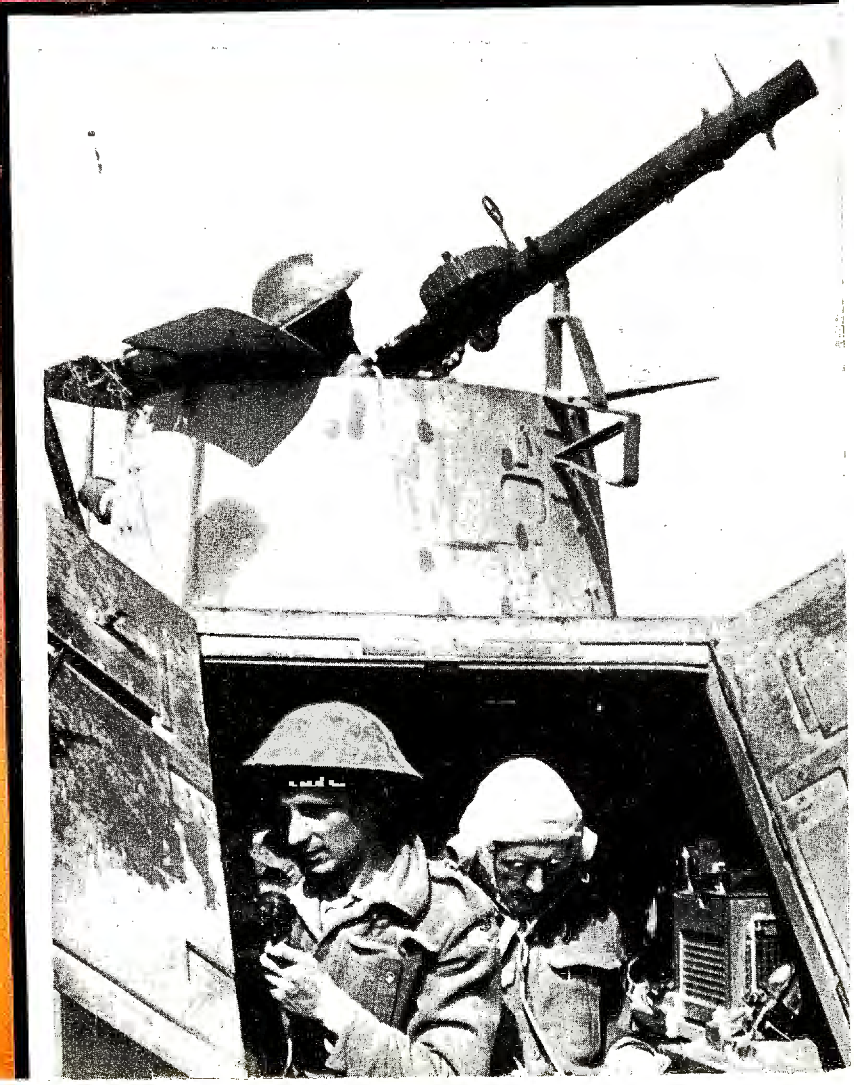
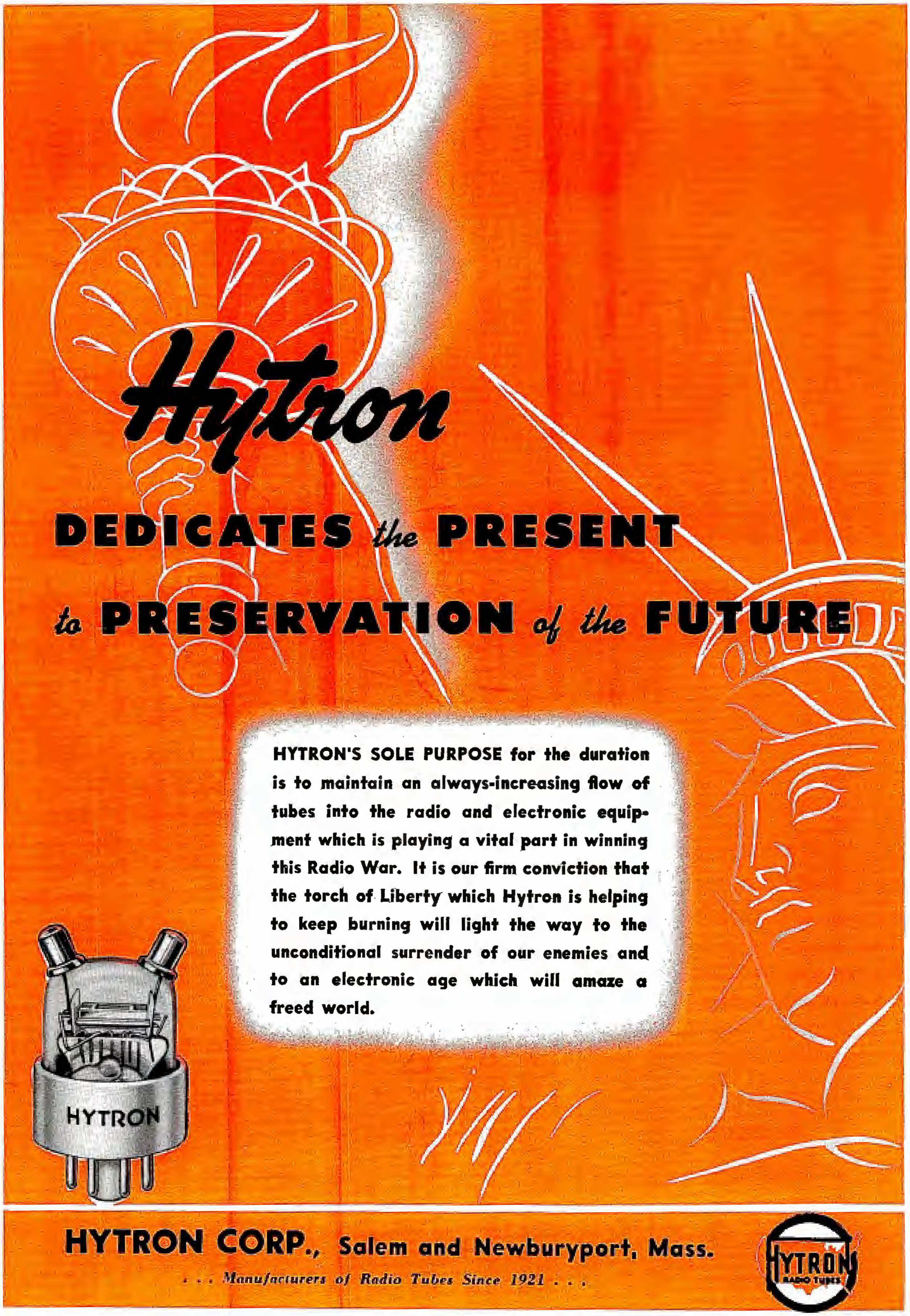
COMMUNICATIONS

★ RADIO ENGINEERING
★ TEST-FLIGHT RECORDER
★ IRE 1943 WINTER CONVENTION
★ U-H-F CIRCUIT CONTOURS
★ R-F TRANSMISSION LINES
★ EMERGENCY BROADCAST LINES
★ TRANSIENT ANALYSIS

FEBRUARY

1943




Hytron
DEDICATES the PRESENT
to PRESERVATION of the FUTURE
HYTRON'S SOLE PURPOSE for the duration is to maintain an always-increasing flow of tubes into the radio and electronic equipment which is playing a vital part in winning this Radio War. It is our firm conviction that the torch of Liberty which Hytron is helping to keep burning will light the way to the unconditional surrender of our enemies and to an electronic age which will amaze a freed world.
HYTRON
HYTRON CORP., Salem and Newburyport, Mass.
. . . Manufacturers of Radio Tubes Since 1921 . . .
HYTRON
RADIO TUBES

LEWIS WINNER, Editor
F. WALEN, Associate Editor

We See...

AFTER WAVES OF CONFERENCES and a flurry of memoranda, a *final ruling* on the status of maintenance, repair and operating supplies for the broadcast industry has been made. Basically the ruling, or as it is officially known, Preference Rating Order P-133, assigns a rating of *AA-2X* to those engaged in radio communication, including broadcasting, commercial sound recording and radio direction finding. All other previous assignments and rulings *are voided* by this newest amendment, issued on February 4. This new rating is, according to Washington, the highest generally obtainable for non-military requirements. It not only provides for the delivery of material to an operator for operating supplies and for maintenance and repair, but also for the delivery to any supplier of material to be physically incorporated in other material required. And not only does this ruling afford the replacement of parts, but the replenishment of spare tubes, providing that inventory is not increased to beyond 100%. The inventory of parts of course must not be increased beyond that declared on the date of the issuance of this order.

Those engaged in recording may now use this rating to secure blanks and other complementary material.

While it is impossible to guarantee that all materials required will be provided immediately upon receipt of the PD-1A form, that must be filled out to secure the necessary replacements, Washington assures broadcasters that every effort will be made to provide as consistent a supply of equipment as is humanly possible. The broadcast industry now appears to have been given a *real helping hand!*

COMMERCIAL AND EXPERIMENTAL TELEVISION seem to be very much alive these days, notwithstanding many balky problems. Most of the television units have been granted license renewals. And every effort is being made to at least maintain some form of schedule for the duration. Both military and commercial authorities have consistently declared that television is a vital branch of communications that *must not be shelved* regardless of the difficulties of the day.—L. W.

COMMUNICATIONS

Including Television Engineering, Radio Engineering, Communication & Broadcast Engineering, The Broadcast Engineer. Registered U.S. Patent Office.
Member of Audit Bureau of Circulations.

FEBRUARY, 1943

VOLUME 23 NUMBER 2

COVER ILLUSTRATION

Armored radio transmission car now serving the RAF and British army radio units in the middle East. These cars serve to establish advance and support communications.

(British Official Photo)

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JOE, MARY, TONY, MAC *You've* WON IT!

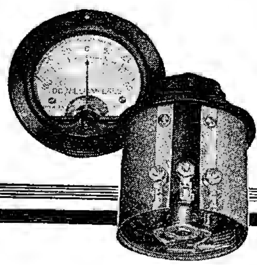
Dear Employees:

You've earned the Army-Navy . . . "E" . . . And yet, we knew you would . . .

Not many months ago, you, of the DeJur Amsco Corporation served a peacetime market in a peacetime world . . . Today you work with fervor . . . hurdling all obstacles to produce for the Armed Forces . . . Your time, your labor have been diverted to PRODUCTION FOR WAR . . . PRODUCTION OF MATERIALS TO WIN THIS WAR . . .

Today DeJur Instruments, Potentiometers, and Meters have joined the fighting fronts . . . to serve America . . . and the World.

RALPH A. DeJUR President



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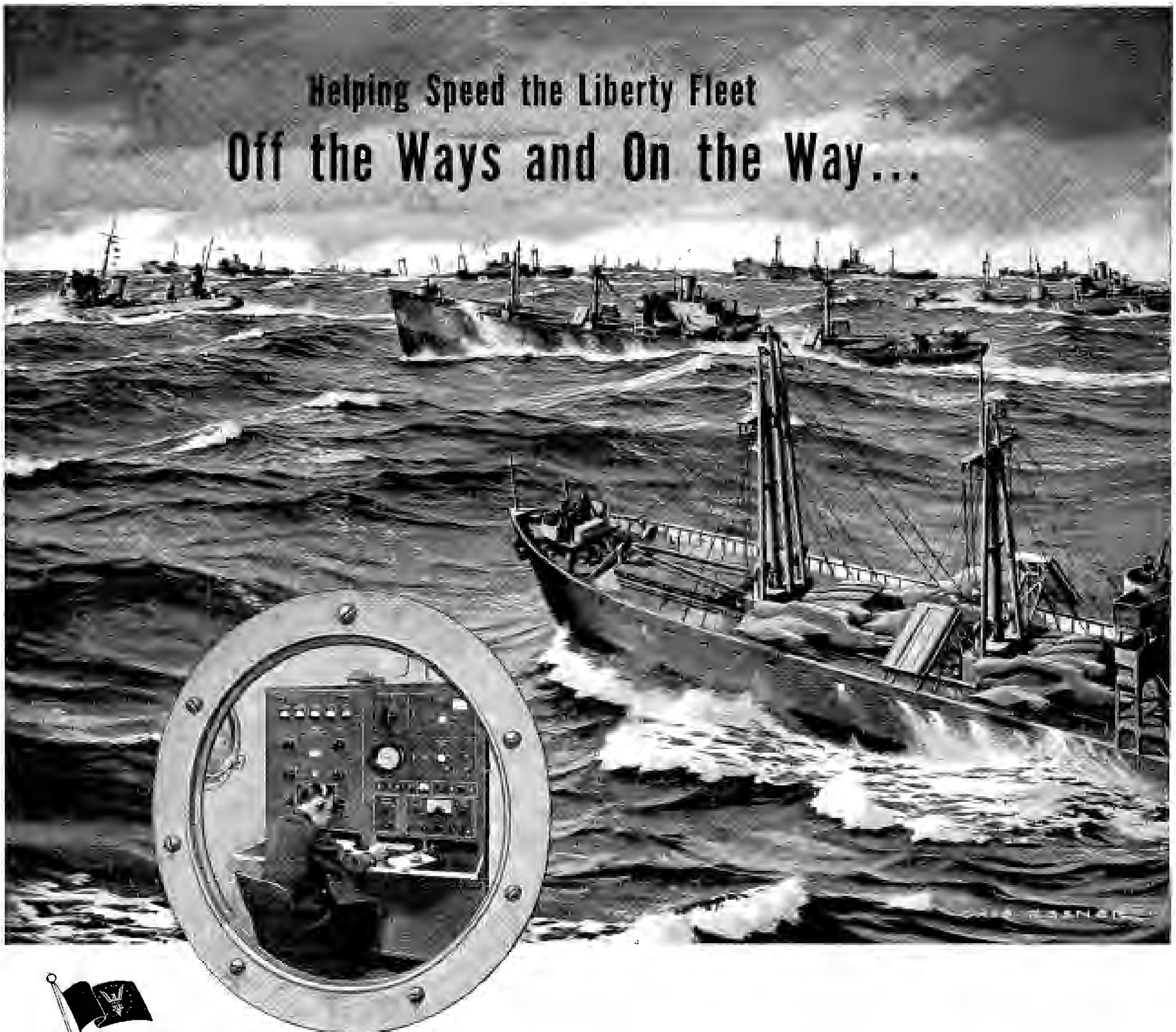

...Awarded the Maritime M "for Outstanding Development and Production of Radio Equipment"

The new Liberty Ship radio
Developed for The Maritime Commission
By I. T. & T.'s manufacturing associate
Federal Telephone and Radio Corporation
Is helping save the manpower hours
That build our bridge of ships.

