operating on 46.5 mc., will cover 6,700 square miles. Daily schedule will run from noon to midnight.

A. James Ebel: Consultant on antenna design, FM, and interference problems, and technical supervisor of University of Illinois Radio Service, has established offices at 113 W. Washington St., Champaign, Ill.

George Henry Payne: Former member of FCC has been named vice president and a director of Finch Telecommunications, Inc., of Passaic, N. J., pioneers in facsimile development. Mr. Payne was at one time political adviser to the late President Theodore Roosevelt.

Patent Royalties: Reference to FM and television patent situation in address by R.M.A. president Paul Galvin has been construed by some manufacturers as indicating that pressure will be brought to bear on RCA to adjust prewar royalty rate to compensate for added cost of Armstrong FM license payments. During the War, the Government's use of RCA patents was covered by payment of a very large sum as a blanket royalty. Major Armstrong made a similar arrangement, but his charge to Uncle Sam was a token fee of one dollar.

GORDON GRAY, WHO ENTERED ARMY AS A PRIVATE, HAS RISEN TO CAPTAIN'S RANK

Gordon Gray: Lawyer, newspaper publisher, state senator in North Carolina, president of AM station WSJS in Winston-Salem, and licensee of FM station WMIT on Mt. Mitchell, surprised many of his friends by enlisting in the Army as a private shortly after Pearl Harbor.

Upon completing basic training at Camp Wheeler, Ga., he was sent to the Infantry's Officer Candidate Course. In February, 1943 he was commissioned as a 2nd lieutenant, and advanced to the rank of 1st lieutenant the following September. Now, as Assistant Executive Officer of the Infantry School, Fort Benning, he wears a captain's bars.

Television Relay: License has been granted to cover construction permit issued to Television Productions, Inc. for a new experimental television relay station to be used with W6XYZ. The relay will use 100 watts on 204 to 216 mc.

Prewar Factory: A review of the prewar status and activities of Philips Gloeilampedfabrieken, Holland, is contained in a very interesting booklet issued by North American Philips Company, Inc., 100 E. 42nd Street, New York City 17. Pictures show the Eindhoven plant of 78 acres where 20,000 employees made lamps, radio tubes, radio receivers and transmitters, television equipment, X-ray tubes, sound-film equipment, amplifiers, radio communications equipment, and industrial appliances. Four acres housed a laboratory staff of 1,000. Plants in other parts of the world then employed 25,000 additional workers. Philips controlled the major part of South American radio set and tube business. Since 1942, four Philips factories have been set up in the U.S.A.

New TBA Members: Accepted as active members in Television Broadcasters Association are Balaban & Katz Corporation, of Chicago, theatre operators and owners of AM station WGN, FM station WGNB, and television station WBKB; and the *Chicago Tribune*, applicants for a television construction permit. General Electric, already an active member, has been accepted as an affiliate member on behalf of its electronics department.

NYC-Boston Relay: Projected AT & T system of relay stations has been authorized by FCC. (Details in *FM* March, 1944) Relays of 10 watts output will be operated on the following bands:

1,914.04 to 1,925.96 mc.	11.92 mc. wide
1,974.01 to 1,985.99	11.98
2,193.90 to 2,206.10	12.20
2,253.87 to 2,266.13	12.26
3,993.00 to 4,007.00	14.00
4,052.97 to 4,067.03	14.06
4,292.85 to 4,307.15	14.30
4,352.82 to 4,367.18	14.36
11,489.25 to 11,510.75	21.50
11,689.15 to 11,710.85	21.70
12,288.85 to 12,311.15	22.30
12,488.75 to 12,511.25	22.50

Facilities may be used experimentally for telephone and telegraph communications, FM, facsimile, or television programs. Commercial traffic may be handled for test purposes provided that other facilities normally used remain available. No charge may be made for program service handled over the relay system in whole or in part.

Army Communications: Regular traffic handled by the Army Communications Service, of which the huge War Department Signal Center is the focal point, averages upward of 6,000,000 words a day, according to official War Department figures.

NEWS PICTURE

NEW R.M.A. president Raymond C. Cosgrove, right, vice president and general manager of the manufacturing division of The Crosley Corporation, received the official gavel from retiring president Paul V. Galvin, president of the Galvin Manufacturing Company, at the R.M.A.'s Third War Production Conference at Chicago on June 7th. Paul Galvin, who has headed the Association for three years, expressed the hope that Raymond Cosgrove will see the industry through the reconversion period, predicting that some civilian sets may be produced in 1945.

FIG. 3. A CONSOLE MODEL COMBINING FACSIMILE AND SOUND BROADCAST RECEPTION

FACSIMILE BROADCASTING AT STATION WELD

A Report Based on Five Years' Experience with Facsimile Broadcasting

BY LESTER NAFZGER*

AS progressive broadcasters plan for the future, they must consider all of the three new services destined for the postwar period. Few, indeed, are the broadcasters who are not making plans for Frequency Modulation and who are not watching Television closely. The third service available for broadcasting, Facsimile, is of equal importance, although little has been said about it since Pearl Harbor.

It is the purpose of this article to present a review of our experience with Facsimile during the past five years. It is our belief, based on this experience, that *FM* AND TELEVISION magazine, by its series of articles on Facsimile, will perform a real service to the broadcasting industry.

*Chief Engineer of AM station WBNS and FM station WELD, Columbus, Ohio.

Going Back Five Years ★ Our Facsimile station, W8XUM at Columbus, Ohio, has been on the air with a daily radio newspaper since April, 1939. During this period, some 6,000 hours of transmission and 2,500 schedules have given us a background of experience which we would like to share with others in the development and furtherance of Facsimile broadcasting.

It is our hope that Facsimile will be given an equal opportunity with other services now, as a part of future planning, and that all concerned will investigate its possibilities, carefully and thoroughly.

In viewing the examples of Facsimile reception reproduced with this article, it should be remembered that they represent the state of the art of at least seven years ago. The equipment we are still using was to have been replaced in 1941 just when the manufacture of all apparatus was stopped. It can be assumed that many additional improvements have been developed and put into operation during the War. This we know to be true.

Back in April, 1939, WBNS, Incorporated established the Facsimile station W8XUM and, in co-operation with the Columbus Dispatch, put 25 receivers in operation. Our arrangement with the newspaper was based upon their supplying material for broadcasting. By drawing upon the experience and facilities of this newspaper, we were able to publish an outstanding radio newspaper. A page from one of the early issues is reproduced from actual Facsimile reception in Fig. 1. Our transmitting facilities consist of an RCA type 100-F, 100-watt transmitter.

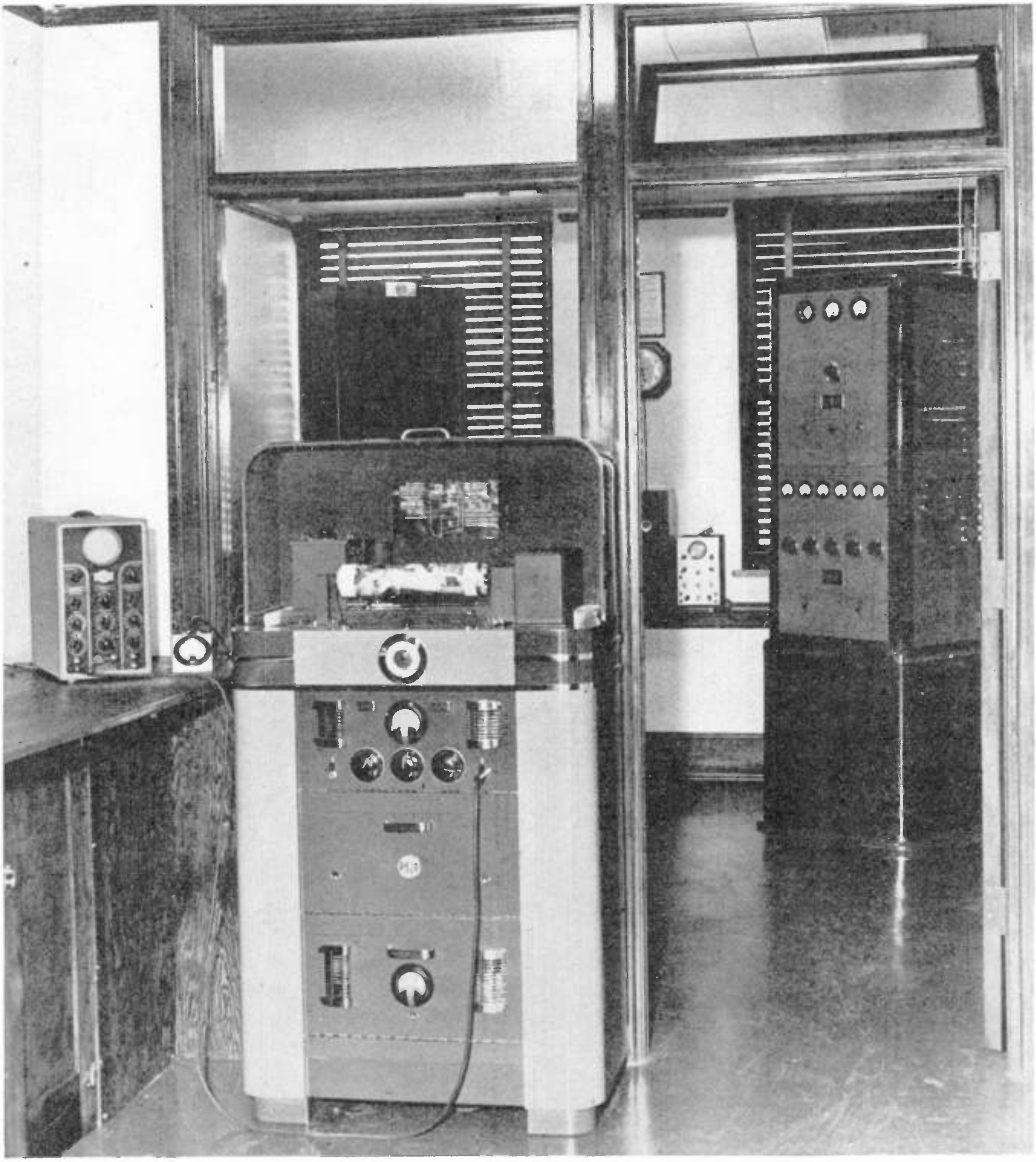


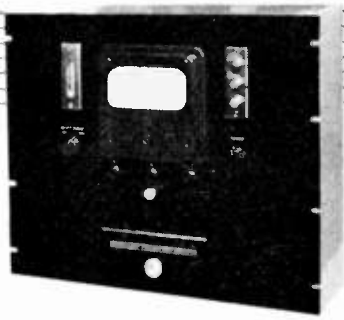
FIG. 2. FOREGROUND, THE FACSIMILE TRANSMITTING MACHINE, WITH A PICTURE ON THE SCANNING DRUM. REAR, THE 100-WATT AM TRANSMITTER NOW USED. LATER, FACSIMILE AND SOUND WILL BE DUPLEXED ON THE WELD FM TRANSMITTER

The Facsimile scanner and receivers are also products of RCA. The complete transmitting installation, Fig. 2, is located in downtown Columbus and operates on a frequency of 25.2 megacycles. Fig. 3 shows the complete receiver. The Facsimile scanner output terminates into 500 ohms. Therefore, we have been able to use it either at the transmitter or at remote points.

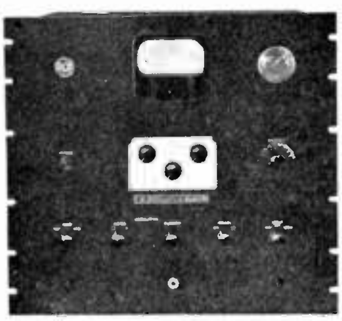
How It Works ★ The operation of the original equipment requires a common power supply for both transmitting scanner and receiving machines, to maintain synchronous operation. Therefore, coverage has been restricted accordingly. Our surveys, however, indicate satisfactory reception over a radius of 25 miles. The new equipment, planned for installation in 1941, eliminated this necessity for a common power supply for scanner and receivers.

Our receivers were first put on display in the downtown area of Columbus for promotional reasons. Later the receivers were installed at homes in the outlying areas. By the proper selection of homes, we were able to survey the attitude of people in a position to buy facsimile receivers when they are available. Covering a sample of 1,600 people, we found a

IN
TEST AND MEASURING
EQUIPMENT



AM MONITORS
For AM Broadcasting the RCA line includes the 311-AB Frequency Monitor shown above and the 66-D Modulation Monitor — both FCC approved types — and the relatively new Type 300-C Phase Monitor, the finest instrument yet designed for adjustment and monitoring of directional antenna arrays.



FM MONITORS
For FM Broadcasting the RCA line before the war included the Type 322-A Modulation Monitor shown above and the Type 336-A Frequency Monitoring Equipment — units which were specifically approved by the FCC for FM station use. Planned for production after the war is a combined modulation and frequency monitor of improved design.

FOR ALL KINDS OF BROADCASTING

RCA manufactures a complete line of broadcast equipment—including not only such operating units as microphones, amplifiers and transmitters, but also such necessary accessories as modulation, frequency and phase monitors; audio measuring equipment; and field intensity meters.

RCA Test and Measuring Equipment units meet all the needs of FM, Television and Short-Wave Broadcasting as well as AM Broadcasting.

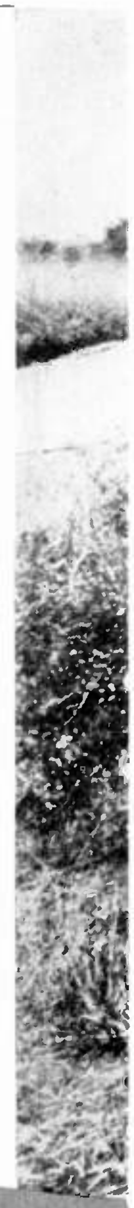
The proof of these RCA equipments is in their widespread use. Almost every broadcast station has one or more; nearly all the networks have several. Other manufacturers use them. The RCA companies—NBC, RCA Communications, Radiomarine Corporation and RCA Laboratories—use them in large numbers.

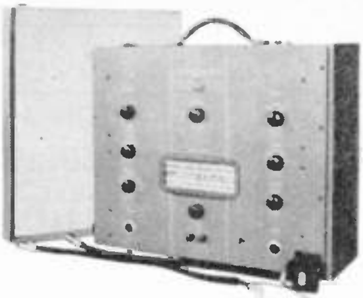
RCA BROADCAST EQUIPMENT

RADIO CORPORATION OF AMERICA

RCA VICTOR DIVISION · CAMDEN, N. J.

LEADS THE WAY . . *IN Radio . . Television . . Tubes . . Phonographs . . Records . . Electronics*



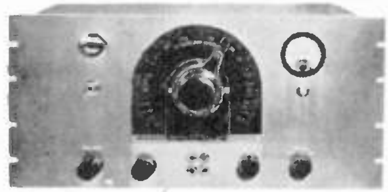


TELEVISION MONITORS

For Television Broadcasting RCA developed and produced the only line of test and monitoring equipment specifically designed for Television use. This line includes the 351-A Video Sweep Oscillator shown above, the 350-A Square-Wave Generator, the 715-A Laboratory-type Oscilloscope and other units of matching design.

AUDIO MEASURING EQUIPMENT

The 68-B Beat Frequency Oscillator (at right) and the 69-C Distortion and Noise Meter (below) are matched units developed for the single purpose of measuring the frequency response, distortion and noise characteristics of broadcast equipment. The only audio measuring units designed especially for the purpose,



they are ideally suited for measurements on separate amplifiers, complete audio channels and transmitters of all types, including AM, FM and Television Audio. These or the preceding models of the same series are in use in nearly every medium or large station, in network studios and in the laboratories and test set-ups of most manufacturers.

FIELD INTENSITY METERS — *RCA field intensity meters have been the industry's standard for over ten years. The latest models are the 308-A Broadcast Field Intensity Meter, covering the range from 120 kc. to 18,000 kc., and the 301-B High-Frequency Field Intensity Meter, covering the range from 20 mc. to 125 mc. They may be used as portables, as shown here, or adapted for permanent mounting in station wagon or truck.*

BUY MORE WAR BONDS

THE NEWS UNROLLS BEFORE YOUR EYES

Columbus Dispatch

MONDAY, MAY 29, 1939
PAGE 11

Co-operating with WBNS through Exp. Sta. W8XUM, 31.6 M. C.
(Ohio's First Newspaper of the Air)

BULLETINS!

CLEVELAND---Stephen Staron, hardware dealer, charged with shooting his wife to death, found hanged in jail cell.

PITTSBURGH---George Slade, Champaign, Ill., sentenced to five years for participation in $116,000 bank holdup.

PORTSMOUTH, N. H. --- Extreme cold ocean forces navy to move sunken submarine Squalus to warmer water before final lifting.

WASHINGTON---Senate judiciary committee approves nomination of L. C. Crawford to U. S. district attorney for southern Ohio.

WASHINGTON---War department asks full report on activities of Kentucky National Guard on duty in coal fields during strike.

WASHINGTON---Neutrality program, lifting arms embargo and widening Roosevelt powers, presented in house.

COLEMAN, MICH.---Vance Blizzard, Midland, Mich., garage mechanic, killed when plane crashes.

LONDON---Air ministry checks report that plane resembling that of Thomas Smith, U. S. flyer on flight from Old Orchard Beach, Me., was sighted 125 miles from London.

Markets At A Glance

NEW YORK

Stocks — Firm; rally follows early dip.

Bonds—Improved; rails in demand.

Curb—Higher; industrials specialties lead upturn.

Foreign Exchange—Steady; sterling up.

Cotton — Lower; foreign hedging.

Sugar—Steady; Cuban demand.

Coffee — Mixed; outside buying; local selling.

CHICAGO

Wheat—About steady.

Corn—Higher.

Cattle—Steady.

Hogs—Fully steady.

Baseball Scores

American Association

St. P.....
Minn.....
Only game scheduled.

American League

N. Y..... 0 1 0 0 3 0
Boston.. 0 1 0 0 0 0

Phila..... 0
Wash.... 1

St. L..... 1
Detroit.. 1
Only games scheduled.

National League

Chic...... 0 0 0
Cin....... 0 0 0

Pitts.....
St. L.....

N. Y..... 0 0 3 0
Phila..... 0 1 0 1
Boston.. 0 0 0 0 0
Bklyn.... 0 0 0 0 0

BULLETINS---BASEBALL!

FIG. 1. LINECUT REPRODUCTION OF FACSIMILE RECEPTION OF TRANSMITTED COPY THAT HAD BEEN SET IN TYPE

WELDRADIONEWS
COLUMBUS, OHIO

PAGE 3 Air-published through Exp. Sta. W8XUM. 25.2 Mc. MAY 13, 1944

NEWS AT A GLANCE

NEW YORK--Secretary of State Cordell Hull and Commerce Secretary Jesse Jones predict that private business men in the western hemisphere will find Great Opportunities for economic progress in the post-war period. The views were expressed in messages read to the first Conference of Commissions of Inter-American Development.

Jones declared that the success of the transition from war to peace production will depend upon the experience of business management and the initiative of free men. Hull asserted that the conference could provide leadership for what he termed the almost unlimited opportunities and possibilities in the post-war era.