Not eight or ten separate parts
But *one*
Compact, all-in-one
Radiotelegraph Unit—
Takes care of
Both sending and receiving.

Installed in one-fifth the time
Normally required—
Ready to plug in and tune in—
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For other vital jobs.

In recognition of
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INTELLIGIBILITY

Built to Civil Aeronautics Administration specifications, CAA-515, the Electro-Voice Model 7-A microphone is widely used for airport landing control and is highly suitable for many other sound pick-up applications.

The smooth frequency curve, rising with frequency, gives extremely high intelligibility even under adverse conditions. Desk mounting incorporates easily accessible switch which can be operated by thumb of either right or left hand. Microphone may be moved without danger of pressing this switch.

SPECIFICATIONS

SWITCH: Push-to-talk Acro-switch, SPDT, for relay operation; positive action; slight pressure required for actuation; 1/16" over-travel; connections terminate on terminal strip in base.

OUTPUT IMPEDANCE: 25 ohms.

CABLE: Eight feet, 4 conductor, shielded, overall rubber jacket, equipped with MC4M connector.

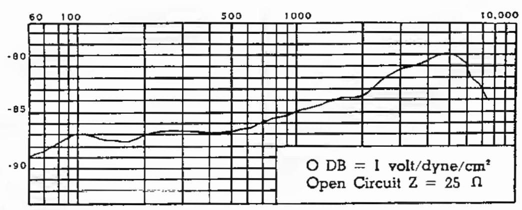
DISTORTION: Not exceeding 5% for sinusoidal sound waves from any direction from 100-4000 cps, up to 50 dynes/cm^2.

INSULATION: Leads from the moving coil are insulated from the microphone housing and stand, and are capable of withstanding 500 volts RMS, 60 cps.

STAND TUBE: Wear resistant, $\frac{1}{8}$" XXM bakelite.

CORROSION RESISTANCE: The entire microphone is completely inhibited against corrosion and will successfully withstand a 20% salt spray atmosphere for 100 hours at 95° F.

NET WEIGHT: $3\frac{1}{2}$ lbs.; Shipping wt.: 5 lbs.



This Model 7-A Desk Mounting Communication Microphone supersedes our previous Model S-7. Our Engineering Department may be able to assist you with your microphone problem. *Electro-Voice Manufacturing Co., Inc., 1239 South Bend Avenue, South Bend, Indiana. Export Division: 100 Varick Street, New York, N. Y., U. S. A.— Cable Address: "Arlab"*

Electro-Voice MICROPHONES

DO YOU KNOW? HOW THEY LIKE FM?

Independent survey shows that 91% of FM radio set owners would recommend them to their friends!

Americans want FM radio. *Facts* show that FM has what it takes to win public acceptance. An independent, doorbell-ringing consumer survey of hundreds of FM set owners proved this beyond any doubt. Overwhelmingly, FM set owners like FM's better tone quality, its virtual freedom from static, its breath-taking "background of silence"!

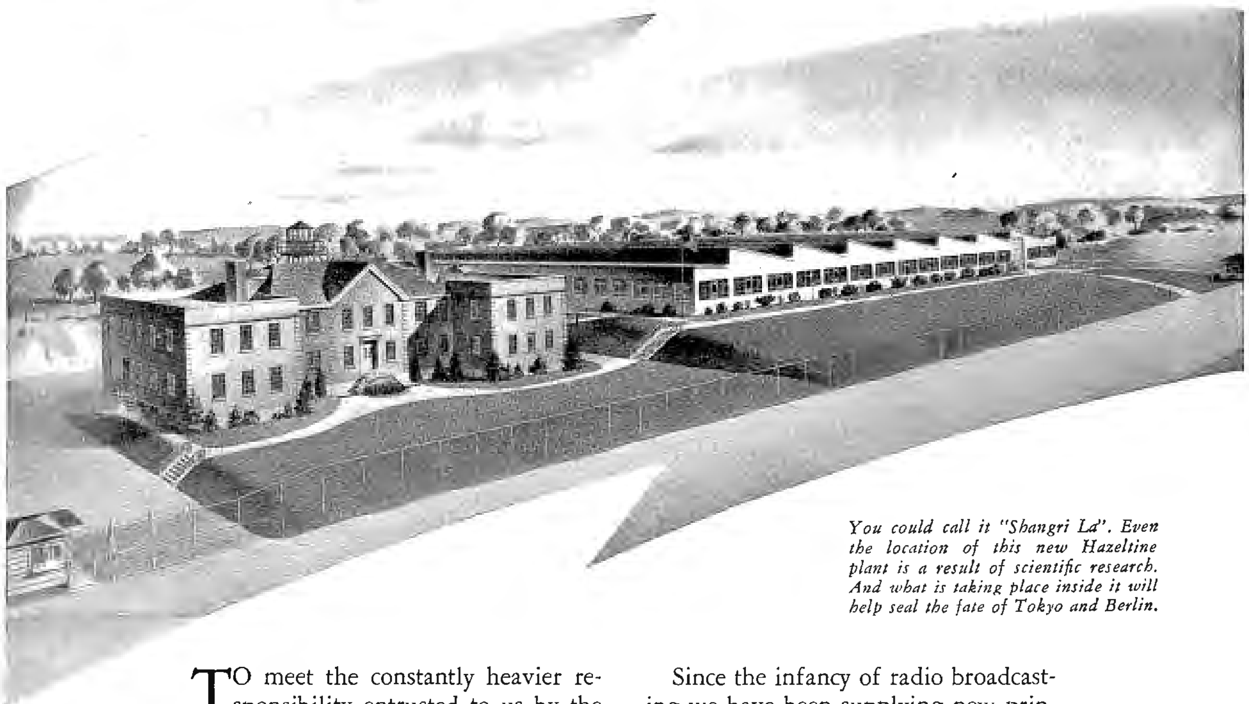
For example: That FM reception is better than regular broadcast reception is the conviction of 85% of FM set owners. And more than half of these classified it as a "great improvement"! Some 79% of FM owners expressed full satisfaction with their FM reception quality. And 91% would recommend it to their friends!

Announcing a change of name

HAZELTINE SERVICE CORPORATION

becomes...

HAZELTINE *Electronics* CORPORATION



You could call it "Shangri La". Even the location of this new Hazeltine plant is a result of scientific research. And what is taking place inside it will help seal the fate of Tokyo and Berlin.

TO meet the constantly heavier responsibility entrusted to us by the Army and Navy — and ultimately to serve industry better—we at Hazeltine have enlarged all facilities for research and development in the field of electronics.

With the completion of this project it is fitting that we take the new name —HAZELTINE ELECTRONICS CORPORATION. For we are equipped in plant and personnel to undertake solution of the most complex problems in electronics.

Since the infancy of radio broadcasting we have been supplying new principles, circuits, techniques and equipment. Today, Hazeltine developments are playing a vital part in keeping the United Nations superior to the enemy.

Under the stress of war we are concentrating years of research into the space of months. When our facilities once again can be turned to peace-time use, there will be at Hazeltine a deep reservoir of knowledge and experience that can be invaluable in tomorrow's world of electronics.

HAZELTINE ELECTRONICS CORPORATION

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COMMUNICATIONS

LEWIS WINNER, Editor

* * F E B R U A R Y , 1 9 4 3 * *

AUTOMATIC AIRCRAFT-RADIO RECORDER

Now Provides Vital Performance Data Of Planes In Flight To Ground Crew

by RALPH G. PETERS

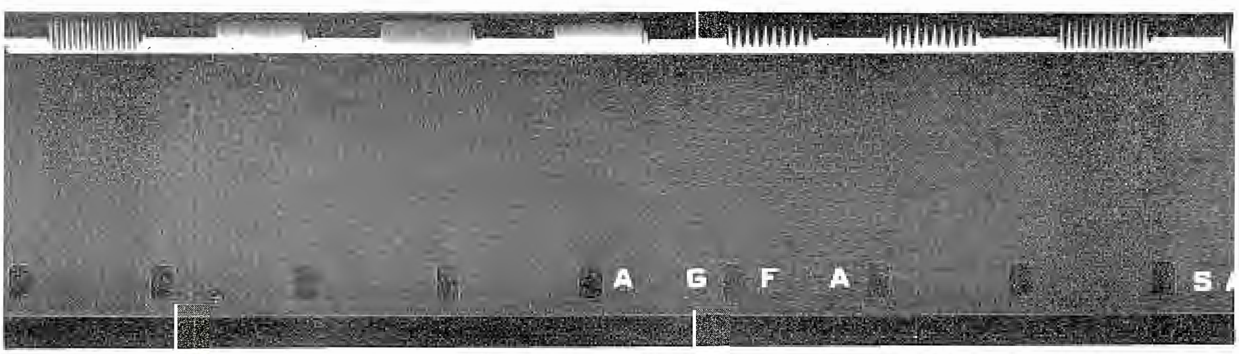
THE stringent demands of warfare have again provided a development that is most unusual. The development, a radio test-flight recorder, provides, for the first time a complete automatically-radioed record of the operating characteristics of an airplane *in flight,* to ground crews below. All of the strains, flutters, and other characteristic operating variables, which in today's high performance aircraft occur too rapidly for a test pilot's eyes and hands to notice and record, are, with the aid of this new recorder, permanently available.

Figures 1 (right), Figure 2 (below)

At right, an automatic analyzer that provides individual graphic charts of the reactions reported by each individual instrument and gauge of the plane's "nervous system." This comprehensive coordinated data, for the first time, gives engineers an accurate basis for design improvements. Below, the recorded signal on a sound track containing 'plane structural information.

Solution to a Major Problem

Satisfactory observations and recording of flight test data on experimental aircraft have long been a major problem confronting aeronautical engineers. Pilots and observers have been unable to observe and manually record data sufficiently fast and to interpret correctly the operational "feel" of an airplane in flight. During unstabilized conditions, such as climbs, dives and acrobatics, the number and accuracy of observations are very limited due to rapidly changing conditions of velocity, acceleration, power, altitudes, air temperatures and engine temperatures. As a result, serious conditions often went unobserved, or, if observed, led to improper conclusions due to incomplete observation. Dependence upon such meager information resulted in numer-



ous duplication of flights with resultant delays in development.

A test pilot usually was so busy flying his ship that he had scarcely time to observe his flight instruments, to say nothing of his special instruments. For these reasons the aircraft industry has for several years sought a means of automatic or semi-automatic test-flight recording. The most commonly employed method has been a photographic one. A motion picture camera mounted in an airplane filmed in either motion or single shot exposures, the readings of a bank of instruments. The method has not proved to be a solution for many reasons.

In modern combat airplanes, there isn't space for a movie camera. And in addition it is impossible for a camera to focus on all points throughout a ship where stress and other indications are to be found. There is the natural undesirable delay in the compilation of sufficient data. And in the event of a crash all data is lost.

This new device invented by H. D. Giffen, a former motion picture sound engineer, and now on the staff of development engineers of Vultee Aircraft, "sees" seventy points throughout the structure of a plane. To provide such wide coverage, seventy pick-up instruments are scattered throughout the plane. And each of the seventy indications may be recorded once each in three-quarters of a second for as long a time as desired. Or a complete seventy-instrument recording may be made at regular intervals by means of an auxiliary device known as an intervalometer. This latter arrangement is used to economize on film and also provide a subsequent analysis at a later date.

The recorder provides a continuous, unbroken recording of any one instrument so as to determine the strain, vibration, and other characteristics of a rapidly changing function. Thus data on control loads, hinge loads, air speed and acceleration during dives, pull-outs, and other operations are available. A

Figure 3

Disc recorder and electronic discriminator that decodes the instrument-reading transmission and feeds the resultant energy to the meter element of a graphic pen.

switching arrangement permits continuous recording of as many as fifteen instruments, one at a time, during a single flight. And a flight test of unlimited duration may be recorded, with the airplane as far as a hundred miles from the receivers.

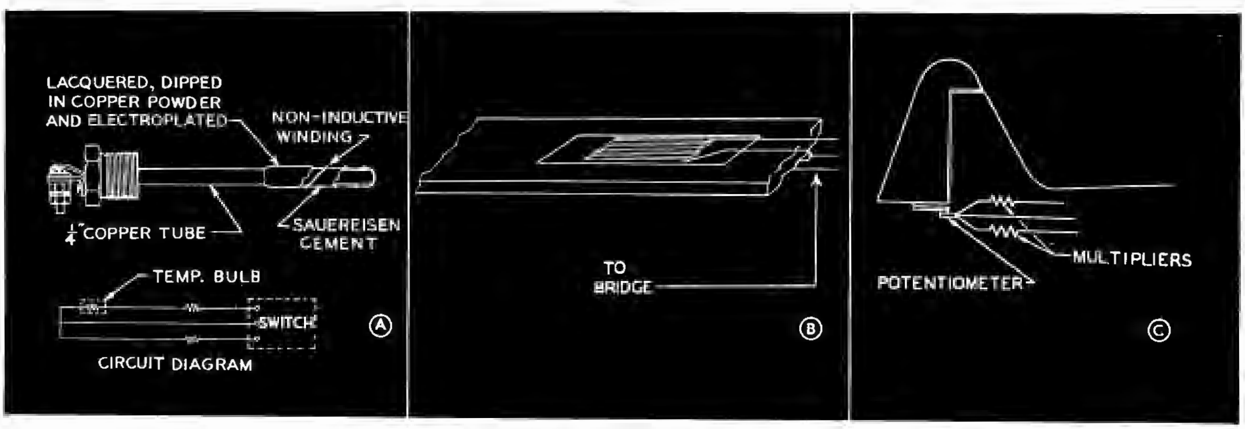
The recording of instrument dial changes provides signals whose frequency is predicated on the voltage of a pick-up; this voltage itself being a function of the instrument indications. This signal frequency is transmitted over the customary aircraft transmitter in the plane, to the ground unit where it is automatically recorded. Recording is accomplished by a standard sixteen-millimeter sound recorder, or in the case of continuous indications, by a standard high fidelity disc recorder.

An analysis of the frequencies recorded on a sound film (three-quarters second intervals) or on the disc plate (continuous) is accomplished automatically by a device, to be described later, that not only analyzes each signal but also plots the analysis on a paper chart. Each of the seventy functions is plotted automatically on separate charts so that the flight engineers have a complete charted analysis of the entire flight. In the case of a continuous recording, the resultant automatically plotted chart is a continuous chart of whatever variations occurred on the particular function during the period recorded.

Since the transmitted signals cannot be decoded, they have no meaning to an enemy, should he receive these signals on his receiver. The instrument indications are transmitted as variable frequencies rather than variable volume. Therefore, the signals are not affected by changes in volume due to distance of transmission. This makes it possible to conduct test flights anywhere within the effective radius of the radio transmitter and receiver used. Incidentally, the functioning and accuracy of the recorder are not affected by static since frequency modulation is used.

As mentioned previously, the existing transmitter on the plane can be used. An auxiliary phone transmitter on any band may also be used. Where only one transmitter is available, switching from normal communication to radio recorder service is possible.

In the past, radio recording has not been successful because of fading, limited range, and static interference. These problems have been overcome in this recorder. When static interference is present, the analysis is not affected unless continuous static totaling more



Figures 4, 5 and 6

In Figure 4 (left), a type of pickup used for temperature purposes. Figure 5 (center), a strain gauge. Figure 6, an angular measurement device.

than 30% of the signal is present. The familiar limiter circuits used in f-m receivers is used here too.

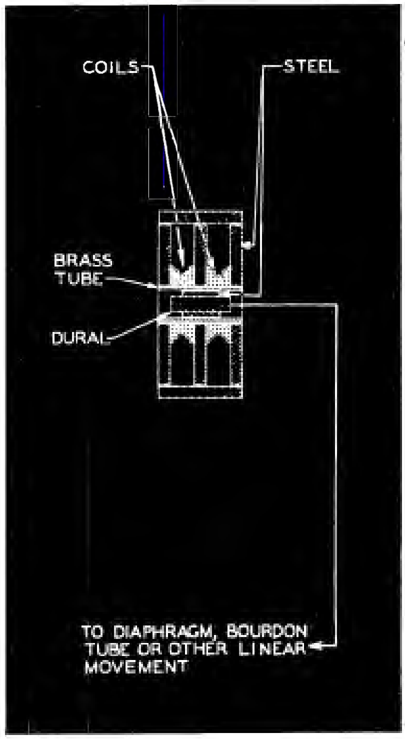
To provide this recording service, equipment consisting of pick-ups, a twelve-pound scanning switch that occupies but three-quarters of a cubic foot, and a fifteen-pound converter unit occupying approximately one cubic foot, are used.

The various components used in this recorder are, of necessity, of special design. The pick-ups, for instance, are so constructed that all variable factors involved are automatically canceled out except that factor which is to be measured. In Figure 4, appears one type of a pick-up used for temperature purposes. This is of the resistance type designed to follow rapid changes in whatever is being measured. The device consists of a thin copper tube and a resistance wire winding, with a thin copper plating over this winding. A thermal insulator of special cement is also provided. To prevent the introduction of errors, due to mechanical strains that might be caused by expansion and contraction, copper parts are used throughout. Stainless steel and platinum wire are used in this instrument to measure high temperatures that prevail in exhaust gases.

Since it has been found that a change of five-thousand cycles-per-second for the total range of each instrument is the most practical now, this range has been arbitrarily chosen as the full scale. Accordingly, all pick-ups provide a five-thousand cycle-per-second change in the converter unit when the pick-up is subjected to the maximum change in stimulus which it is required to measure. Graphic recorders used as frequency meters respond full scale to this five-thousand-per-cycle change. If, for instance, an airspeed pick-up designed for a five-hundred miles-per-hour range causes a frequency change of one thousand cycles-per-second in a converter (when a ship is flying at one hundred miles-per-hour) the charting will be at one-fifth full deflection on a similar chart that has been calibrated at a five-hundred mile-per-hour full range.

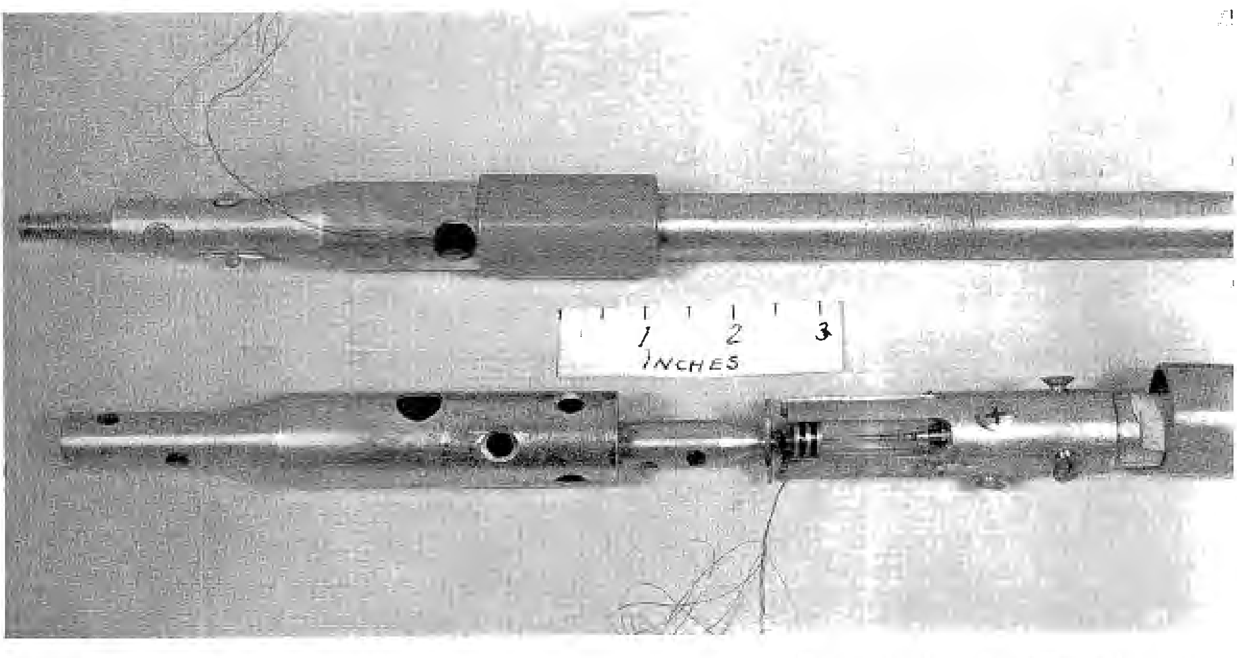
In Figure 5 appears the standard type wire wound strain gage that is used to measure strain. In addition to this unit an unstressed dummy gage mounted adjacent is also used. The leads from these devices form two arms of the bridge that cancel out the effects of temperature. These strain gages have a resistance of 88 ohms and vary 2 ohms over a range from —60,000 to +60,000 psi stress in 24 st-al. Strains can be read for small loads over, let us say, a total range of approximately 3,000 pounds. To do so, it is only necessary to increase the gain on the bridge amplifier. In this way the converter unit can be made to swing through its entire range.

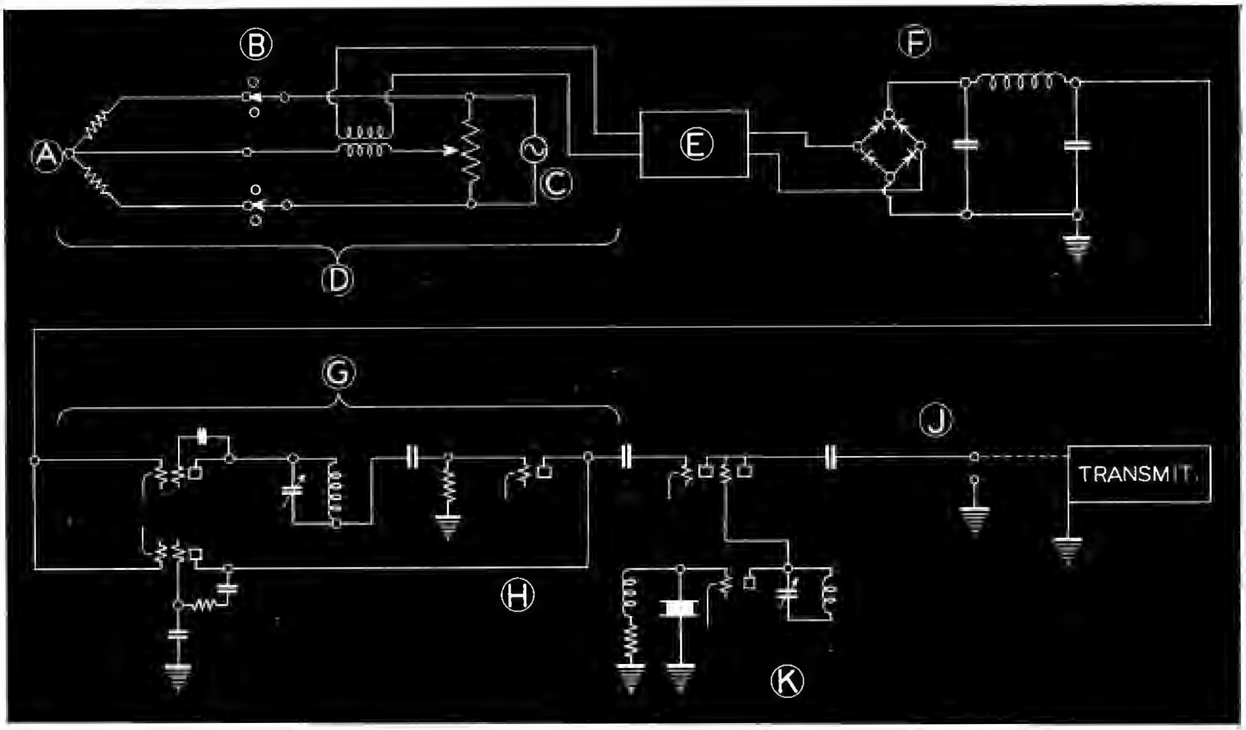
To control the ranges of other types of pick-ups that may be more sensitive than required, shunts or multipliers are used. For instance in the temperature measurement device, the units are first made to approximate specification ranges. With the aid of proper multiplier resistances in series with the unit, the ranges can be adjusted exactly as conditions require. For a 150° C range a standard temperature unit has approximately 4 ohms of 36 copper wire, in series with 100 ohms of zero temperature coefficient resistance in its arm of the bridge. The zero of the range

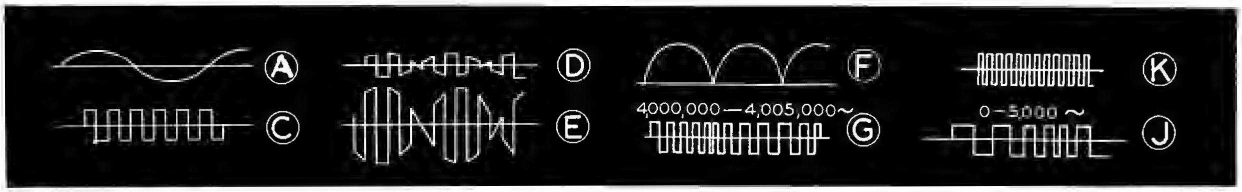


Figures 7 and 8

Figure 7 (top), the reactance bridge coil in the pressure unit. Movement of the diaphragm causes small armature to move between two coils, forming two arms of a reactance bridge. Figure 8 (below), a push-pull flight control rod. Reactance bridges are used here, too, for measuring the deflection of a spring in a push-pull flight control rod.





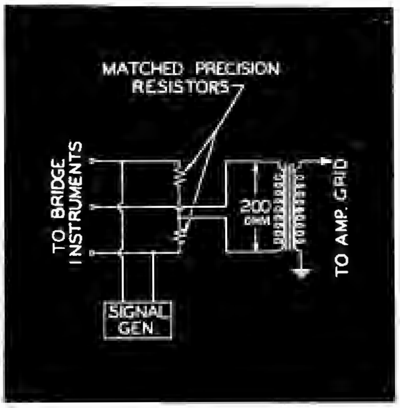


is determined by the amount of resistance used in the other arm of the bridge.

Standard diaphragms are used in all of the pressure units (see Figure 7). In this device, the movement of the diaphragm causes a small armature to move between two coils. The latter provides two arms of a reactance bridge. This type of bridge is used also for measuring deflection of a spring in a push-pull flight control rod (Figure 8) or the movement of an instrument element, such as we have in gyroscopic instruments.

In Figure 10 appear diagrams illustrating how these various pick-up bridges are energized. It will be noted that energy is provided by an a-c generator "C". These a-c energized bridges are scanned in rapid succession by the switch identified as "B". The gage under test, modulates the amplitude of the bridge carrier. This causes a change in the amplitude of the bridge carrier "D", which is amplified at "E" and rectified at "F". In this way, a substantial d-c amplitude change is produced, which is equivalent to the change in gage "A".

Into the control bridge of a pair of reactance tubes, which act as part of the capacity of oscillator circuit "H" is fed the current "F". These control grids act also as a part of the inductance of the oscillator circuit "H", which varies in frequency between 4,000,500 and 4,005,500 cycles in accordance with the amplitude of "F" providing the resultant "G" or f-m. A beat note "J" between 500 and 5500 cycles is caused by this varying frequency which beats against a fixed frequency of oscillator "K". Then the audio signal "J" is fed into the microphone of the transmitter in the plane.