NEW ORLEANS--A chemist for the Federal Department of Agriculture reveals that the production of tung oil can be increased 15 per cent by a new chemical process of extraction. The process was made known to the American Oil Chemists' Society in New Orleans today by R. S. McKihney. Tung oil is used for a variety of purposes, including wire insulation, waterproofing of airplane wings and paints and varnishes.

FROM THE SOUTH PACIFIC comes a story of a real blessing that rained down on a group of Navy Seabees.

After a day of hard work the sailors wanted to relax. They thought of football or baseball. But they didn't have a ball. The next day, while clearing a strip of jungle, the Seabees cut down a cocoanut tree. Wedged in the top, the Seabees found a regulation football. How did it get there?

The men are not trying to explain. They're just playing with the ball and having a lot of fun.

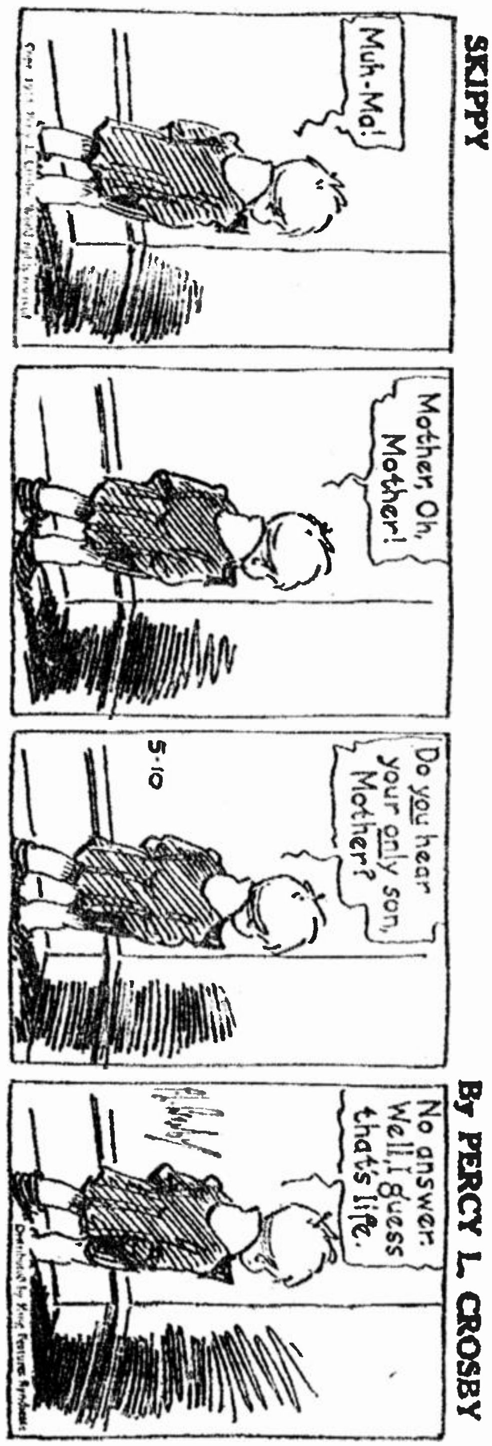


FIG. 4. LINECUT REPRODUCTION OF RECEIVED COPY WHEN ORIGINAL WAS TYPED, AND COMBINED WITH LINE DRAWING

PHOTOGRAPH THIS HALFTONE WAS MADE DIRECTLY FROM AN ORIGINAL PHOTOGRAPH. THE PHOTOGRAPH WAS THEN TRANSMITTED BY FACSIMILE, AND THE HALFTONE OPPOSITE WAS MADE FROM THE RECEIVED PICTURE

most favorable attitude on the part of the public toward Facsimile, as the state of the art existed at that time. The survey disclosed what the public expects of Facsimile, and we know all of the conditions would have been met by the equipment planned for installation in 1941.

When our agreement with the newspaper terminated we decided to program the station with our own staff. Our major problem was some method of printing which would be comparable to that provided by the newspaper. For this phase of our work, we selected a Vari-typer. The Vari-typer is an electric typewriter, operating with a carbon paper tape, affording a selection of type sizes and styles, and an arrangement whereby the right hand margin is maintained evenly. We found this electric typewriter to be easily operated by an experienced typist and to fulfill our needs. It has the additional advantage of speed, for within a few minutes copy could be made available for transmission, and news flashes typed on gummed paper could be inserted in the transmission schedule without delay. An example of the typing will be seen in Fig. 4.

In the course of our program experiments, many different sizes and styles of type have been used. For general copy we found that type sizes of 10, 12, and 14 points to be most satisfactory for text, and of course large type is available for headlines. A detailed account of the extent of our experimentations in the program field would require far more space than is available here. However, they will be described briefly.

It will be of interest to review the makeup of a facsimile radio newspaper from the original copy to actual home re-

FACSIMILE TO PERMIT COMPARISON OF THE ORIGINAL PHOTO AND THE QUALITY OF FACSIMILE PICTURES, THIS HALFTONE WAS MADE FROM A RECEIVED PICTURE. A CLOSE EXAMINATION IS REQUIRED TO DETECT THE DIFFERENCE

ception. First, the editor selects the pictures, comics and news material. Special care is given to the pictures, since they must contain a maximum of detail and contrast, so as to be most suitable for our transmission system. While any picture can be transmitted, we attempt to take advantage of the Facsimile system's maximum capabilities. We are able to transmit 8 shadings of contrast, permitting excellent reproduction. Only photographs are used, since screened halftones of less than 150 lines per inch will result in streaked reproduction. That is because the scanner beam falls between the dots of a coarse-screen picture.

The pictures and comics selected are then outlined on master pages as to space required. This is done with a red pencil since the scanner photocell tube is not panchromatic and therefore reproduces only black. The red pencil is thus a convenient time saver. Next the descriptive captions for the pictures and the news material is typed on a regular typewriter. By counting the letters required for the desired length of line, it is possible to set the electric typewriter margin justifier to provide an even right hand margin. The material is then typed on the master pages with the electric typewriter, and the pictures and comics are pasted within the outlines previously marked off. To prevent cracking and shrinkage, pictures and comics are pasted with rubber cement. The headings of the master pages are printed in ink, with only the date, page, and volume numbers to be typed in with the electric typewriter.

The master copy is then placed on the scanner drum of the Facsimile machine.

(CONTINUED ON PAGE 58)

FM & TELEVISION PRODUCTS DIRECTORY

The Radio Engineers' & Purchasing Agents' Guide to Essential Materials, Components, and Equipment

★ Indicates advertiser in this issue of FM and TELEVISION

SUPPLY HOUSES

CALIFORNIA
SAN FRANCISCO, Zack Radio Supply Co., 1426 Market St.

CONNECTICUT
BRIDGEPORT, Hatry & Young, 117 Cannon St.
HARTFORD
Hatry & Young, 203 Ann St.
Scell & Co., 227 Asylum St.
NEW HAVEN, Hatry & Young, 1172 Chapel St.

DISTRICT OF COLUMBIA
WASHINGTON, Southern Wholesalers, Inc., 1519 L St. N. W.

GEORGIA
ATLANTA
Lafayette Radio Corp., 265 Peachtree St.
Yancey Co., Inc., W. Peachtree St.
MACON, Specialty Dist. Co.
SAVANNAH, Specialty Dist. Co.

ILLINOIS
CHICAGO
Allied Radio Corp., 833 W. Jackson Blvd.
Chicago Radio App. Co., 4155 S. Dearborn St.
Lafayette Radio Corp., 901 W. Jackson Blvd.
Radio Parts Co., 612 W. Randolph St.
Walker-Jimieson, Inc., 311 S. Western Ave.
ELGIN, Fox Elec. Supply Co., 67 N. State St.
PEORIA, Klaus Radio & Elec. Co., Main St.

INDIANA
INDIANAPOLIS, Kiefer-Stewart Co., W. Georgia St.

IOWA
CEDAR RAPIDS, Checker Elec. Supply, Inc., 1st S. E.
DAVENPORT, Midwest-Timmerman Co., Western Ave.

KENTUCKY
LOUISVILLE, Smith Dist. Co., E. B'way

MARYLAND
BALTIMORE, D & H Distributing Co., 202 S. Pulaski St.

MASSACHUSETTS
BOSTON, Radio Wire Television, Inc. 110 Federal St.
CAMBRIDGE, Eastern Co.
SPRINGFIELD, Cushing, T. F.
WORCESTER, Radio Maint. Supply Co.

MICHIGAN
FLINT, Shand Radio Spec., W. Kearsley St.

MISSOURI
★ KANSAS CITY, Burstein Applebee Co., 1012 McGee St.
ST. LOUIS, Interstate Supply Co., 10th & Walnuts Sts.

NEW JERSEY
NEWARK
Radio Wire Television, Inc., 24 Central Ave.
Krich-Radisco, Inc., 422 Elizabeth Ave.
Lippman & Co., Aaron, 246 Central Ave.

NEW YORK
BINGHAMTON, Morris Distributing Co., Inc., 25 Henry St.
GLOVERSVILLE, Fulton County Dist. Co.
ITHACA, Stallman of Ithaca, N. Tioga St.
NEW YORK
Bruno-New York, Inc., 460 W. 34th St.
Com. Radio-Sound Corp., 570 Lexington Ave.
Harrison Radio Corp., 12 W. B'way
Radio Wire Television, Inc., 100 Sixth Ave.
Sanford Electronics Corp., 136 Liberty St.
Sun Radio & Electronics Co., 212 Fulton St.
Terminal Radio Corp., 85 Cortlandt St.
SYRACUSE, Morris Distributing Co., Inc., 412 S. Clinton St.

NORTH CAROLINA
RALEIGH, Southeastern Radio Supply Co., E. Hargett St.

OHIO
CLEVELAND, Goldhamer, Inc., Huron Rd.

PENNSYLVANIA
HARRISBURG, D & H Distributing Co., 3115 Cameron St.
PHILADELPHIA, Radio Elec. Service Co., 7th & Arch Sts.
PITTSBURGH, Cameradio Co., 963 Liberty St.
WILLIAMSPORT, Williamsport Auto Parts Co.

RHODE ISLAND
PROVIDENCE, Edwards Co., W. H., 94 B'way

SOUTH DAKOTA
SIOUX FALLS, Power City Radio Co., S. Main Ave.

TENNESSEE
KNOXVILLE, McClung Co., C. M.
MEMPHIS, Bluff City Dist. Co., Union Ave.
NASHVILLE, Electra Dist. Co., W. End Ave.

TEXAS
HOUSTON, Hall, R. C. & L. F., Caroline St.

UTAH
SALT LAKE CITY, Radio Studios, Inc., E. B'way

VIRGINIA
DANVILLE, Five Forks Battery Station
RICHMOND, Wyatt-Cornick, Inc., Grace St.

WASHINGTON
SEATTLE
Seattle Radio Supply, Inc., 2nd Ave.
Sobrist Co., 2016 Third Ave.

WEST VIRGINIA
CHARLESTON, Chemcity Radio Elec. Co., E. Washington St.
MORGANTOWN, Trenton Radio Co.

WISCONSIN
RACINE, Standard Radio Parts Co., State St.

NEW LISTINGS ADDED THIS MONTH

Company addresses will be found in the Directory listings

We shall be pleased to receive suggestions as to company names and hard-to-find items which should be added to this Directory

NOTE: For the convenience of engineers and purchasing agents, we have added, under the heading "SUPPLY HOUSES," a list of parts jobbers in 48 cities. These houses carry large stocks of components, instruments, and tubes, and are prepared to fill mail or telegraph orders.

ANTENNAS, Mobile Whip & Collapsible
Bendix Aviation Corp., Pacific Div.

CHOKES, AF
Hadley Co., R. M.

CHOKES, RF
Fast & Co., John E.

COIL FORMS
Northeastern Molding, Inc.

CONTACT POINTS
Fansteel Metallurgical Corp.

CRYSTAL HOLDERS
Howard Mfg. Co.

FACSIMILE EQUIPMENT
Bunnell & Co., J. H.
Faximile, Inc.
Federal Tel. & Radio Corp.
Finch Telecommunications, Inc.
Press Wireless, Inc.
RCA Mfg. Co.

FILTERS, Electrical Noise
Bendix Aviation Corp., Pacific Div.
Solar Mfg. Corp.

FREQUENCY STANDARDS, Quartz Secondary
Higgins Industries, Inc.

HANDSETS, Telephone
Automatic Electric Co.
Western Electric Co.

HORNS, Outdoor
Altec Lansing Corp.

IRONS, Soldering
Sound Equipment Corp. of Calif.

KNOBS, Radio & Instrument
Northeastern Molding, Inc.

LABELS, Coding
Western Litho. Co.

LABELS, Removable
Western Litho. Co.

LABELS, Stick-to-Metal
Western Litho. Co.

LUGS, Solderless
Thomas & Betts Co.

METERS, Frequency
Higgins Industries, Inc.

MOTOR-GENERATORS, Rotary Converters
Bendix Aviation Corp., Pacific Div.

MOTOR-GENERATORS, Small
Bendix Aviation Corp., Pacific Div.

NAME PLATES, Plastic
Virginia Plate Co.

RADIO RECEIVERS & TRANSMITTERS
Higgins Industries, Inc.
Bendix Aviation Corp., Pacific Div.

RELAYS, Small Switching
Advance Elec. Co.
Automatic Elec. Co.
Bendix Aviation Corp., Pacific Div.

RELAYS, Small Telephone Type
Advance Elec. Co.

RELAYS, Time Delay
Advance Elec. Co.
Automatic Elec. Co.

SOLDER POTS
Sound Equip. Corp. of Calif.

SPEAKERS, Cabinet Mounting
Altec Lansing Corp.

SPEAKERS, Outdoor Type
Altec Lansing Corp.

STAMPINGS, Metal
Hadley Co., R. M.

SWITCHES, Rotary, Ceramic Wafer
Comm. Prods. Co.

TRANSFORMERS, Receiver Audio & Power
Altec Lansing Corp.
Hadley Co., R. M.

TRANSFORMERS, IF, RF
Sound Equip. Corp. of Calif.

VARNISHES, Insulating, Air-Drying & Baking
Comm. Prods. Co.

AIRPORT RADIO Installations
Aircraft Accessories Corp., Funston Rd., Kansas City, Kans.
Air Associates, Inc., Los Angeles, Calif.
Bendix Radio, Towson, Md.
Communications Equip. Corp., 134 Colorado St., Pasadena, Calif.
Erco Radio Labs. Inc., Hempstead, L. I., N. Y.
Radio Receptor Co., Inc., 251 W. 19 St., N. Y. C.

ANTENNAS, Mobile Whip & Collapsible
Aircraft Accessories Corp., Funston Rd., Kansas City, Kans.
Bendix Aviation Corp., Pacific Div., 116 Sherman Way, N. Hollywood
Birnbach Radio Co., 145 Hudson St., N. Y. C.
Brach Mfg. Corp., L. S., Newark, N. J.
Camburn Elec. Co., 484 Broome St., N. Y. C.
★ Galvin Mfg. Corp., Chicago, Ill.
★ Link, F. M., 125 W. 17th St., N. Y. C.
Premax Products, 4214 Highland Ave., Niagara Falls, N. Y.
★ Radio Eng. Labs., Inc., L. I. City, N. Y.
★ Snyder Mfg. Co., Noble & Darien Sts., Phila.
Tech. Appl. Co., 516 W. 34 St., N. Y. C.
Ward Products Corp., 1523 E. 45 St., Cleveland, O.

ANTENNAS, Tower Type
Blaw-Knox Co., Pittsburgh, Pa.
★ Harco Steel Cons. Co., E. Broad St., Elizabeth, N. J.
Lehigh Structural Steel Co., 17 Battery Pl., N. Y. C.
★ Lingo & Son, John E., Camden, N. J.
Truscon Steel Co., Youngstown, O.
★ Wincharger Corp., Sioux City, Iowa

ATTENUATORS
Cinema Engineering Co., Burbank, Calif.
Daven Co., Summit Ave., Newark, N. J.
General Radio Co., Cambridge, Mass.
International Resistance Co., 429 Broad St., Phila.
Mallory & Co., P. R., Indianapolis, Ind.
Ohmite Mfg. Co., 4835 W. Flournoy St., Chicago
Remler Co., Ltd., 2101 Bryant St., San Francisco
Shallcross Mfg. Co., Collingdale, Pa.
Tech Laboratories, Lincoln St., Jersey City, N. J.
Utah Radio Prod. Co., 842 Orleans St., Chicago

BEADS, Insulating
Amer. Lava Corp., Chattanooga, Tenn.
Corning Glass Works, Corning, N. Y.
Dunn, Inc., Struthers 1321 Cherry, Phila., Pa.
Star Porcelain Co., Trenton, N. J.
Steward Mfg. Co., Chattanooga, Tenn.

BEARINGS, Glass Instrument
Bird, Richard H., Waltham, Mass.

BINDING POSTS, Plain
Amer. Hdware Co., Mt. Vernon, N. Y.
Franklin Mfg. Corp., 175 Varick St., N. Y. C.
Radex Corp., 1308 Elston Ave., Chicago

BINDING POSTS, Push Type
Amer. Radio Hdware Co., Mt. Vernon, N. Y.
Eby, Inc., H. H., W. Chelten Ave., Phila.

BLOWERS, for Radio Equipment
L-R Mfg. Co., Torrington, Conn.
Trade-Wind Motorfans, Inc., 5725 S. Main St., Los Angeles

BOOKS on Radio & Electronics
Macmillan Co., 60 Fifth Ave., N. Y. C.
Maedel Pub. House, 593AE 38 St., Bklyn, N. Y.
McGraw-Hill Book Co., 330 W. 42 St., N. Y. C.
Pitman Pub. Corp., 2 W. 45 St., N. Y. C.
Radio Tech. Pub. Co., 45 Astor Pl., N. Y. C.
Rider, John F., 404 Fourth Ave., N. Y. C.
Ronald Press Co., 15 E. 26 St., N. Y. C.
Van Nostrand Co., D., 250 Fourth Ave., N. Y. C.
Wiley & Sons, John, 440 Fourth Ave., N. Y. C.

BRIDGES, Percent Limit Resistance
Leeds & Northrup Co., 4901 Stenton Ave., Phila.
Radio City Products Co., 127 W. 26 St., N. Y. C.
Shallcross Mfg. Co., Collingdale, Pa.

BRIDGES, Wheatstone
Industrial Instruments, Inc., Culver Ave., Jersey City, N. J.

Leeds & Northrup Co., 4901 Stenton Ave., Phila.
Shallcross Mfg. Co., Collingdale, Pa.

BUSHINGS, Hermetic Sealing

Corning Glass Works, Corning, N. Y.
Westinghouse Elect. & Mfg. Co., E. Pittsburgh, Pa.

BUSHINGS, Terminal Sealing

Corning Glass Works, Corning, N. Y.
Peerless Electrical Prod. Co., 6920 McKinley Ave., Los Angeles 1
Westinghouse Elect. & Mfg. Co., E. Pittsburgh, Pa.

CABINETS, Metal

Par-Metal Prod. Corp., 32-49th St., L. I. City, N. Y.
Insuline Corp. of Amer., Long Island City, N. Y.

CABINETS, Wood, for Home Radios

Churchill Cabinet Co., 2119 Churchill St., Chicago
Tillotson Furniture Co., Jamestown, N. Y.