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Figures 9 and 10

Figure 9 (left), diagram of a bridge circuit, that is formed by each pickup and its leads. In Figure 10 (top), the method of pickup operation is explained diagrammatically. At (A), we have modulation; (C)—bridge carrier; (D)—modulated bridge carrier; (E)—amplifier; (F)—rectifier and filter; (G)—frequency modulation; (K)—oscillator, and (J)—the beat.

•

Signals from the plane are picked up at a ground station and then recorded. A disc recorder is used in most instances to make a master record as a safety measure in case of the failure of any of the other instantaneous recorders or of the decoding equipment. The signals can also be recorded in an electronic manner and recorded on paper charts. The chart width and accuracy depends on the speed of the scanning switch on the plane.

When studying strain, such as load distributions, during plane maneuvers, the readings may be made at the rate of

(Continued on page 72)

A Report on the 1943

IRE WINTER CONFERENCE

by LEWIS WINNER
Editor

Highlights of Papers Presented by Van Dyck, Wheeler, Miles, Espenschied, Southworth, Brown-Epstein-Peterson, Smith-Gove, Foust-Frick, and Aggers-Pakala-Stickel.

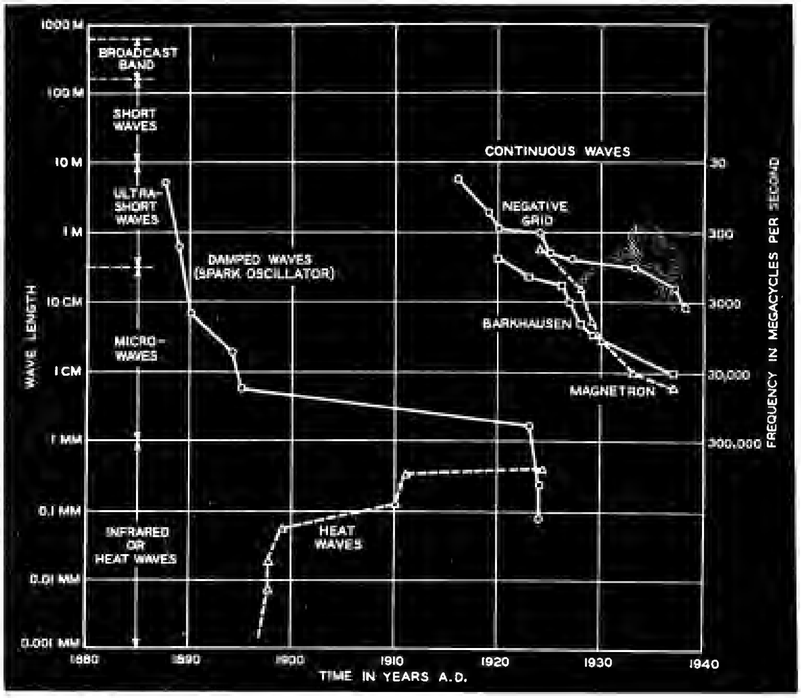

Figure 1
Progress of ultra-high frequencies as analyzed by Dr. George C. Southworth in his talk on "Beyond the Ultra-Shorts." (See page 46.)

THAT the interest in communications development, design and practice, is more intense than ever was again demonstrated at the one-day Winter Conference of the IRE, held in New York during the latter part of January. As at Rochester, in November of last year, a record-breaking audience attended all sessions. This time the khaki and blue were more predominant than ever and represented the Nation from coast to coast. Notwithstanding the variety of prevailing time and releaseable data problems, the papers presented were timely, topical and highly educational.

This annual meeting, being the occasion of the retirement and inauguration of the Institute's presidents, brought together A. F. Van Dyck, retiring president, and Dr. L. P. Wheeler, the new president, with attendant comment on the completed and anticipated accomplishments of last year and the year to come.

Figure 2
Dr. Southworth with one of the resonant chambers used for tests for wave guide transmission. Behind him are two experimental wave guide transmission lines.

Van Dyck's Message

In his retiring speech Mr. Van Dyck pointed out that the ranks of radio engineers have been increased over 20% during 1942. He said that engineers and scientists have an unusual opportunity now to decide to do something in the future which will encourage happier results and safer progress in the development of civilization. Something must be done in the future, he said, which will give saner judgment and more scientific control of the forces unleashed by science. Today, with science making the rapid strides it is, isolation is as impossible for scientists as for nations, he added.

The might of science was further emphasized by Mr. Van Dyck in his comment on the Russian campaign. He pointed out that it was because of the effective contributions of the engineers in both home and at-the-front capacities, that the campaigns have been so successful. For the first time, he said, the ability of the scientist has demonstrated its importance in warfare on all fronts. And communications advancements, he added, have certainly contributed in a most dominant way to this wartime progress.

Dr. Wheeler, one of the nation's foremost communications authorities, and at present with the FCC, also applauded the contributions of engineers, and stressed the fact that the coming year will provide developments of which Americans will be prouder than ever.

INSTITUTE AWARDS

The Medal of Honor, this year, was presented to William Wilson, who has just retired from the Bell Laboratories, for his achievements in the development of modern electronics, including its applications to radio telephony and for his contributions to the welfare and work of the Institute.

On ten of the year's outstanding engineers, the Institute conferred fellowships. Those so honored were Andrew Alford, of I. T. & T., for his contributions to the theory of radiation and the design of short wave antennas; Ivan S. Coggeshall, of Western Union, for his services to the welfare of the engineering profession; Captain Jennings B. Dow, United States Navy, for his engineering accomplishments in the development and procurement of radio equipment for the United States Navy; Peter C. Goldmark, of C B S, for his contributions to the development of practical color television; Dorman D. Israel, of Emerson Radio, for his contributions to broadcast receiver engineering design; Lt. Col. George F. Metcalf, United States Army, for his development work on vacuum tubes and vacuum tube circuits; Irving Wolf, of RCA, for his basic research in centimeter-wave radio and its application in navigation instruments; Axel G. Jensen, for his constructive participation in the development of short wave transatlantic telephony and television, and Daniel E. Harnett and Lee A. Du Bridge, for their outstanding contributions in radio engineering activities.

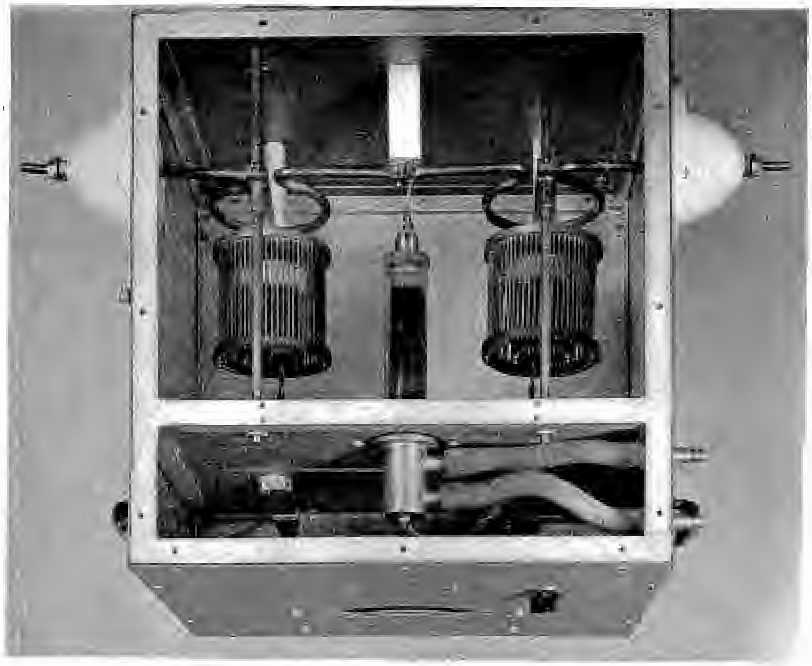

Figure 3
View of the broadcast frequency wattmeter described by Dr. Brown at the conference. (See page 47.)

T. K. MILE'S TALK ON MANPOWER

One of the most important problems facing the world today is manpower. In the engineering profession, this has become an extremely critical problem. An effective analysis of the situation was presented by T. K. Miles, of the National Roster of Scientific and Specialized Personnel, War Manpower Commission.

The principal functions of the War Manpower Commission in Washington, he pointed out, are now carried on by five bureaus. These are . . . Program Planning and Review, Selective Service, Placement, Training, and Labor Utilization. In the bureau of placement is the National Roster of Scientific and Specialized Personnel, and in this bureau we also find the Washington staff of the former United States Employment Service.

There are three classifications of a "necessary man," according to Mr. Miles. First, he must be engaged in war production or in activities supporting the war effort. And, second, he must be in a critical occupation or, in other words, there must be a shortage of personnel of his qualifications and training so that if he were removed he could not be replaced. And, third, his removal would cause a loss of effectiveness in the activity in which he is engaged.

As we know, all professional and technical engineers have been classified as being in critical occupations if they are working either in war production or in activities supporting the war effort. According to Mr. Miles, the case of each individual must be considered separately on its own merits, since the Selective Service Act does not provide a blanket deferment of individuals or occupational groups.

Through its military advisory section, the National Roster has been giving advice to the Selective Service boards on the professional qualifications of its male registrants, said Mr. Miles. The information supplied is provided from the Roster, which contains a listing of such qualifications. Thus, the Selective Service board is able to determine from this information whether or not the man in consideration is a "necessary" man and as such should be deferred. This, explained Mr. Miles, is not a binding action but rather one of co-operation.

In the field of physics, this program of assistance has been given more power. According to a release (No. 159) the Selective Service may authorize the appointment of a national committee to review affidavits for occupational classification. This plan provides the setting

(*Continued on page* 46)

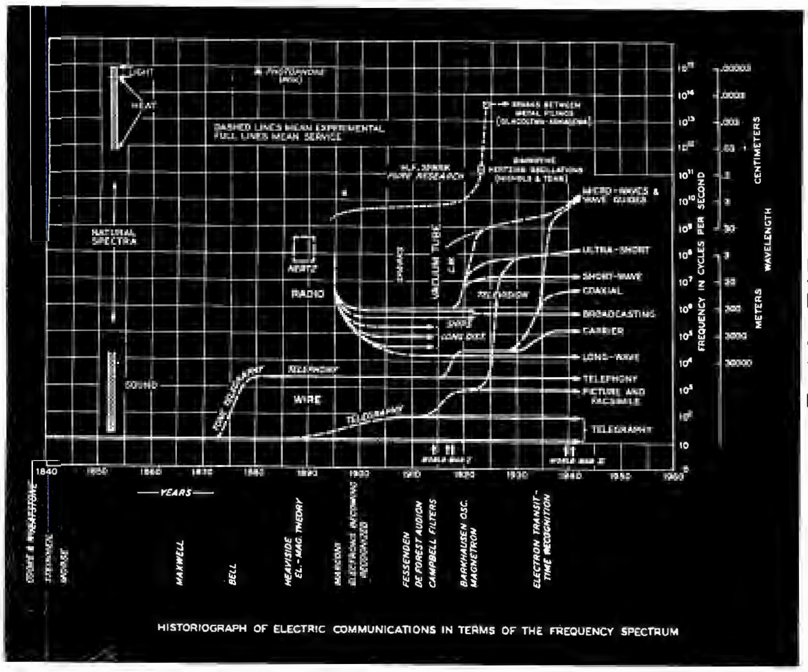

Figure 4
Pictorial presentation of the history of communications as described by Lloyd Espenschied. (See page 46.)

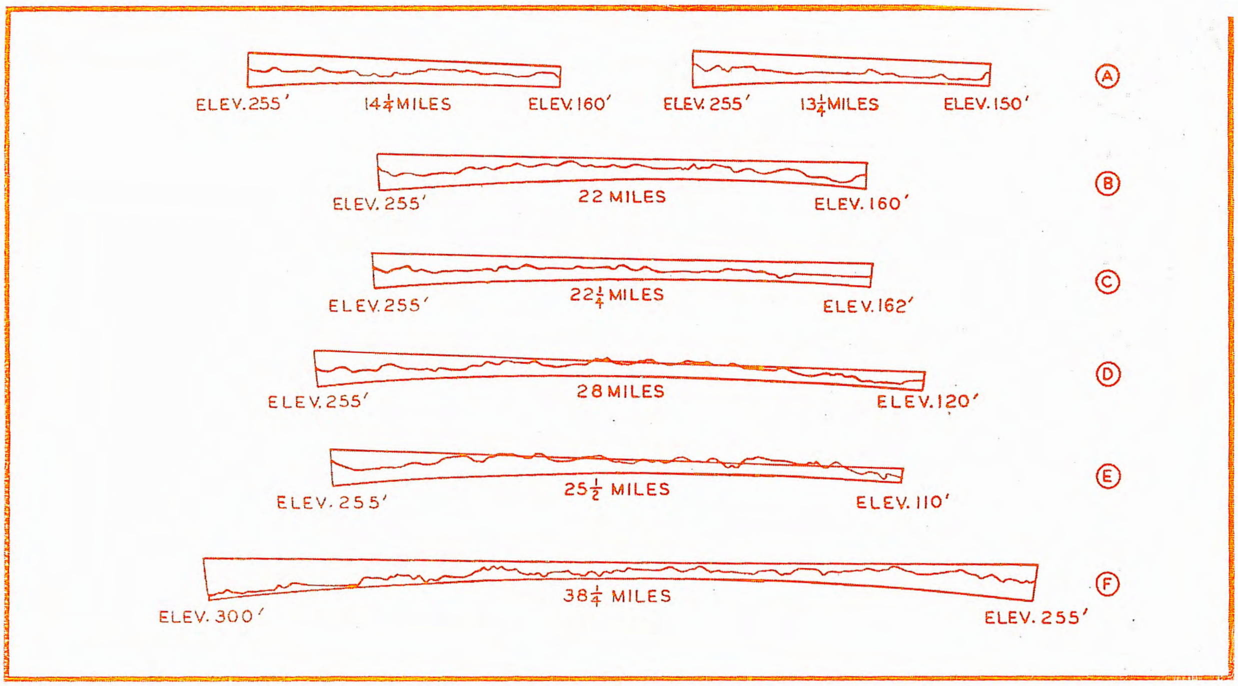

Figure 1
Typical transmission paths over flat country with some slight elevations.

U-H-F CIRCUIT CONTOURS

A Revealing Study, Based On Systems In Operation

by DR. CARLETON D. HAIGIS

Consulting Radio Engineer, New Jersey Forest Fire Service

THE propagation of electro-magnetic waves having a frequency above 30 million cycles per second, is in general independent of any action action of the "Kennelly-Heaviside" layer. Any effect of the earth's atmosphere takes place within the first kilometer above the earth. In other words, we are dealing with radiation traveling along or near to the surface of the ground. A discussion, then, of this type ground or surface wave propagation follows the same method as we would use in an optical study. The waves are subject to refraction by the earth's atmosphere, to reflection by the surface and to diffraction over the ridges of intervening terrain.

Refraction of the radio wave by the earth's atmosphere is in general advantageous and aids transmission. The density of the atmosphere decreases with the height above the ground. The wave front, traveling more slowly in the denser region near the ground, than it does in the rarer upper layers, is tilted forward as it travels. Stated briefly, this effect makes the distance to the radio horizon greater than that to the visible horizon.

Calculating Visible Horizon Distance

By a simple mathematical calculation, it can be shown that the distance, d, in miles to the visible horizon when the observer is at a height, h, feet above sea level is 1.23 x the square root of h. Thus when an observer is 100 feet above sea level, everything is visible within a radius of 12.3 miles: similarly when the height is increased by four times or to 400 ft. the radius is doubled and becomes 24.6 miles.

Because of the refraction which can be calculated quite closely from the known variation of the density of the atmosphere with height, the distance to the horizon as seen by the radio eye of the transmitter is 1.41 x the square root of the height making the radio visibility from a height of 100 feet, 14.1 miles instead of 12.3 miles. It can be seen therefore, that this effect is an aid to transmission. It should be pointed out at this time that changes in the density gradient of the atmosphere caused by temperature and moisture, may result in a marked change in the transmission characteristics and that these changes probably do account for observed daily variations and a rather marked seasonal one.

Attenuation and Reflection

Reflection of the waves from the earth's surface between the two stations results in a most serious attenuation of the signals. In circuits over which ultra-high frequency transmission is ordinarily employed the wave travels over the earth's surface at or very near to grazing incidence. Under these conditions a

(Continued on page 20)

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(*Continued from page* 17)

rough earth acts like a perfect mirror.

A case familiar to everyone will illustrate this. The rough surface of a concrete highway, as rough in comparison to the wavelength of visible light as elevation differences of 100 feet would be to radio waves, becomes an excellent mirror far ahead of a car and reflections of sky and clouds on the horizon ahead can be seen clearly.

It is evident then, that reasonably regular reflection can take place from rough terrain.

When radio waves arriving at such a surface at or near grazing incidents are reflected, the phase suffers a change of 180° and suffers only a slight loss of amplitude. The reflected wave and the direct wave arriving at the receiving point are therefore out of phase and tend to cancel each other. In ordinary cases, the length of the direct ray path and that of the reflected ray path are very nearly alike. The difference usually amounts to only a fraction of a meter which may correspond to a phase change due to path of less than 30°. This fact together with the probability that the amplitude of the reflected wave is reduced to about eight-tenths, provides the only escape by which transmission can be affected.

The "Brewster" Angle

Reversal of phase takes place over the surface for all angles of incidence less than a small critical angle, known as the "Brewster" angle. For ground with a fairly small dielectric constant and low conductivity this angle may be as high as 20°, while for water with a high dielectric constant and reasonably good conductivity it, may be as low as 1°. For angles of incidence above this angle, no reversal of phase takes place and reinforcement would occur at the receiving antenna but this case is of no interest since transmission always takes place within the "Brewster" angle.

The above remarks apply in general to middle distance reflection; local reflection at both the transmitting and receiving points can be made additive by proper choice of the height of the antenna above the ground because large path differences between the direct and locally reflected waves can be realized.

Transmission over paths extending beyond the radio horizon is possible and reliable. This is contrary to the wide spread belief that ultra-short waves suffer because of their inability to bend around obstacles. While it is true that a sharp edge casts an almost perfect shadow to extremely short light waves it is also true that an intervening edge will not cast an appreciable shadow to ultra-shortwaves, some 16 million times longer. Calculations show that except where very high mountains are involved the loss of transmission is slight and more likely due to reflection.

Diffraction thus provides the means enabling transmission over paths far in excess of the radio line of sight. Results of many tests indicate that transmission takes place according to the inverse square law so that field strength varies inversely as the square of its distance instead of inversely as the first power of the distance.

Plotting Circuit Contours

To illustrate some of these factors in a qualitative way, some contours of circuits in actual operation over which reliable communication is possible at all times, have been made.

In plotting contours, the elevations

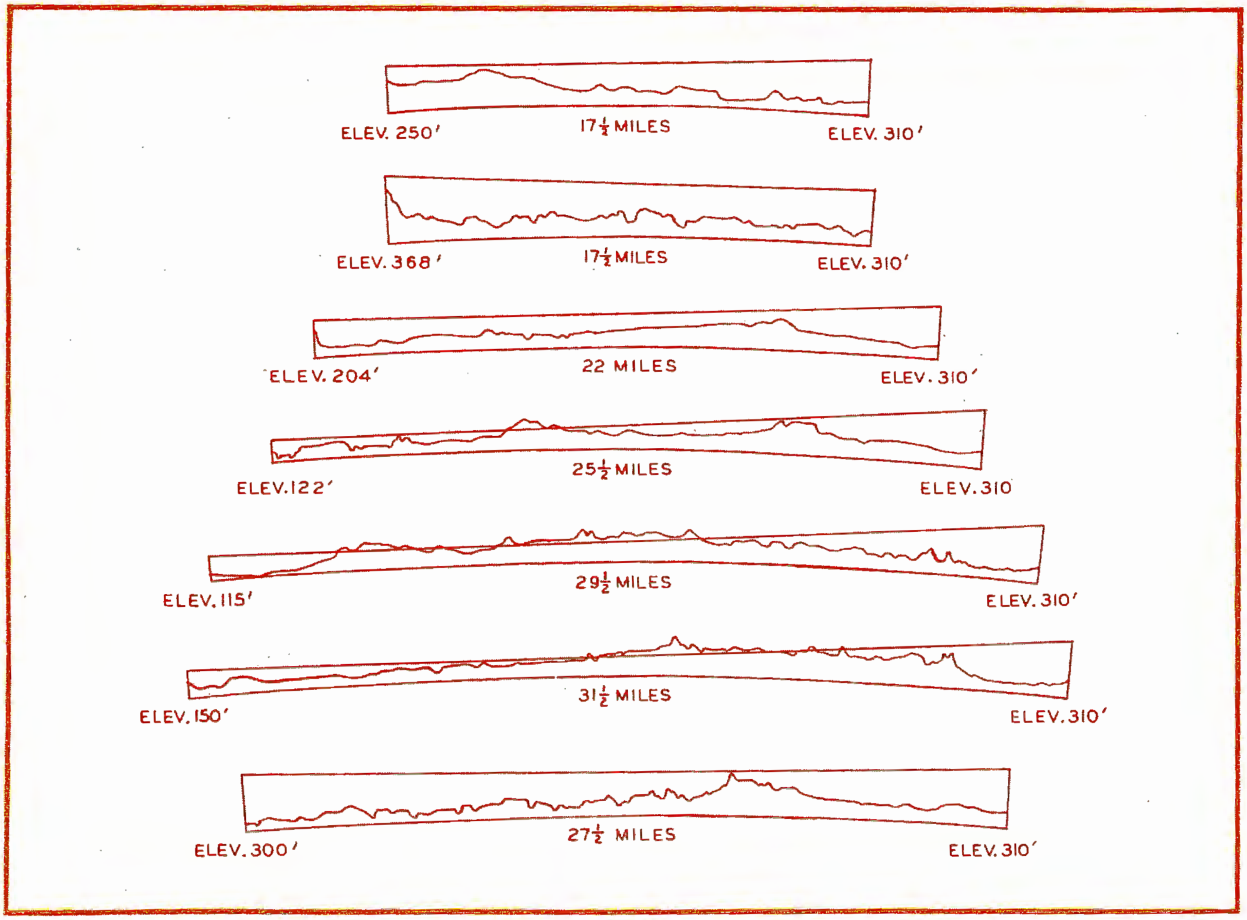


Figure 2
Transmission paths over a bit more hilly country with long multiple diffraction circuits.

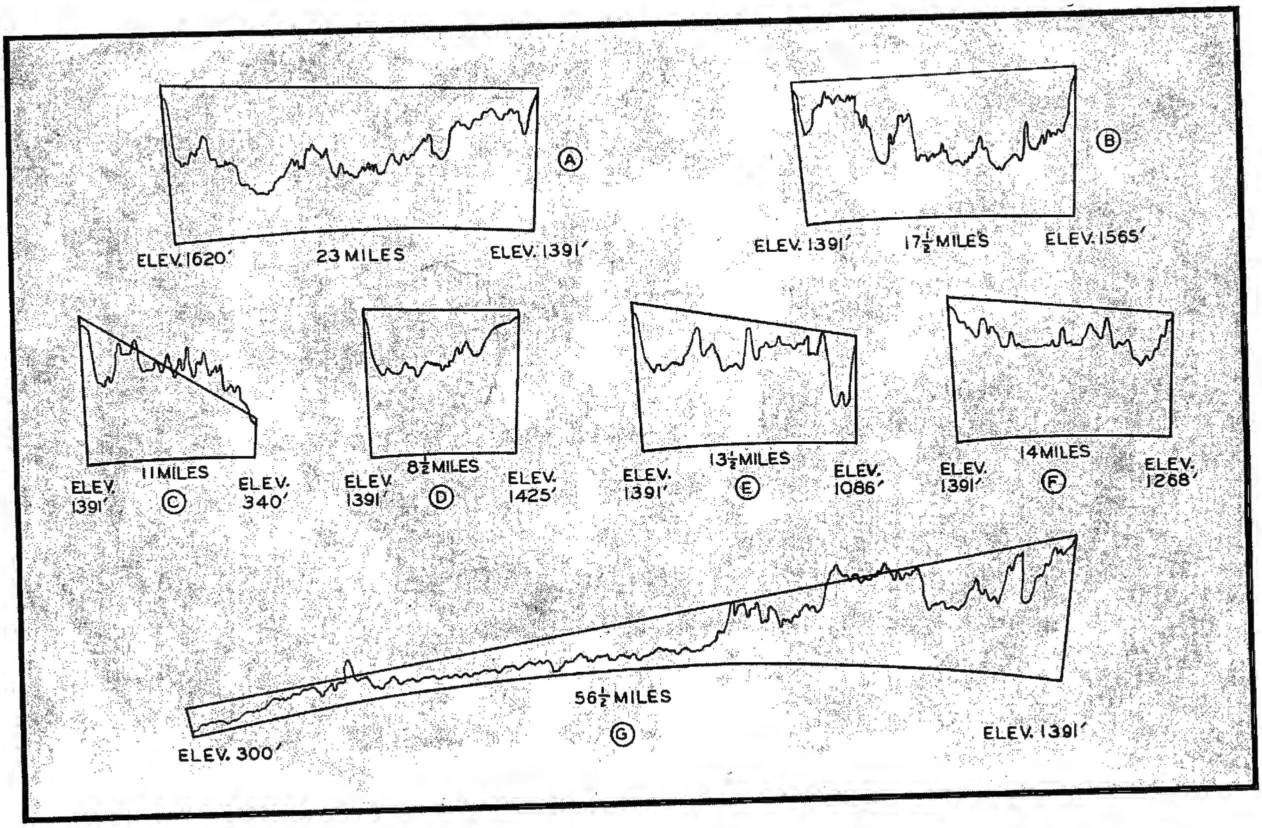


Figure 3
Mountainous country transmission paths. Note the C contour, where diffraction at 40 mc is shown.

above the sea level are so small compared with the distances along the surface, that they cannot be plotted to the same scale. This difficulty was overcome by increasing the scale used in plotting the elevations and decreasing the scale used in plotting the radius of the earth by the same proportion.

If this is done it can be shown geometrically that a line which was straight in the actual case remains the same with the new co-ordinates. It is also further possible to include in these plots, the effect of refraction by increasing the radius of the earth so that the actually curved wave path appears straight. From the known constants we find that this is equivalent to an increase of 1.33 times. In the plots shown, elevations are plotted to a scale ⅛" equals 20 feet and in the horizontal scale, 1 inch equals 1 mile or 5280 feet. This gives a factor of 33 by which the radius of the earth must be reduced. Its actual radius, 3950 miles multiplied by 1.33 to correct for refraction, equals 5260 miles which divided by 33, gives us a radius of 159 inches, using the scale of one inch equals one mile.

Flat Country Transmission

In Figure 1, typical transmission paths over flat country having only slight variations in elevation are shown. These circuits are all operated with 15-watt a-m transmitters between 35 and 40 mc. and terminate at a receiver at the 225 feet point. The 14¼ and 13¼ mile circuits at A, both under 15 miles, and with ample clearance, require no discussion. They could be operated perfectly reliably with ¼ the power. On an arbitrary scale, both lay down a field of plus 44 db at the receiving point. Path differences between the direct and the reflected waves are sufficient to provide ample reinforcement.

The 22 and 22¼ mile circuits at points B and C lay down fields of plus 34 and plus 40 db respectively, corresponding to a field strength ratio of 2 to 1.

Circuits of this type usually show more variation than circuits clearing the intervening terrain by a greater distance. The town at point C with an elevation of 162 feet, is 2 db below inverse square, while the town at point B, with an elevation of 160 feet, is 4 db above. Rarely will such a circuit go more than 1 or 2 db below the inverse square value and they often show a considerable gain.

Proceeding now to the circuits at D and E, we pass to the case where radio line of sight no longer exists and the field at the receiving point is the result of the effectiveness of diffraction. The circuit at D lays down a field of plus 33, while the circuit at E, 2½ miles shorter, provides a field of only plus 31.