CABLE, Coaxial

★ American Phenolic Corp., 1830 S. 54 Av., Chicago
Anaconda Wire & Cable Co., 25 B'way, N. Y. C.
★ Andrew Co., Victor J., 363 E. 75 St., Chicago
Belden Mfg. Co., 4673 W. Van Buren, Chicago
Boston Insulated Wire & Cable Co., Boston
Comm. Prods. Co., 744 Broad, Newark, N. J.
Cornish Wire Co., 15 Park Row, N. Y. C.
Doolittle Radio, Inc., 7521 S. Loomis Blvd., Chicago
General Cable Corp., 420 Lexington, N. Y. C.
General Insulated Wire Corp., 53 Park Pl., N. Y. C.
Johnson Co., E. F., Waseca, Minn.
★ Lenz Electrical Mfg. Co.
Radex Corp., 1308 Elston Ave., Chicago
Simplex Wire & Cable Corp., Cambridge, Mass.

CABLE, Coaxial, Solid Dielectric

American Phenolic Corp., 1830 S. 54 Ave., Chicago
Federal Tel. & Radio Corp., E. Newark, N. J.
Simplex Wire & Cable Corp., Cambridge, Mass.

CABLE, Microphone, Speaker & Battery

Alden Prods. Co., Brockton, Mass.
Anaconda Wire & Cable Co., 25 Broadway, N. Y. C.
Belden Mfg. Co., 4633 W. Van Buren, Chicago
Boston Insulated Wire & Cable Co., Dorchester, Mass.
Gavett Mfg. Co., Brookfield, Mass.
Holyoke Wire & Cable Corp., Holyoke, Mass.
★ Universal Microphone Co., Inglewood, Calif.

CABLES, Preformed

Belden Mfg. Co., 4633 W. Van Buren St., Chicago
Wallace Mfg. Co., Wm. T., Rochester, Ind.

CASES, Wooden Instrument

Hoffstatter's Sons, Inc., 43 Ave. & 24 St., Long Island City, N. Y.
Tillotson Furniture Co., Jamestown, N.Y.

CASTINGS, Die

Aluminum Co. of Amer., Pittsburgh, Pa.
American Brass Co., Waterbury, Conn.
Dow Chemical Co., Dow Metal Div., Midland, Mich.

CERAMICS, Bushings, Washers, Special Shapes

Akron Porcelain Co., Akron, O.
Amer. Lava Corp., Chattanooga, Tenn.
Centralab. Div. of Globe-Union Inc., Milwaukee, Wis.
Corning Glass Works, Corning, N. Y.
Electronic Mechanics, Inc., Paterson, N. J.
Gen'l Ceramics & Steatite Corp., Keasbey, N. J.
Isolantite, Inc., Belleville, N. J.
Lapp Insulator Co., Leroy, N. Y.
Lenox, Inc., Trenton, N. J.
Louthan Mfg. Co., E. Liverpool, O.
Star Porcelain Co., Trenton, N. J.
Steward Mfg. Co., Chattanooga, Tenn.
Stupakoff Ceramic & Mfg. Co., Latrobe, Pa.
Victor Insulator Co., Victor, N. Y.
Westinghouse Elect. & Mfg. Co., E. Pittsburgh, Pa.

CHASSIS, Metal

See STAMPINGS, Metal

CHOKES, AF

Hadley Co., R. M., 707 E. 61 St., Los Angeles

CHOKES, RF

Aladdin Radio Industries, 501 W. 35th, Chicago
Alden Prods. Co., Brockton, Mass.
American Communications Corp., 306 B'way, N. Y. C.
Barker & Williamson, Upper Darby, Pa.
Coto-Coil Co., Providence, R. I.
D-X Radio Prods. Co., 1575 Milwaukee, Chicago
Fast & Co., John E., 3109 N. Crawford, Chicago 41
Gen. Winding Co., 420 W. 45 St., N. Y. C.
Guthman & Co., Edwin, 15 S. Throop, Chicago
★ Hammarlund Mfg. Co., 424 W. 33 St., N. Y. C.
Johnson Co., E. F., Waseca, Minn.
Lectrohm, Inc., Cicero, Ill.
Meissner Mfg. Co., Mt. Carmel, Ill.
Miller Co., J. W., 5917 S. Main, Los Angeles, Cal.
Muter Co., 1255 S. Michigan, Chicago
★ National Co., Malden, Mass.
Ohmite Mfg. Co., 4835 W. Flournoy St., Chicago
Radex Corp., 1328 Elston Av., Chicago
Sickles Co., F. W. Chicopee, Mass.
Teleradio Eng. Corp., 484 Broome St., N. Y. C.
Triumph Mfg. Co., 913 W. Van Buren St., Chicago

CLIPS, Connector

Mueller Electric Co., Cleveland, O.

CLIPS & MOUNTINGS, Fuse

Alden Prods. Co., Brockton, Mass.
Dante Elec. Mfg. Co., Bantam, Conn.
Ilsco Copper Tube & Prods., Inc., Station M., Cincinnati
Jefferson Elec. Co., Bellwood, Ill.
Jones, Howard B., 2300 Wabansia, Chicago
Littlefuse, Inc., 4753 Ravenswood, Chicago
Patton MacGuyer Co., Providence, R. I.
Sherman Mfg. Co., H. B., Battle Creek, Mich.
Stewart Stamping Co., 621 E. 216 St., Bronx, N. Y.
Zierick Mfg. Co., 385 Girard Ave., Bronx, N. Y. C.

SCHEDULE OF DIRECTORIES

FM & TELEVISION PRODUCTS DIRECTORY

February, April, June, August, October, December

BROADCAST STATIONS

General Managers & Chief Engineers — March, September

EMERGENCY RADIO STATIONS

Radio Supervisors — January, July

RADIO MANUFACTURERS

General Managers & Chief Engineers — May, November

Under this schedule, FM and TELEVISION presents up-to-date listings, with complete corrections and additions, available in no other publication.

CLOTH, Insulating

Acme Wire Co., New Haven, Conn.
Brand & Co., Wm., 276-4th Av., N. Y. C.
Endurette Corp. of Amer., Cliffwood, N. J.
Insulation Mfgrs. Corp., 565 W. Wash. Blvd., Chicago
Irvington Varnish & Insulating Co., Irvington, N. J.
Mica Insulator Co., 196 Varick, N. Y. C.

COIL FORMS, Glass

Corning Glass Works, Corning, N. Y.

COIL FORMS, Phenolic

Creative Plastics Corp., 963 Kent Ave., B'klyn, N. Y.
Northeastern Molding, Inc., 534 Commonwealth Ave., Boston 15, Mass.

COILS, Radio

See Transformers, IF, RF

CONDENSERS, Ceramic Case Mica Transmitting

★ Aerovox Corp., New Bedford, Mass.
Cornell-Dubilier, S. Plainfield, N. J.
★ RCA Mfg. Co., Inc., Camden, N. J.
Sangamo Electric Co., Springfield, Ill.
Solar Mfg. Corp., Bayonne, N. J.

CONDENSERS, Fixed

★ Aerovox Corp., New Bedford, Mass.
★ American Condenser Corp., 2508 S. Michigan, Chicago
Art Radio Corp., 115 Liberty, N. Y. C.
Atlas Condenser Prods. Co., 548 Westchester Ave., N. Y. C.
Automatic Winding Co., E. Newark, N. J.
Bud Radio, Inc., Cleveland, O.
Capacitrons, Inc., 318 W. Schiller St., Chicago
Centralab, Milwaukee, Wis.
Condenser Corp. of America, South Plainfield, N. J.
Condenser Prods. Co., 1375 N. Branch, Chicago
Cornell-Dubilier Elec. Corp., S. Plainfield, N. J.
Cosmic Radio Co., 699 E. 135th St., N. Y. C.
Crowley & Co., Henry, W. Orange, N. J.
Deutschmann Corp., Tobe, Canton, Mass.
Dumont Elec. Co., 34 Hubert St., N. Y. C.
Electro-Motive Mfg. Co., Willimantic, Conn.
Erie Resistor Corp., Erie, Pa.
★ Fast & Co., John E., 3109 N. Crawford, Chicago 41
General Radio Co., Cambridge, Mass.
Girard-Hopkins, Oakland, Calif.
Guthman & Co., Edwin I., 15 S. Throop St., Chicago
H. R. S. Prods, 5707 W. Lake St., Chicago
Illinois Cond. Co., 1160 Howe St., Chicago
Industrial Cond. Corp., 1725 W. North Av., Chicago
Insuline Corp. of America, Long Island City, N. Y.
Johnson Co., E. F., Waseca, Minn.
Magnavox Co., Fort Wayne, Ind.
Mallory & Co., P. R., Indianapolis, Ind.
Micamold Radio Corp., Brooklyn, N. Y.
Muter Co., 1255 S. Michigan, Chicago
Noma Electric Corp., 55 W. 13 St., N. Y. C.
Polymet Condenser Co., 699 E. 139 St., N. Y. C.
Potter Co., 1950 Sheridan Rd., N. Chicago
★ RCA Mfg. Co., Camden, N. J.
Sangamo Elec. Co., Springfield, Ill.
Sickles Co., F. W., Chicopee, Mass.
Solar Mfg. Corp., Bayonne, N. J.
Sprague Specialists Co., N. Adams, Mass.
Teleradio Engineering Corp., 484 Broome St., N. Y. C.
Westinghouse Elect. & Mfg. Co., E. Pittsburgh, Pa.

CONDENSERS, Gas-filled

Lapp Insulator Co., Inc., Leroy, N. Y.

CONDENSERS, High-Voltage Vacuum

Centralab, Milwaukee, Wis.
★ Eitel-McCullough, Inc., San Bruno, Calif.

Erie Resistor Corp., Erie, Pa.
★ General Electric Co., Schenectady, N. Y.
General Electronics, Inc., Paterson, N. J.

CONDENSERS, Small Ceramic Tubular

Centralab; Div. of Globe-Union, Inc., Milwaukee, Wis.
Erie Resistor Corp., Erie, Pa.

CONDENSERS, Variable Receiver Tuning

Alden Prods. Co., Brockton, Mass.
American Steel Package Co., Defiance, Ohio
Barker & Williamson, Ardmore, Pa.
Bud Radio, Inc., Cleveland, O.
Cardwell Mfg. Corp., Allen D., Brooklyn, N. Y.
General Instrument Corp., Elizabeth, N. J.
★ Hammarlund Mfg. Co., 424 W. 34th St., N. Y. C.
Insuline Corp. of Amer., L. I. City, N. Y.
Meissner Mfg. Co., Mt. Carmel, Ill.
Millen Mfg. Co., Malden, Mass.
★ National Co., Malden, Mass.
Oak Mfg. Co., 1267 Clybourn Ave., Chicago
Radio Condenser Co., Camden, N. J.
Rauland Corp., Chicago, Ill.

CONDENSERS, Variable Transmitter Tuning

Barker & Williamson, Upper Darby, Pa.
Bud Radio, Cleveland, O.
Cardwell Mfg. Corp., Allen D., Brooklyn, N. Y.
★ Hammarlund Mfg. Co., 424 W. 33 St., N. Y. C.
Insuline Corp. of Amer., L. I. City, N. Y.
Johnson, E. F., Waseca, Minn.
Millen Mfg. Co., James, Malden, Mass.
★ National Co., Malden, Mass.
Radio Condenser Co., Camden, N. J.

CONDENSERS, Variable Trimmer

Alden Prods. Co., Brockton, Mass.
American Steel Package Co., Defiance, O.
Bud Radio, Inc., Cleveland, O.
Cardwell Mfg. Corp., Brooklyn, N. Y.
Centralab, Milwaukee, Wis.
Fada Radio & Elec. Corp., Long Island City, N. Y.
General Radio Co., Cambridge, Mass.
Guthman, Inc., E. I., 400 S. Peoria, Chicago
★ Hammarlund Mfg. Co., 424 W. 33 St., N. Y. C.
Insuline Corp. of America, Long Island City, N. Y.
Johnson Co., E. F., Waseca, Minn.
Mallory & Co., Inc., P. R., Indianapolis, Ind.
Meissner Mfg. Co., Mt. Carmel, Ill.
Millen Mfg. Co., James, Malden, Mass.
Miller Co., J. W., Los Angeles, Cal.
Muter Co., 1255 S. Michigan Av., Chicago
★ National Co., Malden, Mass.
Potter Co., 1950 Sheridan Rd., N. Chicago
Sickles Co., F. W., Chicopee, Mass.
Solar Mfg. Corp., Bayonne, N. J.
Teleradio Eng. Corp., 484 Broome, N. Y. C.

CONNECTORS, Cable

Aero Electric Corp., Los Angeles, Calif.
Airadio, Inc., Stamford, Conn.
Alden Prods., Brockton, Mass.
Amer. Microphone Co., 1915 S. Western Av., Los Angeles
★ Amer. Phenolic Corp., 1830 S. 54th St., Chicago
Amer. Radio Hdware Co., Mt. Vernon, N. Y.
★ Andrew, Victor J., 363 E. 75 St., Chicago
Astatic Corp., Youngstown, O.
Atlas Sound Corp., 1442 39th St., Brooklyn, N. Y.
Birnbach Radio, 145 Hudson St., N. Y. C.
Breeze Mfg. Corp., Newark, N. J.
Brush Development Co., Cleveland, O.
Bud Radio, Cleveland, Ohio
Cannon Elec. Development, 3209 Humboldt, Los Angeles
Eby, Inc., Hugh H., Philadelphia
Electro Voice Mfg. Co., South Bend, Indiana
Franklin Mfg. Corp., 175 Varick St., N. Y. C.
General Radio Co., Cambridge, Mass.
Harwood Co., 747 N. Highland Ave., Los Angeles
Insuline Corp. of Amer., L. I. City, N. Y.
Jones, Howard B., 2432 W. George, Chicago
Mallory & Co., P. R., Indianapolis, Ind.
Monowatt Electric Co., Providence, R. I.
Northam Warren Corp., Stamford, Conn.
Radio City Products Co., 127 W. 26 St., N. Y. C.
Remler Co., Ltd., 2101 Bryant St., San Francisco
Schott Co., W. L., 9306 Santa Monica Blvd., Beverly Hills, Calif.
Selectar Mfg. Co., L. I. City, N. Y.
★ Universal Microphone Co., Ltd., Inglewood, Calif.

CONTACT POINTS

Brainin Co., C. S., 233 Spring St., N. Y. C.
Callite Tungsten Corp., Union City, N. J.
Fansteel Metallurgical Corp., N. Chicago, Ill.
Mallory & Co., Inc., P. R., Indianapolis, Ind.

COUPLINGS, flexible

Cardwell Mfg. Corp., Brooklyn, N. Y.
Johnson Co., E. F., Waseca, Minn.
Millen Mfg. Co., James, Malden, Mass.
★ National Co., Inc., Malden, Mass.

CRYSTAL GRINDING EQUIPMENT

Cons. Diamond Saw Blade Corp., Yonkers Ave., Yonkers 2, N. Y.
Felker Mfg. Co., Torrance, Calif.

CRYSTAL HOLDERS

REC Mfg. Co., Holliston, Mass.
Howard Mfg. Co., Council Bluffs, Ia.

CRYSTALS, Quartz

Aircraft Accessories Corp., Funston Rd., Kansas City, Kans.
Bausch & Lomb Optical Co., Rochester, N. Y.
Bliley Elec. Co., Erie, Penna.
Collins Radio Co., Cedar Rapids, Iowa
Crystal Prod. Co., 1519 McGee St., Kansas City, Mo.
Crystal Research Labs., Hartford, Conn.
DX Crystal Co., 1200 N. Claremont, Chicago
Electronic Research Corp., 800 W. Washington Blvd., Chicago
Federal Engineering Co., 37 Murray St., N. Y. C.
★ General Electric Co. Schenectady, N. Y.
General Radio Co., Cambridge, Mass.
Harvey-Wells Communications, Southbridge, Mass.
Henney Motor Co., Omaha, Nebr.
Higgins Industries, Santa Monica, Calif.
Hipower Crystal Co., 2035 W. Charleston, Chicago
Hunt & Sons, G. C., Carlisle, Pa.
Jefferson, Inc., Ray, Westport, L. I., N. Y.
Kaar Engineering Co., Palo Alto, Cal.
Knights Co., The James, Sandwich, Ill.
Meck Industries, John, Plymouth, Ind.
Miller, August E., North Bergen, N. J.
Monitor Piezo Prod. Co., S. Pasadena, Calif.
Peterson Radio, Council Bluffs, Iowa
Precision Piezo Service, Baton Rouge, La.
Premier Crystal Labs., 63 Park Row, N. Y. C.
Quartz Laboratories, 1512 Oak St., Kansas City, Kans.
Radell Corp., Guilford Ave., Indianapolis, Ind.
★ RCA Mfg. Co., Camden, N. J.
Reeves Sound Labs., 62 W. 47 St., N. Y. C.
Scientific Radio Products Co., Council Bluffs, Ia.
Scientific Radio Service, Hyattsville, Md.
Standard Piezo Co., Carlisle, Pa.

You remember him, the kid next door who tinkered with short wave radio. Well, he's in uniform now, calling his CQ from foxholes in Italy and steaming Pacific jungles. Maybe, he's a radio operator on a bomber ...perhaps, he's an instructor. Whatever it is, you can be sure that his knowledge and experience are serving to help build a wartime communications system. Yes, from the hams came ready trained instructors, operators and engineers at a time when skilled technicians were vitally needed.

The radio amateur will be back one of these days, back to his much-loved tinkering. He'll want new equipment to add to his short wave rig. . . . He'll be looking for a JENSEN speaker because he wants highest fidelity in music, code and voice reproduction. There is no finer acoustic equipment than JENSEN reproducers.

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RADIO MANUFACTURING COMPANY
6601 S. LARAMIE AVE., CHICAGO 38, U. S. A.

Valpey Crystals, Holliston, Mass.
Wallace Mfg. Co., Wm. T., Peru, Ind.
Zeiss, Inc., Carl, 485 Fifth Ave., N. Y. C.

DIAL LIGHTS

See PILOT LIGHTS

DIALS, Instrument

Barker & Williamson, Upper Darby, Pa.
Crowe Name Plate Co., 3701 Ravenswood Ave., Chicago
General Radio Co., Cambridge, Mass.
Gits Molding Corp., 4600 Huron St., Chicago
Mica Insul. Co., 198 Varick St., N. Y. C.
★ National Co., Inc., Malden, Mass.
★ Rogan Bros., 2003 S. Michigan Ave., Chicago

DISCS, Recording

Advance Recording Products Co., Long Island City, N. Y.
Allied Recording Products Co., Long Island City, N. Y.
Audio Devices, Inc., 1600 B'way, N. Y. C.
Federal Recorder Co., Elkhart, Ind.
★ Gould-Moody Co., 395 B'way, N. Y. C.
Presto Recording Corp., 242 W. 55 St., N. Y. C.
★ RCA Mfg. Co., Camden, N. J.

DYNAMOTORS — See Motor-Generators, Small

ENAMELS, Wood & Metal Finish

Sullivan Varnish Co., 410 N. Hart St., Chicago 22

ETCHING, Metal

Crowe Name Plate & Mfg. Co., 3701 Ravenswood Ave., Chicago
Etched Prod. Corp., 39-01 Queens Blvd., Long Island City, N. Y.
★ Premier Metal Etching Co., 21-03 44th Ave., Long Island City, N. Y.

FACSIMILE EQUIPMENT

Alden Products Co., Inc., Brockton, Mass.
Bunnell & Co., J. H., 215 Fulton, N. Y. C.
Faximile, Inc., 730 5th Ave., N. Y. C.
Federal Tel. & Radio Corp., Newark, N. J.
Finch Telecom., Inc., Passaic, N. J.
Press Wireless, Inc., 1475 B'way, N. Y. C.
R.C.A. Mfg. Co., Camden, N. J.

FASTENERS, Separable

Camloc Fastener Co., 420 Lexington Ave., N. Y. C.
Shakeproof, Inc., 2501 N. Keeler Ave., Chicago

FELT

Amer. Felt Co., Inc., Glenville, Conn.
Western Felt Works, 4031 Ogden Ave., Chicago

FIBRE, Vulcanized

Brandywine Fibre Prods. Co., Wilmington, Del.
Continental-Diamond Fibre Co., Newark, Del.
Insulation Mfgrs. Corp., 565 W. Wash. Blvd., Chicago
Mica Insulator Co., 196 Varick, N. Y. C.
Nat'l Vulcanized Fibre Co., Wilmington, Del.
Spaulding Fibre Co., Inc., 233 B'way, N. Y. C.
Taylor Fibre Co., Norristown, Pa.
Wilmington Fibre Specialty Co., Wilmington, Del.

FILTERS, Electrical Noise

Avia Products Co., 737 N. Highland Ave., Los Angeles
Bendix Aviation Corp., Pacific Div., 11600 Sherman Way, N. Hollywood
Com. Equip. & Eng. Co., N. Parkside Ave., Chicago
Freed Radio Corp., 200 Hudson St., N. Y. C.
Mallory & Co., Inc., P. R., Indianapolis, Ind.
Miller Co., J. W., 5917 S. Main St., Los Angeles
Solar Mfg. Corp., 285 Madison Ave., N. Y. C. 17
Tobe Deutschmann Corp., Canton, Mass.

FINISHES, Metal

Alrose Chemical Co., Providence, R. I.
Aluminum Co. of America, Pittsburgh, Pa.
Ault & Wiborg Corp., 75 Varick, N. Y. C.
Hilo Varnish Corp., Brooklyn, N. Y.
Maas & Waldstein Co., Newark, N. J.
New Wrinkle, Inc., Dayton, O.
Sullivan Varnish Co., 410 N. Hart St., Chicago 22

FREQUENCY STANDARDS, Primary

General Radio Co., Cambridge, Mass.

FREQUENCY STANDARDS, Quartz Secondary

Garner Co., Fred E., 43 E. Ohio St., Chicago
Hewlett-Packard Co., Palo Alto, Calif.
Higgins Industries, Inc., 2221 Warwick Ave., Santa Monica, Calif.
Millen Mfg. Co., Inc., Malden, Mass.

FUSES, Enclosed

Dante Elec. Mfg. Co., Bantam, Conn.
Jefferson Elec. Co., Bellwood, Ill.
Littlefuse, Inc., El Monte, Calif.

GEARS & PINIONS, Metal

Continental-Diamond Fibre Co., Newark, Del.
Crowe Name Plate & Mfg. Co., 3701 Ravenswood Ave., Chicago
Gear Specialties, Inc., 2650 W. Medill, Chicago
Perkins Machine & Gear Co., Springfield, Mass.
Quaker City Gear Wks., Inc., N. Front St., Phila.
Thompson Clock Co., Bristol, Conn.

GEARS & PINIONS, Non-Metallic

Brandywine Fibre Prods. Co., Wilmington, Del.
Formica Insulation Co., Cincinnati, O.
Gear Specialties, Inc., 2650 W. Medill, Chicago
★ General Electric Co., Pittsfield, Mass.
Mica Insulator Co., 196 Varick St., N. Y. C.
National Vulcanized Fibre Co., Wilmington, Del.
Perkins Machine & Gear Co., Springfield, Mass.
Richardson Co., Melrose Park, Ill.
Spaulding Fibre Co., Inc., 233 B'way, N. Y. C.
Synthane Corp., Oaks, Pa.
Taylor Fibre Co., Norristown, Pa.
Wilmington Fibre Specialty Co., Wilmington, Del.

GENERATORS, Electronic AC

Communication Meas. Lab., 118 Greenwich St., N. Y. C.

GENERATORS, Gas Engine Driven

Hunter-Hartman Corp., St. Louis, Mo.
Kato Engineering Co., Mankato, Minn.
Onan & Sons, Royalston Ave., Minneapolis, Minn.
Pioneer Gen-E-Motor, 5841 W. Dickens Ave., Chicago, Ill.

GENERATORS, Hand Driven

Burke Electric Co., Erie, Pa.
Carter Motor Co., 1608 Milwaukee, Chicago
Chicago Tel. Supply Co., Elkhart, Ind.

GENERATORS, Standard Signal

Boonton Radio Corp., Boonton, N. J.
Ferris Instrument Co., Boonton, N. J.
General Radio Co., Cambridge, Mass.
Hewlett-Packard Co., Palo Alto, Calif.
★ Measurements Corp., Boonton, N. J.

GENERATORS, Wind-Driven, Aircraft

General Armature Corp., Lock Haven, Pa.

GLASS, Electrical

Corning Glass Works, Corning, N. Y.

GREASE, for Electrical Contacts & Bearings

Royal Engineering Co. (Royco Grease), East Hanover, N. J.

HANDSETS, Telephone

Automatic Electric Co., 1033 W. Van Buren, Chicago
Western Electric Co., 195 B'way, N. Y. C.

HEADPHONES

Brush Development Co., Cleveland, O.
Cannon Co., C. F., Springwater, N. Y.
Carron Mfg. Co., 415 S. Aberdeen, Chicago
Connecticut Tel. & Elec. Co., Meriden, Conn.
Consolidated Radio Prod. Co., W. Erie St., Chicago
Elec. Ind. Mfg. Co., Red Bank, N. J.
Kellogg Switchboard & Supply Co., 6650 S. Cicero Ave., Chicago
Murdock Mfg. Co., Chelsea, Mass.
Permoflux Corp., W. Grand Ave., Chicago
Telephonics Corp., 350 W. 31 St., N. Y. C.
Trimm Radio Mfg. Co., 1770 W. Berteau, Chicago
★ Universal Microphone Co., Inglewood, Cal.
Utah Radio Prod. Co., 842 Orleans St., Chicago

HORNS, Outdoor

Altec Lansing Corp., 1680 N. Vine, Hollywood 28
Graybar Elect. Co., Lexington Ave. at 43 St., N. Y. C.
★ Jensen Radio Mfg. Co., 6601 S. Laramie Ave., Chicago
Operadio Mfg. Co., St. Charles, Ill.
Oxford Tartak Radio Corp., 915 W. Van Buren St., Chicago
Racon Electric Co., 52 E. 19 St., N. Y. C.
★ RCA Mfg. Co., Camden, N. J.
University Laboratories, 225 Varick St., N. Y. C.

INDUCTION HEATING EQUIPMENT

Induction Heating Corp., 389 Lafayette St., N. Y. C.
Lepel High Frequency Labs., 39 W. 60 St., N. Y. C.

INDUCTORS, Transmitter

Barker & Williamson, Upper Darby, Pa.

INDUCTORS, Variable Tuning

Barker & Williamson, Upper Darby, Pa.

INSTRUMENTS, Radio Laboratory

Ballantine Laboratories, Inc., Boonton, N. J.
Boonton Radio Corp., Boonton, N. J.
Ferris Inst. Corp., Boonton, N. J.
★ General Electric Co., Schenectady, N. Y.
General Radio Co., Cambridge, Mass.
Hewlett-Packard Co., Palo Alto, Calif.
★ Measurements Corp., Boonton, N. J.

INSULATORS, Ceramic Stand-off, Lead-in, Rod Types

America Lava Corp., Chattanooga, Tenn.
Corning Glass Works, Corning, N. Y.
Electronic Mechanics, Inc., Clifton, N. J.
Isolantite, Inc., Belleville, N. S.
Johnson Co., E. F., Waseca, Minn.
Lapp Insulator Co., Inc., Leroy, N. Y.
Locke Insulator Co., Baltimore, Md.
Millen Mfg. Co., Malden, Mass.
★ National Co., Inc., Malden, Mass.

IRON CORES, Powdered

Aladdin Radio Industries, Inc., 501 W. 35 St., Chicago
Crowley & Co., Henry, W. Orange, N. J.
Ferrocart Corp. of Amer., Hastings-on-Hudson, N. Y.
Genl. Aniline Wks., 485 Hudson St., N. Y. C.
Gibson Elec. Co., Pittsburgh, Pa.
Magner Mfg. Co., Inc., 444 Madison Ave., N. Y. C.
Mallory & Co., P. R., Indianapolis, Ind.
Pyroferric Co., 175 Varick St., N. Y. C.
Stackpole Carbon Co., St. Marys, Pa.
Western Electric Co., 195 Broadway, N. Y. C.
Wilson Co., H. A., Newark, N. J.

IRONS, Soldering

Acme Electric Heating Co., 1217 Washington St., Boston
Amer. Electrical Heater Co., 6110 Cass Ave., Detroit
Drake Elec. Wks., Inc., 3656 Lincoln Ave., Chicago
★ Electric Soldering Iron Co., Deep River, Conn.
★ General Electric Co., Schenectady, N. Y.
Hexacon Elec. Co., Roselle Park, N. J.
Sound Equipment Corp. of Calif., 6245 Lex. Ave., Los Angeles 38
Vasco Electrical Mfg. Co., 4116 Avalon Blvd., Los Angeles
Vulcan Electric Co., Lynn, Mass.

JACKS, Telephone

Alden Prods. Co., Brockton, Mass.
Amer. Molded Prods. Co., 1753 N. Honore St., Chicago
Chicago Tel. Supply Co., Elkhart, Ind.
★ Guardian Elec. Mfg. Co., 1627 W. Walnut St., Chicago
Insuline Corp. of Amer., L. I. C., N. Y.
Johnson, E. F., Waseca, Minn.
Jones, Howard B., 2300 Wabansia Ave., Chicago
Mallory & Co., Inc., P. R., Indianapolis, Ind.
Mangold Radio Pts. & Stamping Co., 6300 Shelbourne St., Philadelphia
Molded Insulation Co., Germantown, Pa.
★ Universal Microphone Co., Inglewood, Calif.
Utah Radio Prod. Co., Orleans St., Chicago

KEYS, Telegraph

Amer. Radio Hdware Co., Mt. Vernon, N. Y.
Bunnell & Co., J. H., 215 Fulton, N. Y. C.
Mossman, Inc., Donald P., 6133 N. Northwest Hy., Chicago
Renler Co., Ltd., 2101 Bryant St., San Francisco
Signal Electric Mfg. Co., Menominee, Mich.
Telegraph App. Co., 325 W. Huron St., Chicago
Telephonics Corp., 350 W. 31 St., N. Y. C.
Winslow Co., Inc., Liberty St., Newark, N. J.

KNOBS, Radio & Instrument

Alden Prods. Co., Brockton, Mass.
American Insulator Corp., New Freedom, Pa.
Chicago Molded Prods. Corp., 1025 N. Kolmar, Chicago
General Radio Co., Cambridge, Mass.
Gits Molding Corp., 4600 Huron St., Chicago
Imperial Molded Prods. Corp., 2921 W. Harrison, Chicago
Kurtz Kasch, Inc., Dayton, O.
Mallory & Co., Inc., P. R., Indianapolis, Ind.
Millen Mfg. Co., James, Malden, Mass.
★ Nat'l Co., Inc., Malden, Mass.
Northeastern Molding, Inc., 584 Commonwealth Ave., Boston 15, Mass.
Radio City Products Co., 127 W. 26 St., N. Y. C.
★ Rogan Bros., 2001 S. Michigan, Chicago

LABELS, Coding

Western Litho. Co., 600 E. 2nd, Los Angeles

LABELS, Removable

Avery Adhesives, 451 3rd St., Los Angeles
Western Litho. Co., 600 E. 2nd, Los Angeles

LABELS, Stick-to-Metal

Ever Ready Label Corp., E. 25th St., N. Y. C.
Tablet & Ticket Co., 1021 W. Adams St., Chicago
Western Litho. Co., 600 E. 2nd, Los Angeles

LABORATORIES, Electronic

★ Browning Labs., Inc., Winchester, Mass.
★ Electronic Corp. of Amer., 45 W. 18 St., N. Y. C.
Hazeltine Electronics Corp., 1775 B'way, N. Y. C.
Sherron Metallic Corp., Flushing Ave., Brooklyn, N. Y.
Worner Electronic Devices, 848 N. Noble St., Chicago 22

LACQUERS, Wood & Metal Finish

Sullivan Varnish Co., 410 N. Hart St., Chicago 22

LOCKWASHERS, Spring Type

Natl. Lock Washer Co., Newark, N. J.

LUGS, Soldering

Cinch Mfg. Corp., W. Van Buren St., Chicago
Dante Elec. Mfg. Co., Bantam, Conn.
Ideal Commutator Dresser Co., Sycamore, Ill.
Ilsco Copper Tube & Prods., Inc., Station M, Cincinnati
Krueger & Hudepohl, Third & Vine, Cincinnati, O.
Patton-MacGuyer Co., 17 Virginia Ave., Providence, R. I.
Sherman Mfg. Co., Battle Creek, Mich.
Zierick Mfg. Co., 385 Girard Ave., Bronx, N. Y. C.

LUGS, Solderless

Aircraft Marine Prod., Inc., Harrisburg, Pa.
Burndy Eng. Co., 107 Eastern Blvd., N. Y. C.
Thomas & Betts Co., Elizabeth 1, N. J.

MACHINES, Impregnating

Stokes Machine Co., F. J., Phila., Pa.

MACHINES, Screwdriving

Detroit Power Screwdriver Co., Detroit, Mich.
Stanley Tool Div. of the Stanley Works, New Britain, Conn.

MAGNETS, Permanent

Arnold Engineering Co., 147 E. Ontario St., Chicago 11
★ General Elec. Co., Schenectady, N. Y.
Indiana Steel Prod. Co., 6 N. Michigan Ave., Chicago, Ill.
Thomas & Skinner Steel Prod. Co., Indianapolis, Ind.

MAIL ORDER SUPPLY HOUSES

See listing at head of Directory

MARKERS, Wire Identification

Brand & Co., Wm., 276 4th Ave., N. Y. C.
Irvington Varnish & Ins. Co., Irvington, N. J.
Minn. Mining Co., 155 Sixth Ave., N. Y. C.
Ntl. Varnished Prod. Corp., Woodbridge, N. J.

MARKING MACHINES, Letters, Numbers

Marken Machine Co., Keene, N. H.

METAL, Thermostatic

Baker & Co., 113 Astor, Newark, N. J.
C. S. Brainin Co., 20 VanDam, N. Y. C.
Callite Tungsten Corp., Union City, N. J.
Chace Co., W. M., Detroit, Mich.
Metals & Controls Corp., Attleboro, Mass.
Wilson Co., H. A., 105 Chestnut, Newark, N. J.

METERS, Ammeters, Voltmeters, Small Panel

Cambridge Inst. Co., Grand Central Terminal, N. Y. C.
De Jur-Amsco Corp., Shelton, Conn.
★ General Electric Co., Bridgeport, Conn.
Hickok Elec. Inst. Co., Cleveland, O.
Hoyt Elec. Inst. Works, Boston, Mass.
McClintock Co., O. B., Minneapolis, Minn.
Readrite Meter Works, Bluffton, O.
Roller-Smith Co., Bethlehem, Pa.
★ Simpson Elec. Co., 5218 W. Kinzie, Chicago
Triplett Elec. Inst. Co., Bluffton, O.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Weston Elec. Inst. Corp., Newark, N. J.
Wheelco Inst. Co., 847 W. Harrison St., Chicago

METERS, Frequency

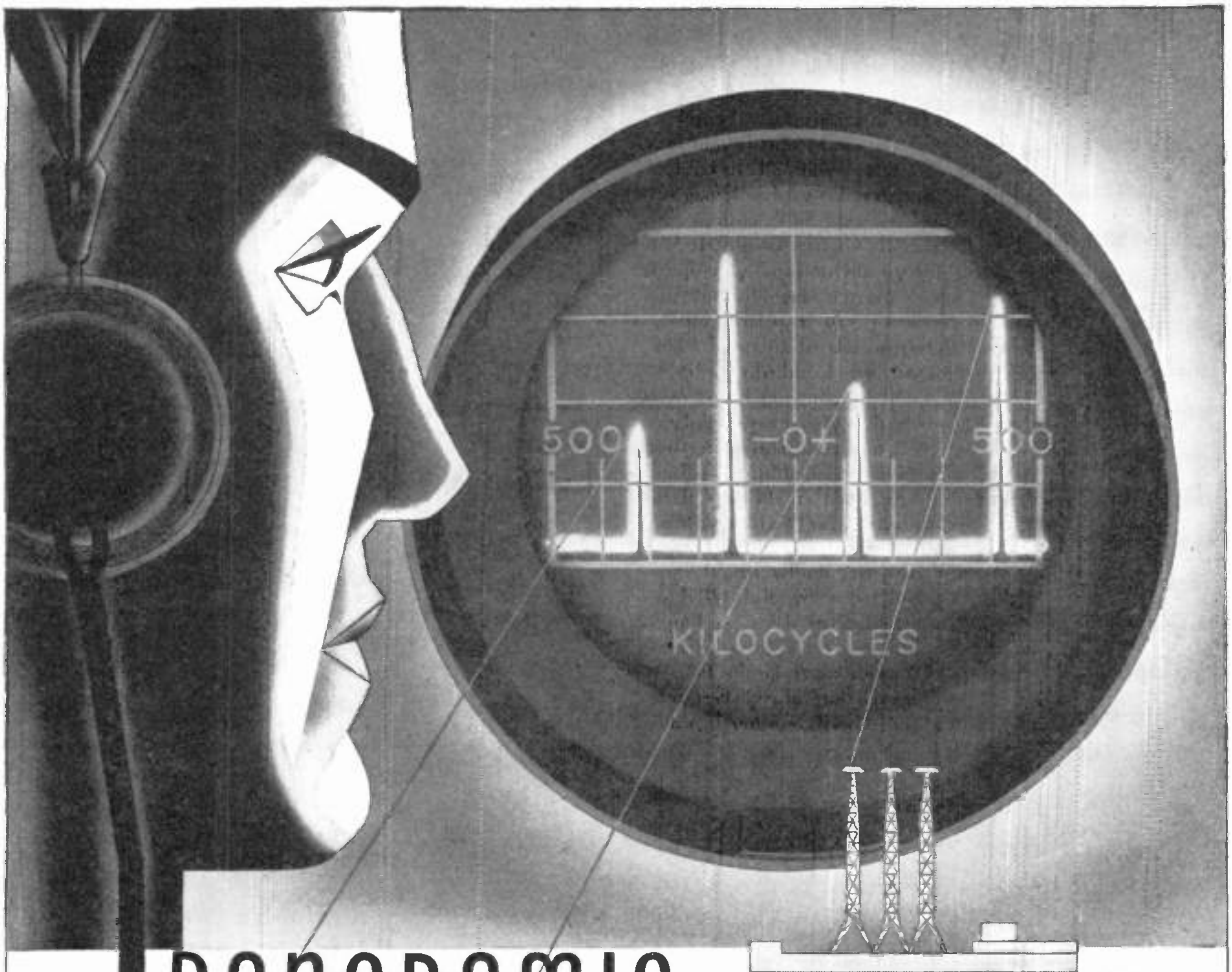
Bendix Radio, Towson, Md.
★ Browning Labs., Inc., Winchester, Mass.
General Radio Co., Cambridge, Mass.
Higgins Industries, Inc., 2221 Warwick Ave., Santa Monica, Calif.
Lavoie Laboratories, Long Branch, N. J.
★ Link, F. M., 125 W. 17 St., N. Y. C.
★ Measurements Corp., Boonton, N. J.
North Amer. Philips Co., Inc., 419 Fourth Ave., N. Y. C.