A little consideration of the contours show that the circuit at E, reaches the receiving point by multiple diffraction past several intervening ridges, while the D circuit requires only one. Even so, the E circuit is only 1.5 db below the inverse square value of plus 32½. These contours serve to show that an engineer familiar with their interpretation, can predict the performance in a fairly satisfactory manner.

The F circuit operates with higher power (50-watts) and so it is not comparable with the others. By calculating the equivalent strength, it was found that this circuit operates with a considerable gain over that predicted by the inverse square law.

Multiple Diffraction Circuits

In Figure 2, we see a similar series of circuits all of which are in continuous operation. Gain data is not at the moment available, but even the long multiple diffraction circuits have provided gains better than plus 30.

In Figure 3, appears a series of circuits that would be encountered in mountainous country and with the exception of the C and G circuits, a field in excess of plus 42, which is several db above the inverse square value. results. The C contour demonstrates

(*Continued on page* 71)

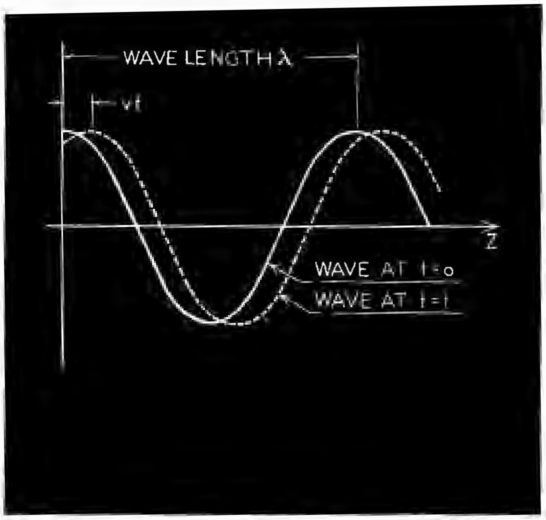


Figure 2
A travelling wave.

AN ANALYSIS OF R-F TRANSMISSION LINES*

Rapid Solutions To Problems Evolved

by GEORGE B. HOADLEY

Ass't Professor of Graduate Electrical Engineering
Polytechnic Institute of Brooklyn

THE electrically long transmission line has received a considerable amount of attention from various writers, and the problem of its behavior has been worked out many times in the past. The results of some of these analyses are, however, unduly complicated because the equations presented are not readily interpreted in physical terms, but remain merely mathematical formulas which can be used to compute results.

It often happens that one wishes to be able to think about transmission line problems without doing much paper work. Problems can sometimes be solved rather quickly by this sort of thinking, provided the concepts involved are not too complicated. We will try, in this discussion, to present the development of a fairly simple way of looking at problems on a lossless line.

The fundamental concept which we wish to develop can be described in two basic theorems. They are . . .

A. Any load on a lossless transmission line may be replaced by a pure resistance load on the end of an extension of the line. Such a load we will call a "virtual load."

B. The equivalent parallel resistance R_p looking into a lossless line towards the load varies *sinusoidally* as the distance from the load, and is biased so that it is always positive.

These theorems go a long way towards simplifying the transmission line ideas. We must, of course, reinforce these theorems with quantitative relations, and become accustomed to using them, before the maximum utility will result.

Travelling Waves

The basic phenomenon on transmission lines consists of two electromagnetic waves, one travelling towards the load, and called an "incident" wave, and another travelling towards the source and called a "reflected" wave. The whole performance of lines can be developed from these two waves unless the wavelength gets too small. If the half-wavelength is less than approximately the spacing of the two conductors, some other waves may appear, but we will not consider them here.

Each of these two waves may be discussed in terms of electric and magnetic fields, or in terms of currents and voltages. We will use the latter. Thus the incident wave can be described by voltage V_i and a current I_i, as shown in Figure 1a, and the reflected wave can be described by V_r and I_r as shown in Figure 1b.

In writing an equation for V_i we can refer to Figure 2. The solid line shows the wave of instantaneous voltage at time $t = o$. At a time $t = t$, this wave has moved towards the load, i.e. in the z-direction, by a distance equal to vt, where v is the wave velocity. Thus, for the instantaneous voltage, we may write

$$V_i = V_i \cos \frac{2\pi}{\lambda} (z - vt) \qquad (1)$$

Some algebraic and trigonometric manipulation of this yields

$$V_i = V_i \cos (\omega t - \beta z) \qquad (2)$$

in which

$$\left.\begin{aligned} \omega &= 2\pi f \\ \beta &= \frac{2\pi}{\lambda} \\ v &= f\lambda \end{aligned}\right\} \qquad (3)$$

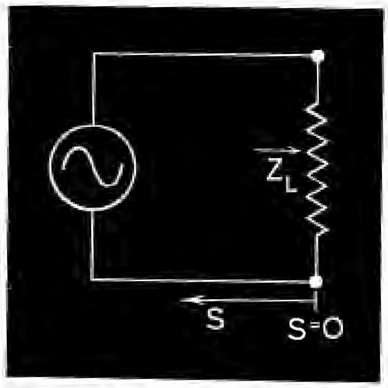
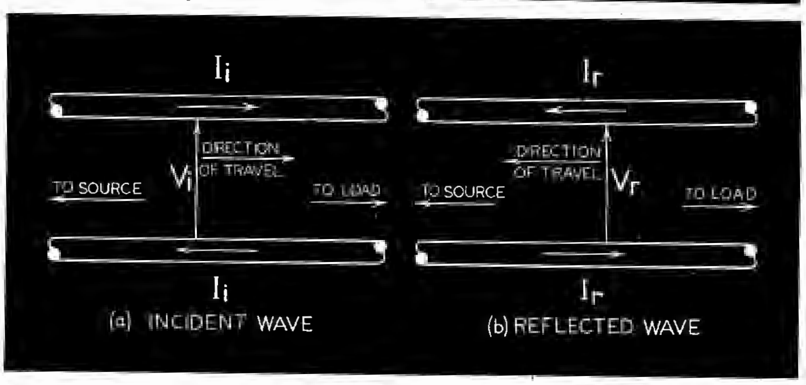
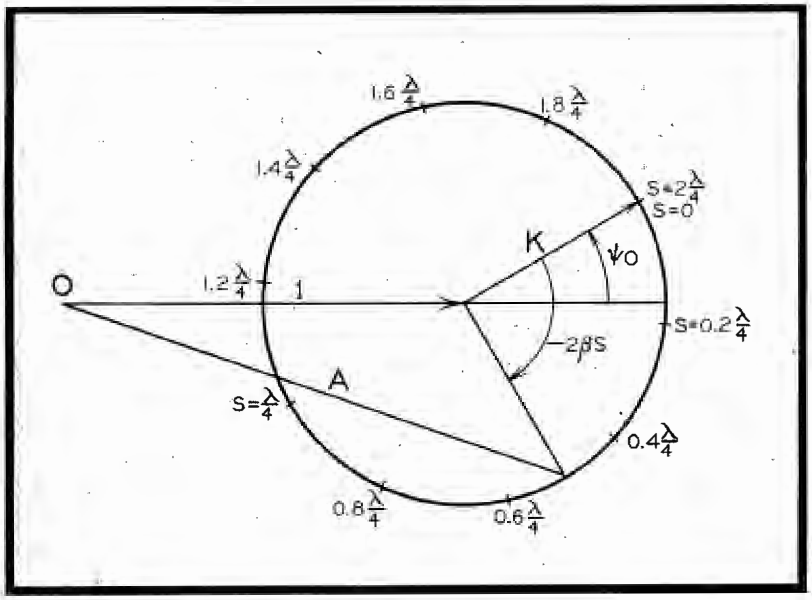


Figure I (below) and 3 (right)
In Figure I we have two waves on a transmission line; (a) shows the relative directions of voltage rise current and direction of travel in the incident wave, whereas (b) shows the same for the reflected wave. In Figure 3 we have a loaded transmission line showing the positive direction of S.



*This treatent of transmission line problems is being presented within a special u-h-f course by Professor Hoadley at Polytechnic Institute.


UP GOES THE AMERICAN ENGINEER!



We can also write this voltage as a phasor,* thus

$$\overrightarrow{V_i} = V_i \underline{/-\beta z} \equiv V_i \varepsilon^{-j\beta z} \quad (4)$$

and the reflected voltage becomes

$$V_r = V_r \underline{/+\beta z + \psi_0} \quad (5)$$

in which ψ_0 is an arbitrary phase angle, to be discussed later.

Characteristic Resistance

Another result of the analysis of waves on lossless transmission lines is that the voltage and current in each wave are in phase. Thus their ratio is a *pure resistance,* which we will call the characteristic resistance R_0. It is defined by the equations

$$R_0 = \frac{\overrightarrow{V_i}}{\overrightarrow{I_i}} = \frac{\overrightarrow{V_r}}{\overrightarrow{I_r}} \quad (6)$$

This indicates that each travelling wave "doesn't know what is in front of it." The conditions on the ends of the line then determine the sizes and phases of the two waves, but have no bearing on the relations inside of the waves themselves.

Many formulas have been developed for characteristic resistances of transmission lines. Probably the most common are

$$R_0 = \frac{138}{\sqrt{\varepsilon_r}} \log \frac{\text{Outer Diameter}}{\text{Inner Diameter}} \quad \text{for the coaxial line}$$

and

$$R_0 = \frac{276}{\sqrt{\varepsilon_r}} \log \left(\frac{D}{d} + \sqrt{\left(\frac{D}{d}\right)^2 - 1} \right) \quad (7)$$

for the open line,

where D is the center-to-center spacing
d is the wire diameter
ε_r is the relative dielectric constant.

*A better name than "vector" (which is wrong) for the complex numbers representing alternating voltages, currents and impedances.

Figure 4

A plot of $1 + K\underline{/\psi O - 2\beta s}$, to show the variation of "A" with position on the line.

Reflection Factor

The ratio of the reflected wave to the incident wave is determined entirely by conditions at the end of the transmission line, and the location at which we determine this ratio. It turns out that this ratio, which we shall call $\overrightarrow{K}$, is more useful in thinking about lines than is the actual load impedance.

Consider a line to be loaded at z = o with an impedance $\overrightarrow{Z_L}$. If the source is on the left, all of the line is then in the region of the negative z, so it is handy to substitute

$$s = -z, \quad (9)$$

as is shown in Figure 3.

We now can write

$$\overrightarrow{K} \equiv \frac{\overrightarrow{V_r}}{\overrightarrow{V_i}} = \frac{V_r \underline{/-\beta s + \psi_0}}{V_i \underline{/+\beta s}} = \frac{V_r}{V_i} \underline{/\psi_0 - 2\beta s} \quad (10)$$

The magnitude K of this reflection factor is then

$$K = \frac{V_r}{V_i} \quad (11)$$

and is *independent* of the position on the line. The *angle* ψ of this reflection factor is

$$\psi = \psi_0 - 2\beta s = \psi_0 - 180 \frac{s}{\lambda/4} \text{ degrees.} \quad (12)$$

This increases negatively with increasing s; the increase is proportional to s, and ψ completes one revolution every half-wavelength. The angle ψ_0 is then the value of ψ at the load.

Voltage Distribution

The actual voltage on a transmission line is the sum of the voltages of the two waves. Thus

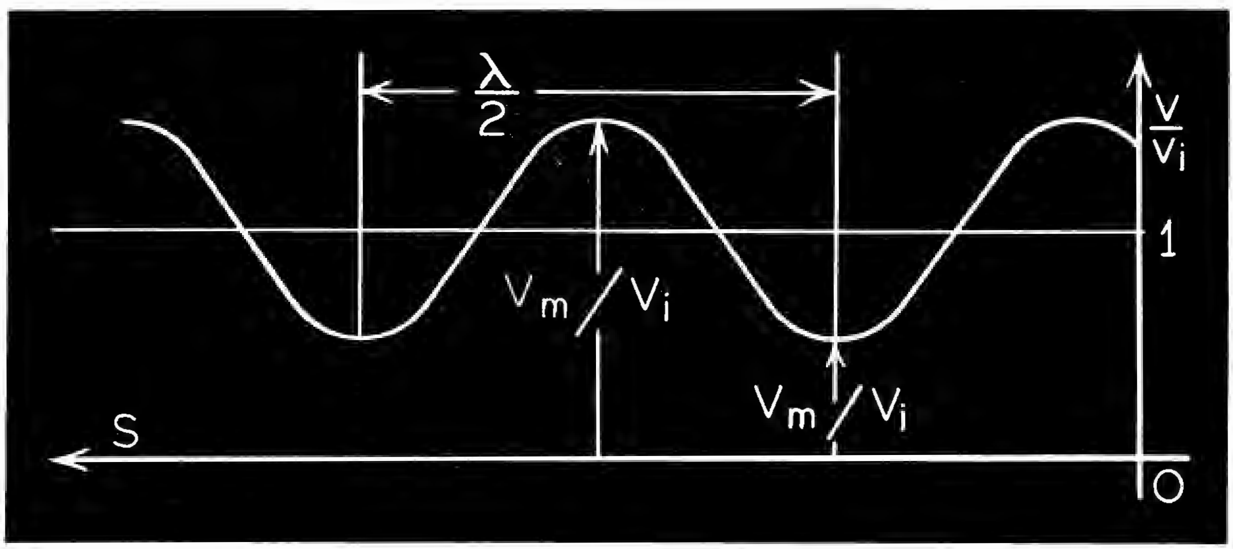
$$\overrightarrow{V} = \overrightarrow{V_i} + \overrightarrow{V_r} = \overrightarrow{V_i} + \overrightarrow{K}\overrightarrow{V_i} = \overrightarrow{V_i}(1 + \overrightarrow{K})$$

or

$$\overrightarrow{V} = V_i \underline{/\beta_s} (1 + K \underline{/\psi_0 - 2\beta_s}) \quad (13)$$

Figure 5

The variation of voltage on a line as a function of distance from the load.