METERS, Q

Boonton Radio Corp., Boonton, N. J.

METERS, Vacuum Tube Volt

Ballantine Laboratories, Inc., Boonton, N. J.
Ferris Instrument Corp., Boonton, N. J.
General Radio Co., Cambridge, Mass.
Hewlett-Packard Co., Palo Alto, Calif.
★ Measurements Corp., Boonton, N. J.
Radio City Products Co., 127 W. 26 St., N. Y. C.



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PANORAMIC RADIO CORPORATION

242-250 WEST 55TH ST., New York 19, N. Y.

METERS, Vibrating Reed

Biddle, James G., 1211 Arch St., Phila.
J-B-T Instruments, Inc., New Haven 8, Conn.
Triplett Elec. Inst. Co., Bluffton, O.

MICA

Brand & Co., Wm., 276 Fourth Av., N. Y. C.
Ford Radio & Mica Corp., 538 63rd St., Bklyn, N. Y.
Insulation Mfgrs. Corp., 565 W. Wash. Blvd., Chicago
Macallen Co., Boston, Mass.
Mica Insulator Corp., 196 Varick, N. Y. C.
Mitchell-Rand Insulation Co., 51 Murray St., N. Y. C.
New England Mica Co., Waltham, Mass.
Richardson Co., Melrose Park, Ill.

MICROPHONES

Amer. Microphone Co., 1015 Western Av., Los Angeles
Amperite Co., 561 B'way, N. Y. C.
Astatic Corp., Youngstown, O.
Brush Development Co., Cleveland, O.
Electro Voice Mfg. Co., South Bend, Ind.
Kellogg Switchboard & Supply Co., 6650 S. Cicero, Chicago
Radio Speakers, Inc., 221 E. Cullerton, Chicago
Philmore Mfg. Co., 113 University Pl., N. Y. C.
Permoflux Corp., 4916 W. Grand Av., Chicago
Rowe Industries, Inc., Toledo, O.
★ Shure Bros., 225 W. Huron St., Chicago
Telephonics Corp., 350 W. 31 St., N.Y.C.
Turner Co., Cedar Rapids, Ia.
★ Universal Microphone Co., Inglewood, Cal.

MONITORS, Frequency

★ General Electric Co., Schenectady, N. Y.
General Radio Co., Cambridge, Mass.
★ RCA Mfg. Co., Camden, N. J.

MOTOR-GENERATORS, Rotary Converters

Alliance Mfg. Co., Alliance, O.
Air-Way Mfg. Co., Toledo, O.
Bendix Aviation Corp., Pacific Div., 11600 Sherman Way, N. Hollywood
Black & Decker Mfg. Co., Towson, Md.
Bodine Elec. Co., 2262 W. Ohio, Chicago
Carter Motor Co., 1608 Milwaukee, Chicago
Clements Mfg. Co., Chicago, Ill.
Continental Electric Co., Newark, N. J.
Delco Appliance, Rochester, N. Y.
Diehl Mfg. Co., Elizabethport, N. J.
Dormeyer Co., Chicago, Ill.
Eclipse Aviation, Bendix, N. J.
Eicor, Inc., 1060 W. Adams, Chicago
Electric Indicator Co., Stamford, Conn.
Electric Motors Corp., Racine, Wis.
Electric Specialty Co., Stamford, Conn.
Electrolux Corp., Old Greenwich, Conn.
Eureka Vacuum Cleaner, Detroit, Mich.
General Armature Corp., Lock Haven, Pa.
★ General Electric Co., Schenectady, N. Y.
Jannette Mfg. Co., 558 W. Monroe, Chicago
Knapp-Monarch, St. Louis, Mo.
Leland Electric Co., Dayton, O.
Ohio Electric Co., 74 Trinity Pl., N. Y. C.
Pioneer Gen-E-Motor, 5841 W. Dickens Av., Chicago
Redmond Co., A. G., Owosso, Mich.
Russell Co., Chicago, Ill.
Small Motors, Inc., 1308 Elston Ave., Chicago
Webster Co., Chicago, Ill.
Webster Products, 3825 Armitage Ave., Chicago
Westinghouse Elect. Mfg. Co., Lima, O.
★ Wincharger Corp., Sioux City, Iowa

MOTORS, Very Small Types

Kollsman Instrument Div., Elmhurst, Long Island, N. Y.
Utah Radio Prod. Co., 842 Orleans St., Chicago

MOUNTINGS, Shock Absorbing

Lord Mfg. Co., Erie, Pa.
Pierce-Roberts Co., Trenton, N. J.
U. S. Rubber Co., 1230-6th Ave., N.Y.C.

MYCALEX

Colonial Kolonite Co., 2212 W. Armitage Ave., Chicago
★ General Electric Co., Schenectady, N. Y.
Mycalex Corp. of Amer., Clifton, N. J.
Precision Fabricators, Inc., Rochester, N. Y.

NAME PLATES, Etched Metal

See ETCHING, Metal

NAME PLATES, Plastic

Crowe Name Plate & Mfg. Co., 3700 Ravenswood Ave., Chicago
Hopp Press, Inc., 460 W. 34 St., N. Y. C.
Parisian Novelty Co., 3502 S. Western Ave., Chicago
Virginia Plate Co., 270 Madison Ave., N. Y. C. 16

NICKEL, Sheet, Rod, Tubes

Eagle Metals Co., Seattle, Wash.
Pacific Metals Co., Ltd., San Francisco, Calif.
Steel Sales Corp., 129 S. Jefferson St., Chicago
Tull Metal & Supply Co., J. M., Atlanta, Ga.
Whitehead Metal Prod. Co., 303 W. 10th St., N. Y. C.
Williams and Co., Inc., Pittsburgh, Pa.

NUTS, Self-locking

Boots Aircraft Nut Corp., New Canaan, Conn.
Elastic Stop Nut Corp., Union, N. J.
Palnut Co., Inc., Irvington, N. J.
Standard Pressed Steel Co., Jenkintown, Pa.

OSCILLATORS, AF

General Radio Co., Cambridge, Mass.
Hewlett-Packard Co., Palo Alto, Calif.
Jackson Electrical Inst. Co., Dayton, O.

OSCILLOSCOPES, Cathode Ray

★ Du Mont Laboratories, Inc., Allen B., Passaic, N. J.
★ General Electric Co., Schenectady, N. Y.
General Radio Co., Cambridge, Mass.
Millen Mfg. Co., Malden, Mass.
★ Panoramic Radio Corp., 242 W. 55 St., N. Y. C.
Reiner Electronics Co., 152 W. 25 St., N. Y. C.
RCA Mfg. Co., Inc., Camden, N. J.
Radio City Products Co., Inc., 127 W. 26 St., N. Y. C.

OVENS, Industrial & Laboratory

★ General Elec. Co., Schenectady, N. Y.
Trent Co., Harold E., Philadelphia

PANELS, Metal Etched (See Etching, Metal)

PANELS, Phenolic, Cast without Molds

Creative Plastics Corp., 963 Kent Ave., B'klyn, N. Y.

PILOT LIGHTS

Alden Prods. Co., Brockton, Mass.
Amer. Radio Hdware Co., Mt. Vernon, N. Y.
Dial Light Co. of Amer., 90 West, N. Y. C.
Drake Mfg. Co., 1713 W. Hubbard, Chicago
General Control Co., Cambridge, Mass.
Gothard Mfg. Co., Springfield, Ill.
Herzog Miniature Lamp Works, 12-19 Jackson Av., Long Island City, N.Y.C.
Kirkland Co., H. R., Morristown, N. J.
Mallory & Co., P. R., Indianapolis, Ind.
Signal Indicator Corp., 140 Cedar St., N. Y. C.

PHOSPHOR BRONZE

American Brass Co., Waterbury, Conn.
Bunting Brass & Bronze Co., Toledo, O.
Driver-Harris Co., Harrison, N. J.
Phosphor Bronze Smelting Co., Philadelphia
Revere Copper & Brass, 230 Park Av., N. Y. C.
Seymour Mfg. Co., Seymour, Conn.

PLASTICS, Extruded

Blum & Co., Inc., Julius, 532 W. 22 St., N. Y. C.
Brand & Co., Wm., 276 4th Ave., N.Y.C.
Extruded Plastics, Inc., Norwalk, Conn.
Industrial Synthetic Corp., Irvington, N. J.
Irvington Varnish & Insulator Co., Irvington, N. J.

PLASTIC SHEET, for Name Plates

Mica Insulator Co. 200 Varick St., N. Y. C.

PLASTICS, Injection Molded

Remler Co., Ltd., 2101 Bryant St., San Francisco
Tech-Art Plastics, 41-01 36th Ave., Long Island City, N. Y.
Universal Plastics Corp., New Brunswick, N. J.

PLASTICS, Laminated or Molded

Acadia Synthetic Prods., 4031 Ogden Av., Chicago
Alden Prods. Co., Brockton, Mass.
American Cyanamid Co., 30 Rockefeller Plaza, N. Y. C.
American Insulator Corp., New Freedom, Pa.
American Molded Prods. Co., 1753 N. Honore, Chicago
Auburn Button Works, Auburn, N. Y.
Barber-Colman Co., Rockford, Ill.
Brandywine Fibre Prods. Co., Wilmington, Del.
Brilhart Co., Arnold, Great Neck, N. Y.
Catalin Corp., 1 Park Av., N. Y. C.
Celanese Celluloid Corp., 180 Madison Av., N. Y. C.
Chicago Molded Prods. Corp., 1024 N. Kolmar, Chicago
Continental-Diamond Fibre Co., Newark, Del.
Creative Plastics Corp., 963 Kent Ave., B'klyn, N. Y.
Dow Chemical Co., Midland, Mich.
Durez Plastics & Chemicals, Inc., N. Tonawanda, N. Y.
Extruded Plastics, Inc., Norwalk, Conn.
Formica Insulation Co., Cincinnati, O.

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751 MAIN STREET • WINCHESTER, MASS.

★ General Electric Co., Plastics Dept., Pittsfield, Mass.
General Industries Co., Elyria, O.
Gits Molding Corp., 4600 Huron St., Chicago
Imperial Molded Prods. Co., 2921 W. Harrison, Chicago
Industrial Molded Prods. Co., 2035 Charleston, Chicago
Kurz-Kasch, Inc., Dayton, O.
Macallen Co., Boston, Mass.
Mica Insulator Co., 196 Varick, N. Y. C.
Monsanto Chemical Co., Springfield, Mass.
National Vulcanized Fibre Co., Wilmington, Del.
Northern Industrial Chemical Co., Boston, Mass.
Printloid Corp., 93 Mercer St., N. Y. C.
Radio City Products Co., 127 W. 26 St., N. Y. C.
Remler Co., Ltd., 2101 Bryant St., San Francisco
Richardson Co., Melrose Park, Ill.
★ Rogan Bros., 2000 S. Michigan Ave., Chicago
Rohm & Haas Co., Philadelphia
Spaulding Fibre Co., Inc., 233 B'way, N. Y. C.
Stokes Rubber Co., Joseph Trenton, N. J.
Surprenant Elec. Ins. Co., Boston
Synthane Corp., Oaks, Pa.
Taylor Fibre Co., Norristown, Pa.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Wilmington Fibre Specialty Co., Wilmington, Del.

PLASTICS, Materials

Bakelite Corp., 30 E. 42 St., N. Y. C.
Carbide & Carbon Chemicals Corp., 30 E. 42 St., N. Y. C.

PLASTICS, Transparent

Carbide & Carbon Chemicals Corp., 30 E. 42 St., N. Y. C.
Celanese Celluloid Corp., 180 Madison Ave., N. Y. C.
Dow Chemical Co., Midland, Mich.
du Pont de Nemours & Co., E. I., Arlington, N. J.
Plax Corp., Hartford, Conn.
Printloid Corp., 93 Mercer St., N. Y. C.
Rohm & Haas Co., Washington Sq., Philadelphia

PLATING, Metal on Molded Parts

Metaplast Corp., 205 W. 19 St., N. Y. C.

PLUGS (Banana), Spring Type

Amer. Radio H'dw're Co., Mt. Vernon, N. Y.
Birnbach Radio Co., 145 Hudson St., N. Y. C.
Eastman Kodak Co., Rochester, N. Y.
Eby, Inc., Hugh H., Philadelphia, Pa.
Franklin Mfg. Corp., 175 Varick St., N. Y. C.
General Radio Co., Cambridge, Mass.
Johnson Co., E. F., Waseca, Minn.
Mallory & Co., Inc., P. R., Indianapolis, Ind.
Ucinite Co., Newtonville, Mass.

PLUGS, Telephone Type

Alden Prods. Co., Brockton, Mass.
American Molded Prods. Co., 1753 N. Honore, Chicago
Chicago Tel. Supply Co., Elkhart, Ind.
★ Guardian Elec. Mfg. Co., 1400 W. Wash. Blvd., Chicago
Insuline Corp. of Amer., L. I. City, N. Y.
Johnson Co., E. F., Waseca, Minn.
Jones, H. B., 2300 Wabansia, Chicago
Mallory & Co., Inc., P. R., Indianapolis, Ind.
Remler Co., Ltd., Bryant St., San Francisco
Trav-Ler Karenola Corp., 1030 W. Van Buren St., Chicago 7
★ Universal Microphone Co., Ltd., Inglewood, Calif.
Utah Radio Prod., Orleans St., Chicago

PLYWOOD, Metal Faced

Haskelite Mfg. Corp., 208 W. Washington St., Chicago

RACKS, Standard Aircraft Types

Delco Radio, Kokomo, Ind.

RACKS & PANELS, Metal

See STAMPINGS, Metal

RADIO RECEIVERS & TRANSMITTERS

Abbott Instrument, Inc., 8 W. 18 St., N. Y. C. 3
Aircraft Accessories Corp., Funston Rd., Kansas City, Kans.
Aircraft Radio Corp., Boonton, N. J.
Aircraft Radio Equip. Corp., 6244 Lex. Ave., Hollywood, Calif.
Air Communications, Inc., 2233 Grant Ave., Kansas City, Mo.
Air King Products Co., 1523 63rd Ave., Brooklyn, N. Y.
Airplane & Marine Inst., Inc., Clearfield, Pa.
Andrea Radio Corp., 43-20 34th St., Long Island City, N. Y.
Amplex Engineering, Inc., New Castle, Ind.
Arnessen Electric Co., 116 Broad St., N. Y. C.
Automatic Radio Mfg. Co., 122 Brookline Ave., Boston, Mass.
Bassett, Inc., Rex, Ft. Lauderdale, Fla.
Belmont Radio Corp., 5921 Dickens Ave., Chicago
Bendix Aviation Corp., Pacific Div., 11600 Sherman Way, N. Hollywood
Bendix Radio, Div. of Bendix Aviation Corp., Baltimore, Md.
Boes Co., The W. W., Dayton, O.
★ Browning Laboratories, Inc., Winchester, Mass.
Bunnell & Co., J. H., 215 Fulton St., N. Y. C.
Burnett Radio Lab., 4814 Idaho St., San Diego, Calif.
Colonial Radio Corp., Rano St., Buffalo, N. Y.
Communications Co., Inc., Coral Gables, Fla.
Conn. Tel. & Elec. Co., Meriden, Conn.
Continental Radio & Telev. Corp., 3800 W. Cortland St., Chicago
Cover Dual Signal Systems, Inc., 125 W. Hubbard St., Chicago
Crosley Radio Corp., Cincinnati, O.
de Forest Labs, Lee, 5106 Wilshire Blvd., Los Angeles
Delco Radio, Kokomo, Ind.
Detrola Corp., 1501 Beard Ave., Detroit, Mich.
De Wald Radio Mfg. Corp., 436 Lafayette St., N. Y. C.
Dictaphone Corp., 420 Lexington Ave., N. Y. C.
★ DuMont Labs., Inc., Allen B., Passaic, N. J.
Echophone Radio Co., 201 E. 26 St., Chicago
Eckstein Radio & Telev. Co., Inc., 1400 Harmon Pl., Minneapolis, Minn.
Electrical Ind. Mfg. Co., Red Bank, N. J.
Elect. Research Lab., Inc., Evanston, Ill.
Electronic Communications Co., 36 N. W. B'way, Portland, Ore.
★ Electronic Corp. of Amer., 45 W. 18 St., N. Y. C.
Electronic Specialty Co., Glendale, Calif.
Emerson Radio & Phone Corp., 111 8th Ave., N. Y. C.
Erco Radio Labs., Inc., Hempstead, N. Y.
Espey Mfg. Co., Inc., 305 E. 63 St., N. Y. C.
Fada Radio & Elec. Corp. 30-20 Thomson Ave., Long Island City, N. Y.
Federal Electronics Div., 209 Steuben St., B'klyn, N. Y.
Federal Tel. & Radio Corp., Newark, N. J.
Finch Telecommunications, Inc., Passaic, N. J.
Fisher Research Lab., Palo Alto, Calif.
Freed Radio Corp., 200 Hudson St., N. Y. C.
★ Galvin Mfg. Corp., 4545 Augusta Blvd., Chicago
Garod Radio Corp., 70 Washington St., B'klyn, N. Y.
Gates Radio & Supply Co., Quincy, Ill.
General Communication Co., 681 Beacon St., Boston, Mass.
★ General Electric Co., Schenectady, N. Y.
General Telev. & Radio Corp., 1240 N. Homan Ave., Chicago
Gibbs & Co., Thomas B., Delavan, Wis.
Gilfillen Bros., Inc., 1815 Venice Blvd., Los Angeles, Calif.
Girdler Corp., Louisville, Ky.
Gray Mfg. Co., Hartford, Conn.
Gray Radio Co., West Palm Beach, Fla.
Grenby Mfg. Co., Plainville, Conn.
Guided Radio Corp., 161 6th Ave., N. Y. C.
★ Hallicrafters Co., 2611 Indiana Ave., Chicago
Halstead Traffic Com. Corp., 155 E. 44 St., N. Y. C.
Hamilton Radio Corp., 510 Sixth Ave., N. Y. C.
★ Hammarlund Mfg. Co., 460 W. 34th St., N. Y. C.
Harrel, D. H., 1527 E. 74 Pl., Chicago
Harvey Machine Co., Inc., 6200 Avalon Blvd., Los Angeles
★ Harvey Radio Labs, Inc., Cambridge, Mass.
Harvey-Wells Com., Inc., Southbridge, Mass.
Hazeltine Electronics Corp., Great Neck, N. Y.
Herbach & Rademan Co., 522 Market St., Phila.
Higgins Industries, Inc., 2221 Warwick Ave., Santa Monica, Calif.
Hollywood Electronics Co., 800 Sunset Blvd., Los Angeles
Howard Radio Co., 1731 Belmont Ave., Chicago
Hudson American Corp., 62 W. 47 St., N. Y. C.
Jefferson, Inc., Ray, Freeport, N. Y.
Jefferson-Travis Radio Mfg. Corp., 245 E 23 St., N. Y. C.
Karadio Corp., 1400 Harmon Pl., Minneapolis, Minn.
Kemlite Labs., 1809 N. Ashland Ave., Chicago
Lear Avia, Inc., Piqua, O.
Lewyt Corp., 60 B'way, B'klyn, N. Y.
★ Link, F. M., 125 W. 17 St., N. Y. C.
★ Machlett Labs., Inc., Springdale, Conn.
Magnavox Co., Indianapolis, Ind.
Majestic Radio & Tel. Corp., 2600 W. 50 St., Chicago
McElroy Mfg. Corp., Brookline Ave., Boston
Megard Corp., 381 W. 38 St., Los Angeles, Calif.
Midwest Radio Corp., Cincinnati, O.
Millen Mfg. Co., Inc., Malden, Mass.
★ National Co., Inc., Malden, Mass.
Noblitt-Sparks Ind. Inc., Columbus, Ind.
North Amer. Philips Co., 100 E. 42 St., N. Y. C.
Operadio Mfg. Co., St. Charles, Ill.
★ Panoramic Radio Corp., 245 W. 55 St., N. Y. C. 19
Philco Corp., Tioga & C Sts., Philadelphia, Pa.
Philharmonic Radio Corp., 216 Williams St., N. Y. C.
Pierson-DeLane, Inc., 2345 W. Washington Blvd., Los Angeles
Pilot Radio Corp., Long Island City, N. Y.

Class 20M—Both terminals insulated (without insulating tube)

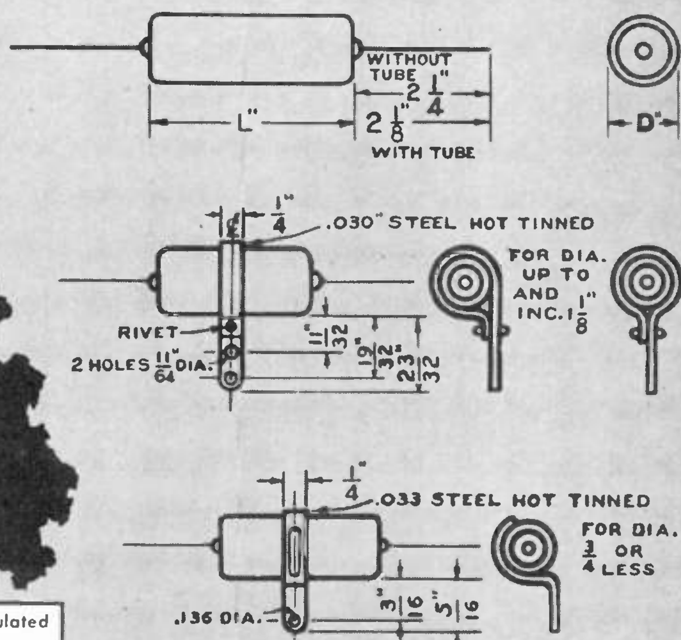
Class 22M—One terminal grounded (without insulating tube)

Class 21M—Both terminals insulated (with insulating tube)

Class 23M—One terminal grounded (with insulating tube)

MEMO:

To Designers, Engineers and Manufacturers of Electronic, Radionic and Electrical Devices, thinking in terms of quality for POST WAR production . . . Here is a convenient "abbreviated listing" of METAL-CASED TUBULAR OIL-PAPER CAPACITORS—hermetically sealed to meet unusual operating conditions.



Class 20M—Both terminals insulated (without insulating tube)			
CAP. MFDS.	VOLTS D. C.	SIZE (inches) D.	L.
.001	1000	1/2	1-3/16
.0025	1000	1/2	1-3/16
.005	1000	1/2	1-3/16
.005	600	3/8	15/16
.01	600	3/8	1-3/16
.02	600	1/2	1-1/16
.05	600	9/16	1-5/16
.1	200	9/16	1-13/16
.25	200	3/4	1-7/8
.5	200	1	1-13/16

Class 21M—Both terminals insulated (with insulating tube)			
CAP. MFDS.	VOLTS D. C.	SIZE (inches) D.	L.
.05	800	11/16	1-5/8
.1	800	13/16	1-7/8
.1	600	11/16	1-3/4
.25	600	13/16	2-5/16
.25	400	13/16	2-5/16
.5	400	1-1/16	2-5/16
1.	400	1-1/16	3-15/16
1.	200	1-1/16	3-3/16
1.5	100	1-1/16	3-3/16
2.	100	1-5/16	2-11/16

Class 22M—One terminal grounded (without insulating tube)			
CAP. MFDS.	VOLTS D. C.	SIZE (inches) D.	L.
.0075	1000	1/2	1-1/16
.01	1000	1/2	1-1/16
.05	1000	5/8	1-13/16
.5	600	1	2
1.	600	1	3-5/8

Class 23M—One terminal grounded (with insulating tube)			
CAP. MFDS.	VOLTS D. C.	SIZE (inches) D.	L.
.1	1000	13/16	2-1/16
.25	1000	1-1/16	2-1/2
.5	1000	1-7/16	2-13/16
.5	800	1-1/16	3-1/16
1.	800	1-7/16	3-1/4

(Standard Capacity Tolerance on the above units is ± 20%. Closer or wider tolerances may be obtained if required.)

Standard or Special Units to Meet Every Need

FAST Capacitors are produced in many types and sizes in standard or special designs. We can supply paper capacitors—oil or wax impregnated—rectangular or tubular—in sizes from the smallest to the largest.

This line of FAST Capacitors has containers made of brass with a heavy tin dip. The terminals are made with bushings of NEOPRENE and BAKELITE and are painted with Glyptal. They have excellent stability over a wide range of temperatures and frequencies — will pass recognized thermal and salt water immersion tests.

Inquiries are particularly invited from organizations planning to build that *better* equipment for the new day ahead. Please feel free to call us on any capacitor problems.

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Bendix Aviation Corp., Pacific Div., 11600 Sherman Way, N. Hollywood
Birtcher Corp., 5087 Huntington Dr., Los Angeles 32
Cook Elec. Co., 2700 Southport Ave., Chicago
Electrical Prod. Supply Co., 1140 Venice Blvd., Los Angeles 15
G-M Laboratories, Inc., 4313 N. Knox Ave., Chicago
★ Guardian Elec. Co., 1400 W. Wash. Blvd., Chicago
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★ Guardian Elec. Co., 1400 W. Wash. Blvd., Chicago
Wick Organ Co., Highland, Ill.

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Presto Elect. Co., N. Y. Ave., Union City, N. J.
Struthers Dunn, Inc., Arch St., Phila.

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Sensitive Research Inst., Corp., 4545 Bronx Blvd., N. Y. C.
Shallcross Mfg. Co., Collingdale, Pa.
Speer Resistor Corp., St. Marys, Pa.
Sprague Specialties Co., N. Adams, Mass.
Stackpole Carbon Co., St. Marys, Pa.
Utah Radio Prod. Co., 842 Orleans St., Chicago
Ward-Leonard Elec. Co., Mt. Vernon, N. Y.
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Amer. Inst. Co., Silver Spring, Md.
Atlas Resistor Co., N. Y. C.
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Centralab, Milwaukee, Wis.
Chicago Tel. Supply Co., Elkhart, Ind.
Cinema Eng. Co., Burbank, Cal.
Clarostat Mfg. Co., 130 Clinton, Bklyn, N. Y.
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Lectrohm, Inc., 5125 W. 25th, Cicero, Ill.
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Ohio Carbon Co., Cleveland, Ohio
Ohmite Mfg. Co., 4835 W. Flournoy St., Chicago
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Stackpole Carbon Co., St. Marys, Pa.
Utah Radio Prods. Co., 820 Orleans St., Chicago
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Conscientious electronic equipment manufacturers avoid special selection of tubes. When a battlefront tube replacement is made, they want "on the button" performance. They allow for possible additive effects of tolerances for other components — and for the many minor differences of equipment assembly, wiring, and adjustment. Also they realize it is impracticable to manufacture all electronic tubes of a given type exactly alike. Yet they demand and deserve close observance of their tolerances for each tube characteristic. (See A and C on the distribution curve.) Hytron insists on still tighter factory specifications. (Compare A′ and C′.)

Hytron goes still further. Based on past experience — its own and others' — whenever practicable a "bogie", or desired goal, for each characteristic is set. (Compare B.) Controlled design and production aim at producing the majority of tubes with this preferred value, which is not necessarily and arbitrarily midway between tolerances. It is rather the ideal for peak performance—dictated by experience and attainable if exact duplication were possible.

Specify Hytron for tighter specifications — for "bogie"-controlled production — for uniform performance.

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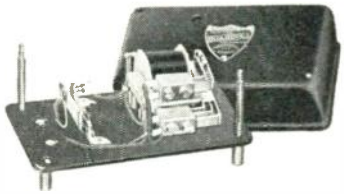
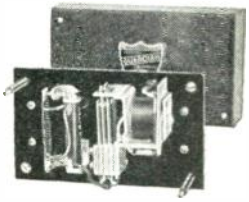


T-100 Laminated Time Delay Relay
Send for Bulletin R-5



T-110 Time Delay Relay (not laminated)
Send for Bulletin R-5

THERE'S A JOB FOR

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The filaments of oscillator type tubes require a "warm up" of 20 to 30 seconds which is usually provided by a time delay relay such as Guardian's Type T-100. In this relay the time delay is adjustable between 10 and 60 seconds and is accomplished by means of a resistance wound bi-metal in series with a resistor. The contact capacity of the T-100 is 1500 watts on 110 volt, 60 cycle, non-inductive AC. The power consumption of coil and time delay during closing of the thermostatic blade is approximately 10 VA; after closing, 5.5 VA.

A similar relay giving almost the same performance but costing somewhat less is the Series T-110. This relay may be equipped with an extra set of open or closed contacts, if desired. In industrial control, both relays may be used in applications requiring the changing of circuits after a predetermined interval.

Consult Guardian whenever a tube is used—however—Relays by Guardian are NOT limited to tube applications but are used wherever automatic control is desired for making, breaking, or changing the characteristics of electrical circuits.

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1637-G W. WALNUT STREET CHICAGO 12, ILLINOIS
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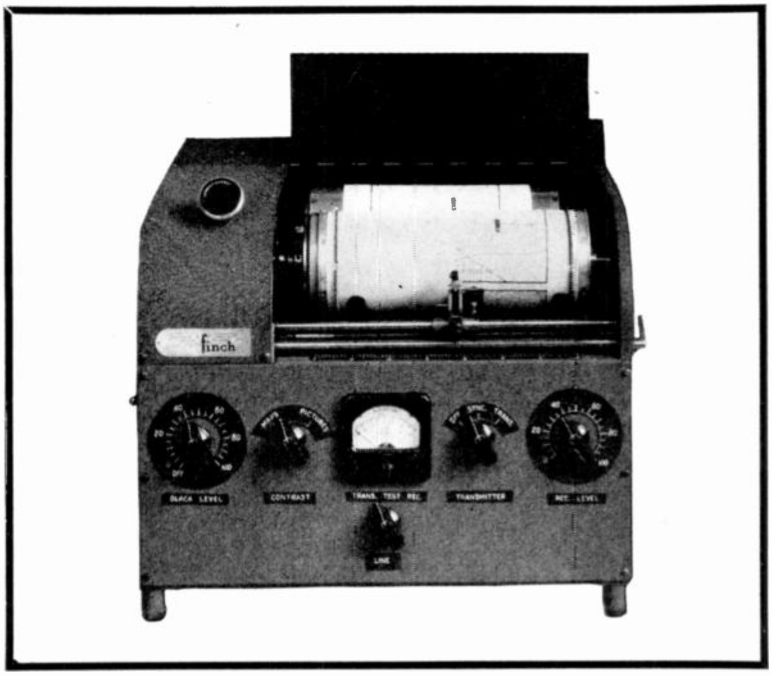

Facsimile transmitter and receiver (commercial type, complete with electronic units), by Finch. Unit encases in one single container all of the transmitting and receiving equipment, including amplifying circuits.

On the day following "Pearl Harbor," Finch — first in Facsimile — dedicated its facilities to whatever the needs of our embattled nation might prove to be.

This has strengthened Finch leadership, and Finch Facsimile today offers:

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- **High-speed, high-definition' advanced design broadcasting facsimile equipment**

Finch engineers are well prepared and ready to discuss details of Facsimile broadcasting services, or commercial services the minute the Government gives the green light for transition from wartime to peacetime activities.

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United Screw & Bolt Corp., 71 Murray St., N. Y. C.

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Lamson & Sessions, Cleveland, O.
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Nat. Screw & Mfg. Co., Cleveland, O.
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Parker Co., Charles, The, Meriden, Conn.
Parker-Kalon Corp., 198 Varick, N. Y. C.
Pawtucket Screw Co., Pawtucket, R. I.
Pheoll Mfg. Co., Chicago
Russell, Burdsall & Ward Bolt & Nut Co., Port Chester, N. Y.
Scovill Mfg. Co., Waterbury, Conn.
Shakeproof, Inc., 2501 N. Keeler Av., Chicago
Southington Hardw. Mfg. Co., Southington, Conn.
Whitney Screw Corp., Nashua, N. H.

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Central Screw Co., 3519 Shields Av., Chicago
Continental Screw Co., New Bedford, Mass.
Federal Screw Prod. Co., 224 W. Huron St., Chicago
Manufacturers Screw Prod., 216 W. Hubbard St., Chicago 10
Parker-Kalon Corp., 198 Varick, N. Y. C.
Shakeproof, Inc., 2501 N. Keeler, Chicago

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Manufacturers Screw Prod., 216 W. Hubbard St., Chicago 10
Parker-Kalon Corp., 198 Varick, N. Y. C.
Republic Steel Corp., Cleveland, O.
Shakeproof, Inc., 2501 N. Keeler Av., Chicago

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Central Screw Co., 3519 Shields, Chicago
Federal Screw Prod. Co., 224 W. Huron St., Chicago
Manufacturers Screw Prod., 216 W. Hubbard St., Chicago 10
Parker-Kalon, 198 Varick, N. Y. C.
Stand. Pressed Steel Co., Jenkintown, Pa.

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Benwood Linze Co., St. Louis, Mo.
Selenium Corp. of Amer., 1800 W. Pico Blvd., Los Angeles

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Breeze Corps., Inc., Newark, N. J.
Mall Tool Co., 7708 S. Chicago Ave., Chicago
Steward Mfg. Corp., 4311 Ravenswood Ave., Chicago
Walker-Turner Co., Inc., Plainfield, N. J.
White Dental Mfg. Co., 10 E. 48 St., N. Y. C.

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Carnegie-Illinois Steel Corp., Pittsburgh, Pa.
Follansbee Steel Corp., Pittsburgh, Pa.
Granite City Steel Co., Granite City, Ill.
Newport Rolling Mill Co., Newport, Ky.
Republic Steel Corp., Cleveland, O.
Ryerson & Son, Inc., Jos. T., Chicago
Westinghouse Elect. & Mfg. Co., E. Pittsburgh, Pa.

SHIELDS, Tube

★ Goat Metal Stampings, Inc., 314 Dean St., Brooklyn, N. Y.

SHOCK ABSORBERS

See MOUNTINGS, Shock Absorbing

SIGNAL GENERATORS

See GENERATORS, Standard Signal

SOCKETS, Cathode Ray Tube

Franklin Mfg. Corp., 175 Varick St., N. Y. C.

SOCKETS, Tube

Aladdin Radio Industries, 501 W. 35th St., Chicago
Alden Prods. Co., Brockton, Mass.
★ Amer. Phenolic Corp., 1830 S. 54th Av., Chicago
Amer. Radio Hdware Co., Mt. Vernon, N. Y.
Birnbach Radio Co., 145 Hudson, N. Y. C.
Bud Radio, Inc., Cleveland, O.
Cinch Mfg. Co., 2335 W. Van Buren St., Chicago
Cont'l-Diamond Fibre Co., Newark, Del.
Eagle Elec. Mfg. Co., Brooklyn, N. Y.
Eby, Inc., H. H., Philadelphia
Federal Screw Prods. Co., 26 S. Jefferson, Chicago
Franklin Mfg. Corp., 175 Varick, N. Y. C.
★ Hammarlund Mfg. Co., 424 W. 33 St., N. Y. C.
Johnson Co., E. F., Waseca, Minn.
Jones, Howard B., 2300 Wabansia, Chicago
Micarta Fabricators, Inc., 4619 Ravenswood, Chicago
Millen Mfg. Co., James, Malden, Mass.
Miller Co., J. W., Los Angeles, Cal.
★ Nat'l Co., Malden, Mass.
Remler Co., San Francisco, Cal.

SOCKETS, Tube, Ceramic Base

Johnson Co., E. F. Waseca, Minn.
★ National Co., Inc., Malden, Mass.
Nat'l Fabricated Products, W. Belden Ave., Chicago
Ucinite Co., Newtonville, Mass.

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Garden City Laboratory, 2744 W. 37th Pl., Chicago
Gardiner Metal Co., S. Campbell Ave., Chicago
★ General Elec. Co., Bridgeport, Conn.
Kester Solder Co., 4209 Wrightwood Ave., Chicago
Ruby Chemical Co., Columbus, O.

SOLDER POTS

★ Elec. Soldering Iron Co., Inc., Deep River, Conn.
Lectrohm, Inc., Cicero, Ill.
Sound Equip. Corp. of Calif., 6245 Lex. Ave., Los Angeles 38
Westinghouse Elect & Mfg. Co., E. Pittsburgh, Pa.

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Crescent Industries, Inc., Belmont Ave., Chicago
★ Jensen Radio Mfg. Co., 6601 S. Laramie St., Chicago
John Meck, Industries, Plymouth, Ind.
Magnavox Co., Fort Wayne, Ind.
Quam-Nichols Co., 33rd Pl., Chicago 16
Rola Co., Inc., Superior St., Cleveland, O.
Utah Radio Prod. Co., 842 Orleans St., Chicago

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Altec Lansing Corp., 1680 N. Vine Hollywood 28
Cinaudagraph Speakers, Inc., 3911 S. Michigan Ave., Chicago
★ Jensen Radio Mfg. Co., 6601 S. Laramie St., Chicago
University Labs., 225 Varick St., N. Y. C.