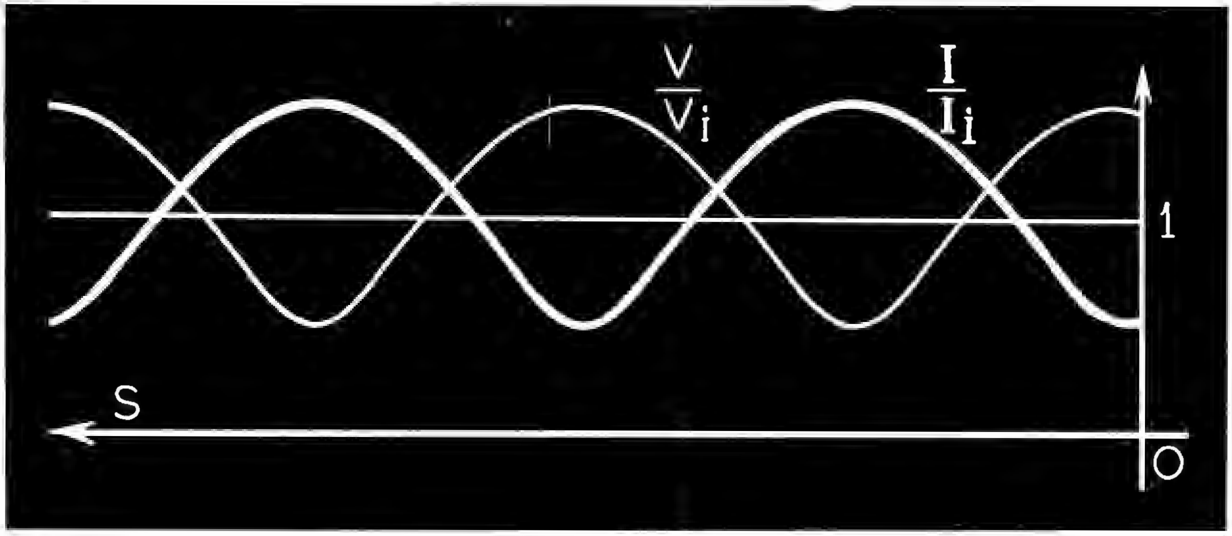


Figure 6
The relation of voltage and current waves on a transmission line. V_M occurs at the same place as I_M. The waves have the same shape, which is *not* sinusoidal.

We wish to concentrate on the magnitude of the voltage, which we find by multiplying V_i by the magnitude of the quantity in the parenthesis. This latter quantity is most easily represented graphically, as is done in Figure 4. The amplitude A of the voltage is then V_i multiplied by the distance from the origin 0 to the point on the circle which corresponds to the value of s in question.

Using such a diagram we can plot the variation of voltage with distance from a load, and obtain a curve such as is shown in Figure 5. The shape of this curve is *not* sinusoidal, but is broad near the maxima, and is narrow near the minima.

These pointed minima become sharp when $K = 1$, and then the curve is a *rectified* sine-wave. This occurs when the load is a pure reactance, as we will see later. When K approaches zero, the curve becomes almost constant, with a ripple which is almost a sine wave. If $K = 0$, these ripples disappear, and the amplitude of the voltage on the line is independent of the position. This occurs when the line is loaded with a pure resistance equal to R_0.

Standing Wave Ratios

A bit of study of the preceding curve will indicate that the most readily determined quantities are probably the maximum and minimum voltages and the position of the minimum. In order to relate these to K and ψ, we refer to Figure 4. Maximum voltage V_M is reached when the radius of the circle is added directly to unity, and minimum voltage V_m results when the radius is subtracted directly from unity, thus

$$V_M = V_i\,(1 + K) \qquad (14)$$
$$V_m = V_i\,(1 - K) \qquad (15)$$

We can eliminate V_i by taking a ratio of the voltages, V_M/V_m, which we shall call the standing-wave ratio q. Thus

$$q \equiv \frac{V_M}{V_m} = \frac{1 + K}{1 - K} \qquad (16)$$

The inverse of this equation is

$$K = \frac{q - 1}{q + 1} = \frac{V_M - V_m}{V_M + V_m} \qquad (17)$$

With these relations, we can easily obtain q and K from measurements of the maximum and minimum voltages on the line.

By reference to Figure 4 again, we can easily see that at the position for V_m, which we shall call s_m, the relations among the angles are

$$\psi_0 - 2\beta s_m = -\pi\,. \qquad (18)$$

whence

$$\psi_0 = 180 \left(\frac{s_m}{\lambda/4} - 1 \right) \text{degrees.} \qquad (19)$$

Measurements of these quantities, V_M and V_m and s_m can be made relatively easily on open lines. In coaxial lines, special slotted sections, sometimes called standing-wave meters are used.

Current Distribution

Sometimes we are interested in current instead of voltage. Then we can proceed as in the above two sections, with the following results:

$$\vec{I} = \vec{I}_i - \vec{I}_r = \frac{V_i}{R_0} \underline{/\beta_s}\, (1 - K \underline{/\psi_0 - 2\beta}\,) \qquad (20)$$

$$q = \frac{I_M}{I_m} = \frac{1 + K}{1 - K} \qquad (21)$$

$$K = \frac{q - 1}{q + 1} = \frac{I_M - I_m}{I_M + I_m} \qquad (22)$$

$$\psi = 2\beta s_m = 180 \frac{s_m}{\lambda/4} \text{degrees,}$$
$$(S_m = \text{location of } I_m) \qquad (23)$$

The current maximum occurs where the voltage minimum occurs, and vice versa. A plot of both current and voltage on a line appears in Figure 6, which shows that both waves have the same shape.

Equivalent Parallel Resistance

Most of the attachments used with transmission lines, such as stubs, constitute impedances in *parallel* with the line. Thus it often is desirable to have equations for the equivalent parallel resistance and reactance of the line at any point. Thus in our thinking we replace a section of line and its load by a resistance and reactance in par-

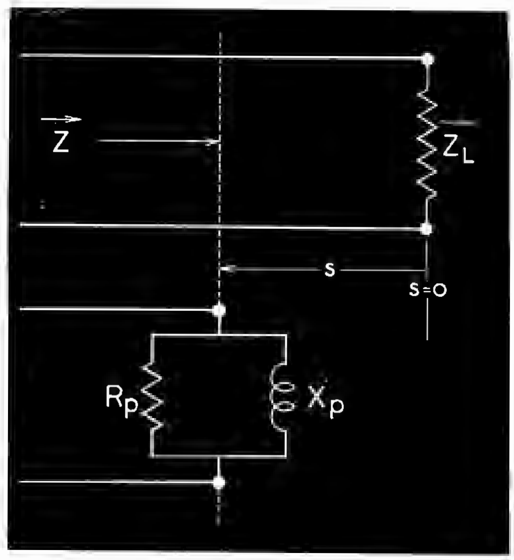


Figure 7
The input impedance $\vec{Z}$ of a loaded line section can be thought of as a resistance R_p in parallel with a reactance X_p.

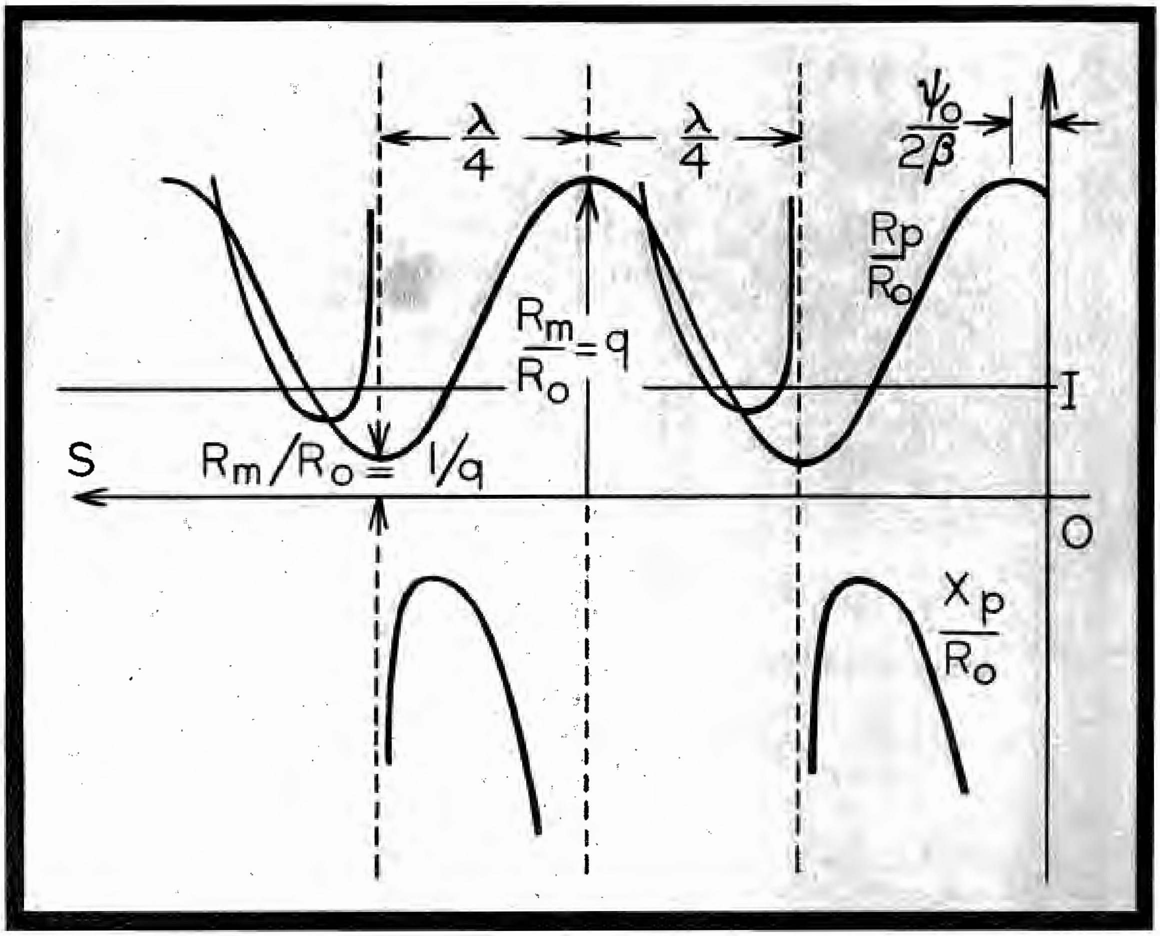


Figure 8

The variation of R_p and X_p with distance from the load. R_p is sinusoidal and has a period of $\frac{\lambda}{2}$.

allel. This equivalence is shown in Figure 7.

To develop equations R_p and X_p we write the admittance

$$\vec{Y} = \frac{\vec{I}}{\vec{V}} = \frac{\frac{V_1}{R_0}/\beta_s\,(1-\vec{K})}{V_1/\beta_s\,(1+\vec{K})} = \frac{1}{R_0}\,\frac{1-K\,/\psi_0-2\beta_s}{1+K\,/\psi_0-2\beta_s} \qquad (24)$$

we desire the real and imaginary components, so we rationalize the fraction, and after some manipulation we obtain

$$\vec{Y} = \frac{1}{R_0}\,\frac{1-K^2-j2K\sin(\psi_0-2\beta_s)}{1+K^2+2K\cos(\psi_0-2\beta_s)} \qquad (25)$$

The real part of this is the conductance G, and the imaginary part is the susceptance B. If we use the reciprocals of G and B we get the equivalent parallel resistance R_p and reactance X_p. Thus

$$R_p = \frac{1}{G} = R_0\,\frac{1+K^2+2K\cos(\psi_0-2\beta_s)}{1-K^2} \qquad (26)$$

and

$$jX_p = \frac{1}{jB} = jR_0\,\frac{1+K^2+2K\cos(\psi_0-2\beta_s)}{2K\sin(\psi_0-2\beta_s)} \qquad (27)$$

The first of these can be recognized as a constant value, which is

$$R_0\,\frac{1+K^2}{1-K^2} \qquad (28)$$

and a cosine wave with an amplitude

$$R_0\,\frac{2K}{1-K^2} \qquad (29)$$

This is then the second of the theorems we stated in the beginning.

The maximum value of R_p is found by setting the cosine equal to + 1, and the minimum is found by setting it equal to — 1. For both of these values, the sine is zero, so X_p is infinite at these values of the resistance. When the expressions resulting from these substitutions are reduced to the simplest form, we get

$$\left[\begin{array}{l} R_M = R_0\,\dfrac{1+K}{1-K} = q\,R_0 \\ Xp = \infty \end{array}\right. \qquad (30)$$

and

$$\left[\begin{array}{l} R_m = R_0\,\dfrac{1-K}{1+K} = \dfrac{R_0}{q} \\ Xp = \infty \end{array}\right. \qquad (31)$$

These infinite reactances are open circuits in parallel with the resistances, so at the maximum and minimum values of R_p, the impedance looking into the line towards the load is pure resistance. Representative curves of equations (26) and (27) are plotted in Figure 8, which shows the type of symmetry exhibited by these curves.