SPRINGS

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Ace Mfg. Corp., 1255 E. Erie Ave., Phila. 24
American Spring & Mfg. Corp., Holly, Mich.
American Steel & Wire Co., Rockefeller Bldg., Cleveland, O.
Barnes Co., Wallace, Bristol, Conn.
Crescent Industries, Inc., 4132 W. Belmont Ave., Chicago
Cuyahoga Spring Co., Cleveland, O.
Gibson Co., Wm. D., 1800 Clybourn Av., Chicago
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Hunter Pressed Steel Co., Lansdale, Pa.
Instrument Specialties Co., Little Falls, N. Y.
Muehlhausen Spring Corp., Logansport, Ind.
Peck Spring Co., Plainville, Conn.
Raymond Mfg. Co., Corry, Pa.
Security Steel Equip. Corp., Avenel, N. J.
Standard Spring & Mfg. Co., Ind., 236-42 St., Brooklyn, N. Y.
★ Willor Mfg. Corp., 794 E. 104 St., N. Y. C. 54

STAMPINGS, Metal

Bud Radio, Inc., E. 55 St., Cleveland, O.
★ Goat Metal Stampings, Inc., 314 Dean St., Brooklyn, N. Y.
Hadley Co., R. M., 707 E. 61st, Los Angeles
Insuline Corp. of Amer., Long Island City, N. Y.
Par-Metal Prod. Corp., Long Island City, N. Y.
Stewart Stamping Corp., 621 E. 216 St., N. Y. C.
Willor Mfg. Corp., 288-A Eastern Blvd., N. Y. C.

History of Communications Number Four of a Series

SMOKE SIGNAL COMMUNICATIONS

While the puffs of our early American smoke Signals were not as complicated as the Morse Code, this type of communication was a speedy and effective means of communication at that time and could be seen for scores of miles on a clear day. Used for transmitting their battle messages, smoke signals in the days of the early American meant a progressive means of communication.

Restricted by climatic conditions this type of communication was limited in its use. Universal microphones in the part they play in modern electronic voice communication must withstand the climates of the Arctic and the Tropics all in a day's work. Built to accomplish a specific job, Universal Microphones are "getting the message through" on every Allied front.

Model T-45, illustrated at left, is the new Lip Microphone being manufactured by Universal for the U. S. Army Signal Corps. Shortly, these microphones will be available to priority users through local Radio Jobbers.

UNIVERSAL MICROPHONE COMPANY
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SUPPRESSORS, Parasitic

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SWITCHES, Aircraft Push

Square D Co., Kollsman Inst. Div., Elmhurst, N. Y.
★ Universal Microphone Co., Inglewood, Calif.

SWITCHES, Key

Audio Development Co., Minneapolis, Minn.
Chicago Tel. Supply Co., Elkhart, Ind.
General Control Co., Cambridge, Mass.
Mossman, Inc., Donald P., 6133 N. Northwest Hy., Chicago

SWITCHES, Midget Snap

Allied Control Co., Inc., E End Ave., N. Y. C.
Aero Electric Co., 3167 Fulton Rd., Cleveland
Micro Switch Corp., Freeport, Ill.

SWITCHES, Rotary, Bakelite Wafer

Mallory & Co., Inc., P. R., Indianapolis, Ind.
Stackpole Carbon Co., St. Marys, Pa.

SWITCHES, Rotary, Ceramic Wafer

Comm. Prods. Co., 744 Broad, Newark, N. J.
Oak Mfg. Co., 1267 Clybourn Ave., Chicago
Ohmite Mfg. Co., 4835 Flournoy St., Chicago
Shallcross Mfg. Co., Collingsdale, Pa.

SWITCHES, Time Delay

Haydon Mfg. Co., Inc., Forestville, Ct.
Industrial Timer Corp., 115 Edison Pl., Newark, N. J.
Sangamo Elect. Co., Springfield, Ill.

SYNTHETICS, Wood & Metal Finish

Sullivan Varnish Co., 410 N. Hart St., Chicago 22

TERMINALS, Hermetically Sealed

See BUSHINGS, Terminal Sealing

TERMINALS, Soldered or Solderless

See LUGS, Soldering and Solderless

TERMINALS (Turret Lugs)

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Manufacturers Screw Prod., 216 W. Hubbard St., Chicago 10
Ucinite Co., Newtonville, Mass.

TERMINAL STRIPS

Burke Electric Co., Erie, Pa.
Cinch Mfg. Corp., W. Van Buren St., Chicago
Curtis Devel. & Mfg. Co., N Crawford Ave., Chicago
Franklin Mfg. Corp., 175 Varick St., N. Y. C.
Jones, H. B., 2432 W. George, Chicago
Kulka Electric Mfg. Co., Mt. Vernon, N. Y.

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American Coils Co., 25 Lexington St., Newark, N. J.
Industrial Filter & Pump Mfg. Co., W. Carroll Ave., Chicago
Jackson Elec. Inst. Co., Dayton, O.
Kold-Hold Mfg. Co., 446 N. Grand Ave., Lansing Mich.
Mobile Refrigeration, Inc., 630–5th Ave., N. Y. C.
Northern Engineering Labs., 50 Church St., N. Y. C.
Radio City Prod. Co., Inc., 127 W. 26 St., N. Y. C.
★ Radio Corporation of America, Camden, N. J.
Supreme Inst. Corp., Greenwood, Miss.
Tenney Engineering, Inc., Montclair, N. J.
Weston Electrical Inst. Co., Newark, N. J.

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Arkwright Finishing Co., Providence, R. I.
Brown & Bro., Arthur, 67 W. 44 St., N. Y. C.
Keuffel & Esser, Hoboken, N. J.

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Dongan Elec. Co., 74 Trinity Pl., N. Y. C.
★ General Electric Co., Schenectady, N. Y.
Raytheon Mfg. Co., Waltham, Mass.
Sola Electric Co., 2525 Clybourn Ave., Chicago

TRANSFORMERS, IF, RF

Aladdin Radio Industries, 501 W. 35th St., Chicago
Amer. Transformer Co., Newark, N J
Automatic Windings Co., E. Passaic, N. J.
★ Browning Labs., Inc., Winchester, Mass
★ Cambridge Thermionic Corp., Concord Ave., Cambridge, Mass.
Caron Mfg. Co., 415 S. Aberdeen, Chicago
D-X Radio Prods. Co., 1575 Milwaukee, Chicago
Essex Specialty Co., Inc., Broad St., Newark, N. J.
Gen'l Winding Co, 420 W. 45 St., N. Y. C.
Greyhound Equip. Co., 1720 Church Ave., Brooklyn, N. Y.
Guthman & Co., 15 S. Throop, Chicago
★ Hammarlund Mfg. Co., 424 W. 33 St., N. Y. C.
Meissner Mfg. Co., Mt. Carmel, Ill
Millen Mfg. Co., James, Malden, Mass
Miller Co., J. W., 5917 S. Main, Los Angeles, Cal.
★ Nat'l Co., Malden, Mass.
Radex Corp., 1308 Elston Ave., Chicago
Siekles Co., F. W., Springfield, Mass
Sound Equip. Corp. of Calif., 6245 Lex Ave., Los Angeles 38
Standard Winding Corp., Newburgh, N. Y.
Super Elec. Prod. Corp., Jersey City, N. J.
Teleradio Eng. Corp., 484 Broome St, N. Y. C.
Triumph Mfg. Co., 4017 W. Lake, Chicago

TRANSFORMERS, Receiver Audio & Power

Acme Elec. & Mfg. Co., Cuba, N. Y.
Altec Lansing Corp., 1680 N. Vine, Hollywood 29
Amer. Transformer Co., Newark, N. J.
Amplifier Co. of Amer., 17 W. 20th St., N. Y. C.
Audio Devel. Co., N. Minneapolis, Minn.
★ Chicago Transformer Corp., 3501 Addison St., Chicago
Cinaudagraph Speakers, Inc., 3911 S Michigan, Chicago
Dinion Coil Co., Caledonia, N. Y.
Dongan Elec. Co., 74 Trinity Pl., N. Y. C.
Electronic Trans. Co., 515 W. 29 St., N. Y. C.
Ferranti Elec., Inc., 30 Rockefeller Plaza, N. Y. C.
Freed Trans. Co., 72 Spring St., N. Y. C.
Gen'l Radio Co., Cambridge, Mass.
General Trans. Corp., 1250 W. Van Buren, Chicago
Hadley Co., R. M., 707 E. 61st, Los Angeles
Halldorson Co., 4500 Ravenswood, Chicago
Jefferson Elec. Co., Bellwood, Ill.
Kenyon Transformer Co., 840 Barry St., N. Y. C.
Magnetic Windings Co., Easton, Pa.
★ Merit Coil & Trans. Corp., 311 N. Desplaines St., Chicago 6
Newark Transformer Co., Newark, N. J.
New York Transformer Co., 51 W. 3rd, N. Y. C.
Norwalk Transformer Corp., S. Norwalk, Conn.
Raytheon Mfg. Co., Waltham, Mass.
Rola Co., Inc., Superior St., Cleveland, O.
Standard Transformer Corp., 1500 N. Halsted, Chicago
Super Elect. Prod. Co., Jersey City, N. J.
Superior Elec. Co., Bristol, Conn.
Thermador Elect. & Mfg. Co., Riverside Dr., Los Angeles
Thordarson Elec. Mfg. Co., 500 W. Huron, Chicago
Utah Radio Prods. Co., 820 Orleans St, Chicago
★ United Transformer Co., 150 Varick St, N. Y. C.
Westinghouse Elect. & Mfg. Co., E. Pittsburgh, Pa.

TRANSFORMERS, Variable Voltage

Amer. Transformer Co., Newark, N J
General Radio Co., Cambridge, Mass
Superior Electric Co., Bristol, Conn

TUBE MANUFACTURING MACHINES

Hilton Eng. Labs., Redwood City, Calif
Eisler Eng. Co., 7518 13th St., Newark, N. J.

TUBES, Cathode Ray

★ Dumont Labs., Allen B., Passaic, N J
Farnsworth Tele. & Radio Corp., Ft. Wayne, Ind.
★ General Elec. Co., Schenectady, N. Y
Ken-Rad Tube & Lamp Corp., Owensboro, Ky.
Nat'l Union Radio Corp., Newark, N J
North Amer. Philips Co., Inc., Dobbs Ferry, N. Y.
Rauland Corp., Chicago, Ill.
★ RCA Mfg. Co., Camden, N. J.
★ Sylvania Elect. Prod., Inc., Emporium, Pa.
Westinghouse Elect. & Mfg. Co., E Pittsburgh, Pa.

TUBES, Current Regulating

Amperite Co., 561 Broadway, N. Y. C.
Champion Radio Works, Danvers, Mass
★ Hytron Corp & Hytronic Labs., Salem, Mass.

THE SCIENCE OF ELECTRONICS ALSO PROVIDES A NEW TRIUMPH IN ELECTRO-MEDICAL ANALYSIS AND LABORATORY RESEARCH . . .

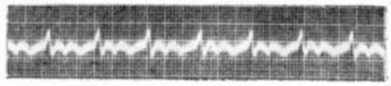

FIGURE A—Photographic Method

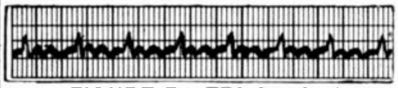

FIGURE B—EPL Method

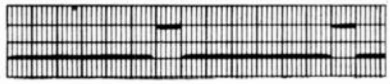

FIGURE C—Calibration

The exact similarity between the standard photographic cardiogram and the direct writing instantaneous cardiogram on this new EPL instrument is indicated in Figures A and B, which are records of the same subject taken a few minutes apart.

New EPL Direct-recording Electrocardiograph*

...giving instantaneous *standard* readings

- **Built to exacting laboratory standards after years of research**
- **Completely eliminates all photographic procedures**
- **Useful in the laboratory as well as a benefit to mankind**
- **Compact, lightweight, portable; simple and efficient in operation**
- **Cardiograph record appears instantaneously**
- **Built-in interference filter makes possible perfectly usable cardiograms in strong interfering electrical field**
- **Operates from any 110-120 volt, 60 cycle, AC service**
- **Uses no ink or other fluids**
- **High operating economy**

*PATENT PENDING

Note to
MEDICAL DIVISION
of the
ARMED SERVICES

We will gladly demonstrate this new Direct-recording Electrocardiograph before you at your convenience. We sincerely believe that this instrument can lend material assistance to the work that the Armed Services are now doing in the rehabilitation of wounded veterans.

For Laboratory Procedure

The recorder of this new Electrocardiograph may be used in conjunction with other equipment for laboratory research. It provides an amplifier and recorder which will give a graphic record between .1 cycle and 80 cycles per second at a sensitivity of 1 millivolt for 2 cms total deflection; or a range from zero to 80 cycles for 60 millivolts for 2 cms deflection. A high speed writer can be supplied which will extend the operating frequency to about 200 cycles. Because of the special damping circuit employed, excellent transient response is secured.

Although in the high sensitivity connection, the amplifier is not a true D-C amplifier, the phase correction is such that perfect square wave response from .25 cycles to 80 cycles is realized with the one millivolt sensitivity connection.

At present, deliveries will be made on priority only.
Write for descriptive booklet.

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45 W. 18th STREET • NEW YORK 11, N. Y. • WAtkins 9-1870
Manufacturers of Electro-Encephalographs and Electric Shock-proof Machines
A Division of the ELECTRONIC CORPORATION OF AMERICA

★ RCA Mfg. Co., Camden, N. J.
★ Sylvania Elec. Prod., Inc., Emporium, Pa.
Western Elec. Co., 195 B'dway, N. Y. C.

TUBES, Photo-Electric

Cont'l Elec. Co., Geneva, Ill.
De Jur-Amsco Corp., Shelton, Conn.
De Vry, Herman A., 1111 W. Center, Chicago
Electronic Laboratory, Los Angeles, Cal.
Emby Prods. Co., Los Angeles, Cal.
★ General Elec. Co., Schenectady, N. Y.
General Scientific Corp., 4829 S. Kedzie Av., Chicago
G-M Labs., 4313 N. Knox Av., Chicago
Leeds & Northrop Co., Philadelphia
Nat'l Union Radio Corp., Newark, N. J.
Photobell Corp., 123 Liberty St., N. Y. C.
★ RCA Mfg. Co., Camden, N. J.
Rectron Corp., 2159 Magnolia Av., Chicago
Westinghouse Lamp Div., Bloomfield, N. J.
Western Elec. Co., 195 B'way, N. Y. C.
Weston Elec. Inst. Corp., Newark, N. J.

TUBES, Receiving

★ General Elec. Co., Schenectady, N. Y.
★ Hytron Corp., Salem, Mass.
Ken-Rad Tube & Lamp Corp., Owensboro, Ky.
Nat'l Union Radio Corp., Newark, N. J.
Raytheon Prod. Corp., 420 Lexington Av., N. Y. C.
★ RCA Mfg. Co., Camden, N. J.
★ Sylvania Elect. Prod., Inc., Emporium, Pa.
Tung-Sol Lamp Works, Newark, N. J.

TUBES, Transmitting

Amperex Electronic Prods., Brooklyn, N. Y.
★ Eitel-McCullough, Inc., San Bruno, Cal.
Electronic Enterprises, Inc., 65-67 Av., Newark, N. J.
Federal Telephone & Radio Corp., Newark, N. J.
★ General Elec. Co., Schenectady, N. Y.
Heintz & Kaufman, S. San Francisco, Cal.
★ Hytron Corp., Salem, Mass.
Ken-Rad Tube & Lamp Corp., Owensboro, Ky.
Nat'l Union Radio Corp., Newark, N. J.
North Amer. Philips Co., Inc., Dobbs Ferry, N. Y.
Raytheon Prod. Corp., 420 Lexington Av., N. Y. C.
★ RCA Mfg. Co., Camden, N. J.
Slater Electric & Mfg. Co., Brooklyn, N. Y.
Sperry Gyroscope Co., Inc., Brooklyn, N. Y.
★ Sylvania Elect. Prod., Inc., Emporium, Pa.
Taylor Tubes, Inc., 2341 Wabansia, Chicago
United Electronics Co., Newark, N. J.
Western Elec. Co., 195 B'way, N. Y. C.
Westinghouse Lamp Div., Bloomfield, N. J.

TUBES, Voltage-Regulating

Amperite Co., 561 Broadway, N. Y. C.
Hytron Corp., Salem, Mass.
★ RCA Mfg. Co., Camden, N. J.
★ Sylvania Elec. Prod., Inc., Salem, Mass.

TUBING, Laminated Phenolic

Brandywine Fibre Prods. Co., Wilmington, Del.
Formica Insulation Co., Cincinnati, O.
★ General Electric Co., Pittsfield, Mass.
Insulation Mfgrs. Corp., 565 W. Washington Blvd., Chicago
Mica Insulator Co., 196 Varick, N. Y. C.
Nat'l Vulcanized Fibre Co., Wilmington, Del.
Richardson Co., Melrose Park, Ill.
Spaulding Fibre Co., 233 B'way, N. Y. C.
Synthane Corp., Oaks, Pa.
Taylor Fibre Co., Norristown, Pa.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Wilmington Fibre Specialty Co., Wilmington, Del.

TUBING, Precision Metal

Superior Tube Co., Norristown, Pa.

TUBING & SLEEVING, Varnished Cambric, Glass-Fibre, Spaghetti

Bentley-Harris Mfg. Co., Conshohocken, Pa.
Brand & Co., Wm., 276 Fourth Av., N. Y. C.
Electro Tech. Prod., Inc., Nutley, N. J.
Endurette Corp. of Amer., Cliffwood, N. J.
★ General Elec. Co., Bridgeport, Conn.
Insulation Mfgrs. Corp., 565 W. Washington Blvd., Chicago
Irvington Var. & Ins. Co., Irvington, N. J.
Mica Insul. Co., 196 Varick St., N. Y. C.
Mitchell-Rand Insulation Co., 51 Murray St., N. Y. C.
Varflex Corp., Rome, N. Y.

TURNTABLES, Phonograph

General Industries Co., Elyria, O.
★ R C A Mfg. Co., Camden, N. J.
Western Electric Co., 125 B'way, N. Y. C.

VARNISHES, Insulating, Air-Drying & Baking

Comm. Prods. Co., 744 Broad, Newark, N. J.
Dolph Co., John C., Newark, N. J.
Irvington Var. & Ins. Co., Irvington, N. J.
Mitchell-Rand Insulation Co., 51 Murray St., N. Y. C.
Stille-Young Corp., 2300 N. Ashland Av., Chicago
Zophar Mills, Inc., 112-26 St., Bklyn., N. Y.

VARNISHES, Wrinkle Finish

Sullivan Varnish Co., 410 N. Hart St., Chicago

VIBRATION TEST EQUIPMENT

Vibration Specialty Co., 1536 Winter St., Philadelphia
All American Tool & Mfg. Co., 1014 Fullerton Ave., Chicago

VIBRATORS, Power Supply

Amer. Telev. & Radio Co., St. Paul, Minn.
Electronic Labs., Indianapolis, Ind.
Mallory & Co., Inc., P. R., Indianapolis, Ind.
Radiart Corp., W. 62 St., Cleveland, O.
Turner Co., Cedar Rapids, Ia.
Utah Radio Prod. Co., Orleans St., Chicago

WAXES & COMPOUNDS, Insulating

Irvington Varnish & Ins. Co., Irvington, N. J.
Western Elec. Co., 195 B'dway, N. Y. C.
Zophar Mills, Inc., 112-26 St., Bklyn., N. Y.

WELDING, Gas, Aluminum & Steel

Treitel-Gratz Co., 142 E. 32 St., N. Y. C.

WIRE, Bare

Amer. Steel & Wire Co., Cleveland, O.
Anaconda Wire & Cable Co., 25 B'dway, N. Y. C.
Ansonia Elec. Co., Ansonia, Conn.
Belden Mfg. Co., 4633 W. Van Buren, Chicago
Copperweld Steel Co., Glassport, Pa.
Crescent Ins. Wire & Cable Co., Trenton, N. J.
★ General Elec. Co., Bridgeport, Conn.
Phosphor Bronze Smelting Co., Phila.
Rea Magnet Wire Co., Fort Wayne, Ind.
Roebling's Sons Co., John, Trenton, N. J.
Velliff Mfg. Corp., Southport, Conn.

WIRE, Glass Insulated

Bentley, Harris Mfg. Co., Conshohocken, Pa.
Garitt Mfg. Corp., Brookfield, Mass.
Holyoke Wire & Cable Corp., Holyoke, Mass.
Insulation Manufacturers Corp., 565 W. Washington Blvd., Chicago 6
Owens-Corning Fiberglas Corp., Toledo, O.

WIRE, HOOKUP

Bentley, Harris Mfg. Co., Conshohocken, Pa.
Gavitt Mfg. Co., Brookfield, Mass.
★ Lenz Elec. Mfg. Co., 1751 N. W. Av., Chicago
Rockbestos Prod. Corp., New Haven, Conn.
Runzel Cord & Wire Co., 4723 Montrose Ave., Chicago
Whitney Blake Co., New Haven, Conn.

WIRE & CABLE

Acme Wire Co., New Haven, Conn.
Amer. Steel & Wire Co., Cleveland, O.
Anaconda Wire & Cable Co., 25 B'dway, N. Y. C.
Ansonia Elec. Co., Ansonia, Conn.
Belden Mfg. Co., 4633 W. Van Buren, Chicago
Collyer Ins. Wire Co., Pawtucket, R. I.
Consolidated Wire Co., 1634 Clinton St., Chicago
Crescent Ins. Wire & Cable Co., Trenton, N. J.
Elec. Auto-Lite Co., The, Port Huron, Mich.
General Cable Corp., Rome, N. Y.
★ General Elec. Co., Bridgeport, Conn.
Hazard Ins. Wire Works, Wilkes-Barre, Pa.
Holyoke Wire & Cable Corp., Holyoke, Mass.
Hudson Wire Co., Winsted, Conn.
Rea Magnet Wire Co., Fort Wayne, Ind.
Rockbestos Prods. Corp., New Haven, Conn.
Roebling's Sons Co., John, Trenton, N. J.
Runzel Cord & Wire Co., 4723 Montrose Ave., Chicago
Simplex Wire & Cable Co., Cambridge, Mass.
Western Ins. Wire, Inc., 1000 E. 62 St., Los Angeles
Wheeler Insulated Wire Co., Bridgeport, Conn.

WOOD, Laminated & Impregnated

Canfield Mfg. Co., Grand Haven, Mich.
Formica Insulation Co., Cincinnati, O.

WOOD PRODUCTS, Cases, Parts

Hoffstatter's Sons, Inc., 43 Ave. & 24 St., Long Island City, N. Y.
Tillotson Furniture Co., Jamestown, N. Y.

FACSIMILE AT STATION WELD

(CONTINUED FROM PAGE 37)

The drum is approximately 3 ins. in diameter, and rotates at 75 revolutions per minute. In order to secure the maximum range of reproduction, the compensating amplifiers are adjusted for maximum black and maximum white, as taken from the master copy page. This provides the transmission characteristic previously set. When the transmission starts, the scanner and receivers are brought into synchronism by reason of the common power supply and in-step frame signal. As the scanning drum rotates, a beam of light is projected onto the master copy and is reflected back to a photo-electric cell. The light scans the copy at 125 lines per inch. The photo-cell, of course, changes the reflected light into electrical impulses. The amount of light reflected responds accurately to the color density of the copy being transmitted, and as the electrical impulses from the photo-cell amplifier pass through additional amplification, filters, and compensations, the signal at the output of the scanner represents the material being transmitted over a tonal range of 8 shadings.

The signal for average copy covers an audio frequency range of approximately 1,100 cycles to 3,500 cycles, with a maximum range of approximately 5,000 cycles. The receiver, turned on manually or by clock, works into the proper selection, amplification and compensation, and drives the printing mechanism of the recorder. Copy is printed by the carbon paper process.

With proper synchronization established between the rotation of the scanner and the recording mechanism, actual printing is the result of a printer bar, actuated by the received signal, pressing the carbon and white paper together as it strikes the helix on the rotating drum. The helix on the rotating drum provides the scanning necessary for the reproduced copy. Copy is now printed at a speed of 3 ft. per hour on a page 7.5 ins. wide. With 10-point type, this represents about 4,000 words per hour or around 65 words per minute. This is somewhat faster than the ordinary maximum speed of the Teletype. The paper comes in rolls of 345 ft. of white paper and 95 ft. of carbon paper. It is possible to feed the carbon paper slower and thus reduce the cost of operation. On a limited production basis, the combination carbon and white paper has cost $3.00 per roll. In quantities, this cost would be reduced considerably.

The item of maintenance is an important consideration of any new equipment at broadcast stations. Our maintenance cost for this Facsimile equipment has been surprisingly low, not exceeding $250.00 for the five years.

As a preview of what to expect in post-war Facsimile, it is interesting to point

(CONTINUED ON PAGE 59)

FACSIMILE AT STATION WELD

(CONTINUED FROM PAGE 58)

out some of the features incorporated in the RCA equipment which we had already planned to purchase in 1940. The system was self-synchronizing, did not require a common power supply for scanner and receivers. Speed had been increased from 65 words to approximately 140 words per minute. Receiving recorders were remotely controlled by radio impulses which started and stopped them without clocks or manual controls. An increased page width was equal to four columns of newspaper copy. Facsimile and broadcast receivers were combined in handsome consoles. Transmission was to be duplexed with sound over FM broadcasting stations. The receiver copy was visible as it was printed, eliminating the delay necessary in the former equipment.

Facsimile as a Public Service ★ In conducting our Facsimile service, receivers, by agreement, were not sold to the public. It was our desire to investigate this new art without commitment or obligation to the public. Starting with this skeptical but realistic attitude, we have become sincere believers in the merits of Facsimile and its future. We see its unlimited possibilities, and we believe duplexing will be used, with Facsimile and Frequency Modulation transmitted on the same carrier. In accordance with this belief, we have put the operation of Facsimile under the control of our FM station WELD.

We feel the potentialities of Facsimile are only limited by the imagination of those who plan the material and those who sell and use the advertising. In addition to its ability to provide an independent news and picture service as a radio newspaper for the public and for advertisers, Facsimile has an equal or even greater value as the visual counterpart of aural programs. This supplemental visual service will enhance the value of aural programs, for it will be possible to show products being described, pictures of artists, recipes, scores, patterns, drawings, weather reports and market reports. Almost every aural program requires the visual counterpart afforded by Facsimile. And the simultaneous transmission of sound and Facsimile, by FM, can make illustrations an integral part of sound programs. This will increase enormously the entertainment and instruction value of broadcasting, and multiply its effectiveness as an advertising medium.

We believe Facsimile remote pickup equipment will be available, bringing news pictures to the home within a few minutes. It is probable that the network distribution of a news-photo service will be feasible, with many national advertisers using the Facsimile network service as an adjunct to their aural programs, to illustrate their products, and for coupons.

(CONTINUED ON PAGE 60)

FACSIMILE AT STATION WELD

(CONTINUED FROM PAGE 59)

Facsimile is destined for a great future, if given the support and opportunities it justly deserves. We believe every progressive broadcaster should look upon Facsimile as an inexpensive service with unlimited possibilities — a service in which the public is definitely interested.

Postwar Facsimile ★ From our experience we have learned that the general use of home facsimile reception requires the following features:

1. Automatic operation. Machine to be turned on and off by broadcast station signals.
2. Self-synchronizing.
3. Economical, quiet operation.
4. Compact size, conveniently attachable to any receiver.
5. As an attachment, to sell for less than $100.00.
6. Speed of transmission in the order of 120 to 150 words per minute.
7. Visible Printing.
8. Four-column newspaper copy width.

Facsimile, to be successful, must be available throughout the day. Therefore, transmission should be multiplexed with FM. We believe multiplexing is the best method for both the broadcaster and the visual-listener, considering convenience and economy. We do not believe the transmission of facsimile on standard band AM stations, after aural program sign-off, to be of value except on clear channel stations, for rural coverage.

We of course look forward to the day when we can give the listeners aural and visual messages simultaneously. Had facsimile been available nationally during the present period, an outstanding service to the Country would have been provided.

NEW AWARD TO FM INVENTOR

(CONTINUED FROM PAGE 12)

War I. In fact, during all the feverish expansion of radio broadcasting which followed the peace, it seemed forgotten. Then, suddenly, it superseded the Neutrodyne and all other types of tuned RF circuits.

The story of Major Armstrong's FM system is somewhat parallel. However, the performance of the FM equipment installed by the Connecticut State Police encouraged the Signal Corps to try it for tank communications. In this application it easily surpassed AM equipment then used for this purpose.

Fortunately, this occurred early enough that there was time to extend the use of FM to many other important applications. Among these about which information has been released is equipment for combat cars and other motor vehicles, the handy-talkie, and the walkie-talkie. Others, of a more spectacular nature, have not been disclosed for security reasons.

A WAR INDUSTRY LOOKS AHEAD

(CONTINUED FROM PAGE 11)

of sets in total that will be allocated to be built by "Y" numbers of manufacturers, starting on "Z" day.

The development of such a program is not only important to the industry, but it is important to the public. A lot of detailed work is involved and a lot of policy determination must be resolved. The parts and tube manufacturers have a real problem of planning to properly integrate war and civilian production. It is therefore of the greatest importance that they have factual information from set manufacturers. This is only possible after we have a program. I think the time is at hand when we and WPB should institute specific activity which will complete the plans, so that we will have this program determined and thoroughly understood by all the parties in the industry, the services, and WPB. Then we can re-enter civilian activity without the confusion we will certainly have if we let this go too long and act too late.

Labor Turnover ★ We read a lot about employees in industry changing jobs, going into set-ups which they consider as better peacetime prospects. We in the radio industry certainly should not be plagued with this condition if our employees intelligently know the true condition and the peacetime prospects of the radio industry.

There is no other industry that I can see which offers a greater peacetime employment opportunity than the radio industry. No employee in the radio industry should move to another industry, because we will be very busily engaged right up to the conclusion of the Japa ese war — and we will be gradually implemented into more and more civilian production as the war production requirements decrease.

Postwar Models ★ The public has been mystified by a lot of what they have heard and read about the radio industry war effort. Many of the mysterious things done by the radio industry had to do with radar devices and not radio communications, and because of military reasons, we are refraining from public discussion of these devices.

We in the radio industry know that when we resume civilian production of radio sets we are not going to put out any fantastic gadgets — we are going to have a radio set with improved tubes, improved components, circuit modification — but the fundamentals will be the same. We must be very sure that this is what the buying public expects. Let's think and talk in terms of "*improved radio.*"

It will be impossible for us to make use of all the knowledge gained in our war effort in our first models, for the application of things learned must be an evolu-

(CONTINUED ON PAGE 62)

FILE IN YOUR NOTEBOOK

PUNCH IN HOLES INDICATED

TECHNICAL NOTES

Excerpts from New Home Study Lessons Being Prepared under the Direction of the CREI Director of Engineering Texts

The Iconoscope

THIS MONTH CREI is publishing the third and final article of a series on the iconoscope. This is one of a series of interesting technical articles appearing each month in the CREI NEWS, official organ of the Capitol Radio Engineering Institute.

This final article analyzes the action of the iconoscope when a scene is optically focused on it, together with a discussion of the advantages and disadvantages of this type of pickup device. Altogether, the reader will have a good physical picture of the action of the iconoscope from these articles.

At some later date, the technical staff of CREI intends to present an analysis of the action of the orthicon.

Since the appearance of these technical articles in the CREI NEWS, copies have been very much in demand. *Write at once for the July issue which includes this final article on the iconoscope.* Also indicate if you would like to be placed on our mailing list to receive the CREI NEWS each month. There is no charge or obligation.

Those who are already receiving this monthly magazine can further benefit from it by writing to The Editor and suggesting technical topics they would like to have discussed. We are anxious to make the CREI NEWS interesting and of service to you.

★ ★ ★

The subject of "The Iconoscope" is but one of many that are being constantly revised and added to CREI lessons by A. Preisman, Director of Engineering Texts, under the personal supervision of CREI President, E. H. Rietzke. CREI home study courses are of college calibre for the professional engineer and technician who recognizes CREI training as a proven program for personal advancement in the field of Radio-Electronics. Complete details of the home study courses sent on request. . . . *Ask for 36-page booklet.*

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WASHINGTON 10, D. C.

Contractors to the U. S. Navy — U. S. Coast Guard — Canadian Broadcasting Corp. — Producers of Well-trained Technical Radiomen for Industry.

A WAR INDUSTRY LOOKS AHEAD

(CONTINUED FROM PAGE 61)

tionary affair. I think we are all conscious of our responsibility to the public — and let's all be sensitive to this responsibility and see that they are not misled as to what they should expect.

Television and FM ★ Television, of course, is in the back of the minds of all of us, and some day we will have another industry as big or bigger than the radio industry.

It is quite reasonable for us in the radio manufacturing business to assume that we will be the ones who will develop, produce and merchandise television sets. There is some variance of opinion as to just when and how television will take hold after the war. This is no time to prejudge the situation.

A very orderly effort is in process for a thorough technical appraisal of television. A study is in progress by the Radio Technical Planning Board to develop facts as to whether, to what degree, and when any alterations should be made in the television systems standard and/or television frequency allocation we now have. I believe proper technical appraisa's will be made in due time, and sober consideration will be given to this entire problem by the Federal Communications Commission.

I personally think that we have to underwrite our success in the Pacific War before we, as set manufacturers, will be producing television sets. In the meantime, the matter of systems standards and frequency allocation will have been resolved. When we do get post-war television, it will be the advent of a great business.

FM is going to be in the picture in post-war radio. FM has a lot of merit, and will play a very important part as a factor in post-war radio merchandising. FM was coming along before the war, but now, with the new policy of the broadcast chains to put their chain programs out through FM channels, greater impetus will be given to FM in the future.

Patent Problems ★ Out of television and FM will arise new patent situations in our industry which look very cloudy at this time — particularly those involving television; and no one has the solution.

I don't believe it is out of order to sound a warning from the industry to anybody or anybodies to whom it might apply. We in the industry will not tolerate any attempts to gag our industry with monopolistic patent control of television. In the interest of the public and the industry, the television patent situation must be resolved with long-view forethought and common sense. There is no monopoly on brains and research, and the radio industry has a lot of both, along with stout vigor in top management.

(CONTINUED ON PAGE 63)

A WAR INDUSTRY LOOKS AHEAD

(CONTINUED FROM PAGE 62)

Responsibilities of the R.M.A. ★ As I look into the future and see some of the problems which will confront us, I see the requirement of an industry association looming up with ever greater importance. There will be many problems which need be resolved between the groups within the industry. We will have the ever increasing problems requiring industry group action in relationship with Government agencies. Industry responsibility to the public will require group action. The industry trade association is the best agency in which to resolve the common problems of industry and to give weight and respect to their common needs.

The Radio Manufacturers Association is now in its twentieth year of fulfilling this requirement for the radio industry. Through its constructive activities, it enjoys a very enviable reputation amongst all industry groups, the public, and Government bodies; and it is expected that the Radio Manufacturers Association will continue to fulfill the group action requirements of the radio industry.

FM FOR RAILROADS

(CONTINUED FROM PAGE 27)

This test installation, set up under the supervision of radio engineer Ernest A. Dahl, provides 2-way communication between the yardmaster's office of the Rock Island's Burr Oak yards and the Diesel switching engines which handle thousands of cars daily in the Blue Island area.

The arrangement of the radio transmitter and receiver is shown in the accompanying view of the Diesel locomotive cab. The equipment was supplied by Galvin Manufacturing Company, and Marion Bond, one of the engineers of that concern, worked with Ernest Dahl on the installation of this initial system. The plan of locomotive installations follows very closely the layout[3] illustrated in the July, 1943 issue of *FM* RADIO-ELECTRONICS.

Thus it can be seen how dangerous it is for outsiders to discount the possibilities of radio, and the constructive thinking of radio engineers. If anyone dares to say, wishfully, that there is something that can't be done by radio, he is very apt to rub his eyes next morning as he reads that it is already an accomplished fact.

[3] *FM Aids Battle of Transportation*, by William S. Halstead, *FM* RADIO-ELECTRONICS, July and August, 1943. This article is available in reprint form on request. *See also Railroads Need Radio Communications*, by Milton B. Sleeper, and *FM Safety Aids on Railway Systems*, by William S. Halstead, *FM* RADIO-ELECTRONICS, January, 1944.


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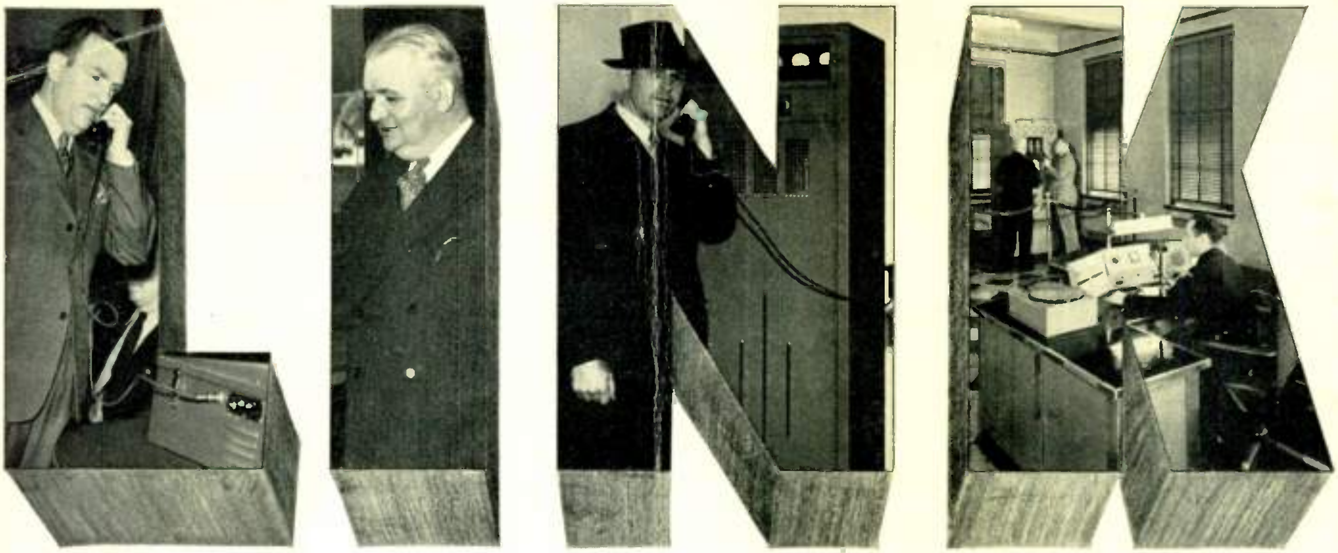

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