Virtual Load

In the foregoing, we have shown how it is possible to obtain considerable information concerning the performance of a transmission line, without a knowledge of the impedance on the end of the line. Of course, we could find this impedance by setting s = 0 and working out equations (26) and (27) after we had found ψ_0 and either q or K. Also, the reciprocal of equation (24) could be written, to give

$$\vec{Z}_L = R_0\,\frac{1+K\,/\psi_0}{1-K\,/\psi_0} \qquad (32)$$

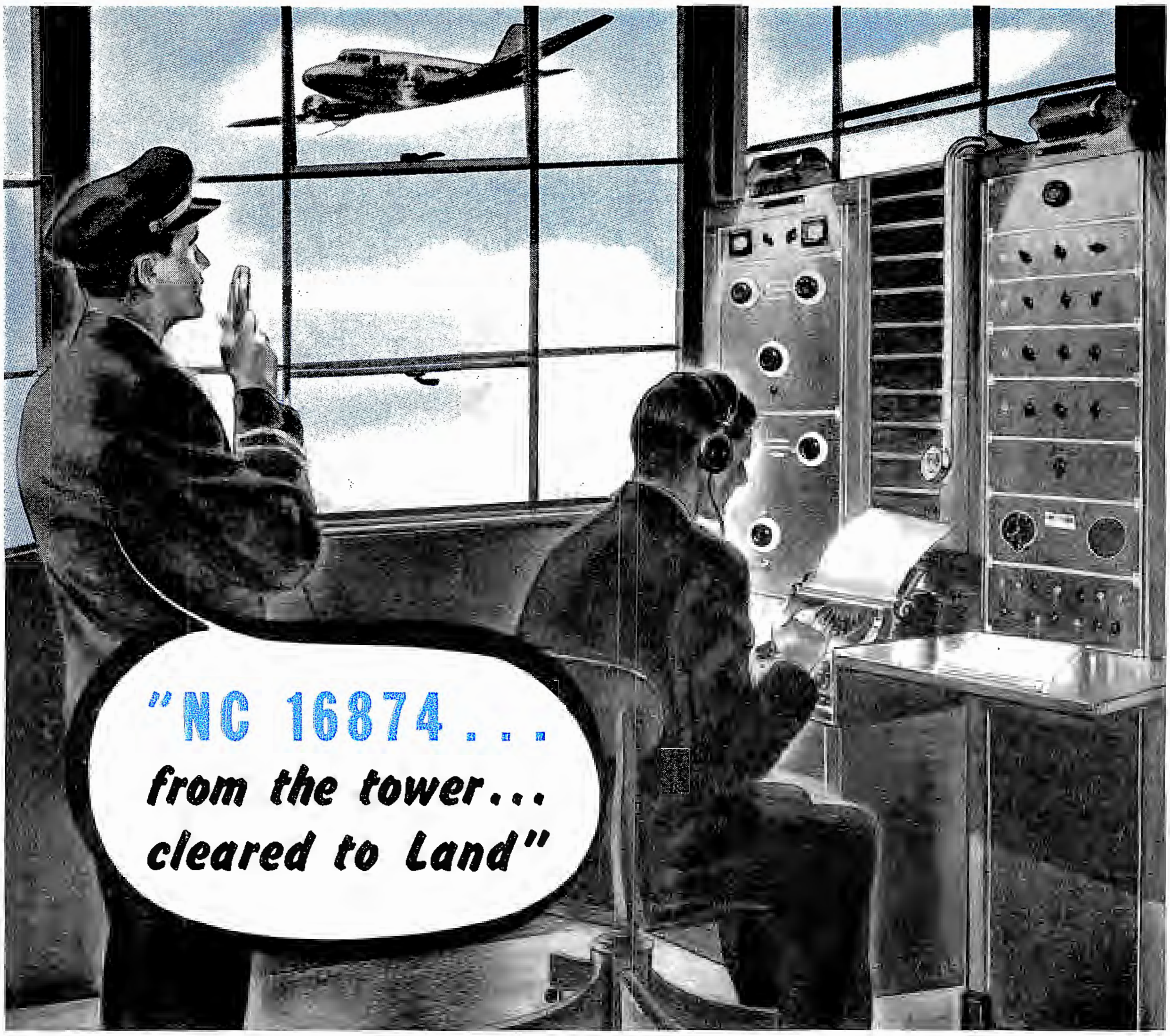
This, of course, can be solved for $\underline{K/\psi_0}$ in terms of $\vec{Z}_L$, with the result

$$K\,/\psi_0 = \frac{Z_L-R_0}{Z_L+R_0}, \qquad (33)$$

which enables us to find $\vec{K}$ if we know Z_L.

These equations are sometimes very handy, but there is an easier way of thinking about the load. We locate the position of V_m and get the value of q.

(*Continued on page* 28)



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Control Apparatus
Transmitting Equipment

WILCOX ELECTRIC COMPANY

Quality Manufacturing of Radio Equipment

14th & Chestnut Kansas City, Missouri

(*Continued from page* 26)

Then the distance to the load is unimportant as far as the patterns of V, R_p and X_p are concerned. We could go towards the load and stop anywhere we desired. Then, to keep the voltage pattern on the line the same, we would have to load the line with the proper R_p and X_p. The easiest place to stop is at R_M or R_m. We will choose the latter.

We do not need to stop *before* we get to the actual load, however. We could consider that the line extended beyond the load, and then we would stop at the first R_m. We will call this the virtual load. Thus we get the equivalence shown in Figure 9, in which *both* loads give exactly the same patterns of voltage and resistance on the part of the line to the left of Z_L. This is the first theorem we stated in the beginning of the paper. This virtual load is located at $s = s_v$, which is readily found by inspection of Figure 9 to be

$$s_v = s_m - \frac{\lambda}{2} \qquad (34)$$

This makes s_v negative, which is correct since it is in the negative region of s.

Now it will be handy to measure distances from this virtual load, and we will designate such distances by s′. A study of Figure 9 will show that the angle which entered equation (26) can be rewritten

$$\psi_0 - 2\beta_s = \pi - 2\beta_s' \qquad (35)$$

Using this and various algebraic and trigonometric transformations, equations (26) and (27) can be written

$$R_p = R_0 \frac{1 + K^2 - 2K\cos 2\beta_s'}{1 - K^2} \qquad (36)$$

$$X_p = R_0 \frac{1 + K^2 - 2K\cos 2\beta_s'}{2K\sin 2\beta_s'} = R_0 \tan\beta_s' + \frac{(1-K)^2}{2K}\,\frac{1}{\sin 2\beta_s'} \qquad (37)$$

These equations can also be written with q instead of K. In rewriting equation (36), we can apply the general ideas evolved in the foregoing. We know that R_M is qR_0 and that R_m is R_0/q. The constant value must be the average of these, and the amplitude of the cosine must be one-half their difference. Thus we can write

$$R_p = R_0\left[\tfrac{1}{2}\left(q + \frac{1}{q}\right) - \tfrac{1}{2}\left(q - \frac{1}{q}\right)\cos 2\beta_s'\right] \qquad (38)$$

The second form of equation (37) can be rewritten as

$$X_p = R_0\left[\tan\beta_s' + \frac{2}{(q^2-1)\sin 2\beta_s'}\right] \qquad (39)$$

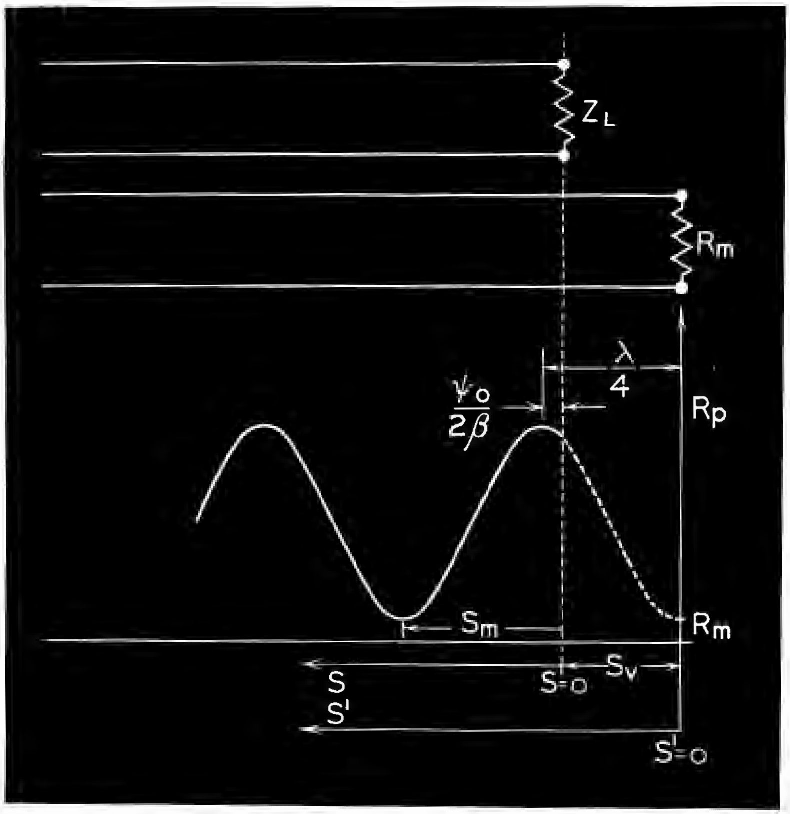


Figure 9

A load is equivalent to a resistance on the end of an extension of the line. This resistance is R_m and is half a wave length away from the just minimum in front of the load.

This equation for X_p can be readily visualized. The first term is always present, and is the only term when the line is short circuited, i.e. for $q = \infty$ For other values of q, the second term is to be added to the tangent curve. It prevents the curve of X_p from going through zero. Instead, it sends the curve to infinity. These characteristics are brought out by Figure 11, which shows the two parts of the reactance curve. (See page 52).

Summary

The theorems we stated in the beginning, have now been demonstrated, and some quantitative relations have been obtained. We can summarize our work in the following.

A. The equivalent parallel resistance looking towards the load varies sinusoidally between qR_0 and R_0/q with a space period of a half-wavelength.

B. The equivalent parallel reactance varies as $R_0 \tan\beta_s'$ plus a secant of $2\beta_s'$. The amplitude of this secant term depends on q, and is zero when q is ∞. As the observer moves toward the generator, the reactance is inductive between R_m and R_M, whereas between R_M and R_m the reactance is capacitive. The reactance is ∞ at both R_M and R_m.

C. Any load on the line can be thought of as a pure resistance R_m on the end of an extension of the line. The location of this resistance is a half-wavelength from the first minimum in front of the load.

Example 1. Power Determination: Find an equation for the power being carried by a lossless line.

At every point on the line, the power must be the same, since none is lost in the line. This power may be written easily in terms of R_p as

$$P = \frac{V^2}{R_p} \qquad (40)$$

This equation can be used to find the voltage distribution if we wish, since we know the variation of resistance. It will confirm our previous remarks about this distribution. Also, it shows that V_M occurs at the same place as R_M, and likewise V_m occurs at the same place as R_m.

Let us write the equations for these values. We have

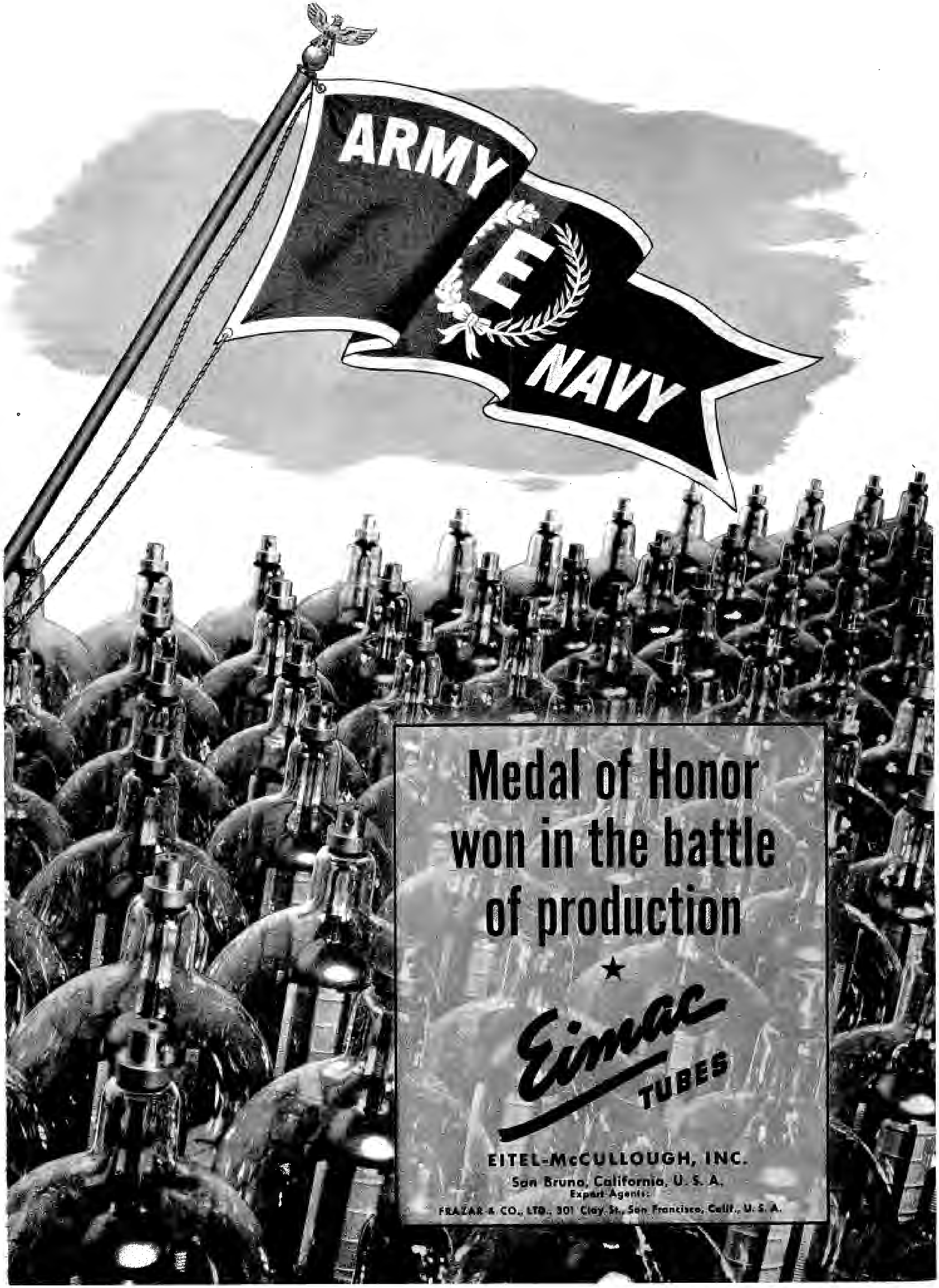
$$P = \frac{V_M^2}{R_M} \quad \text{and} \quad P = \frac{V_m^2}{R_m} \qquad (41)$$

If we multiply these equations together, we have

$$P^2 = \frac{V_M^2 V_m^2}{R_M R_m} \qquad (42)$$

By reference to equations (30) and (31), we find

(*Continued on page* 50)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EMERGENCY CIRCUITS FOR LEVEL EQUALIZING

And Anti-Side Tone Control

by DONALD PHILLIPS

SEVERAL years ago, on the occasion of the stratosphere flight of Captain Stevens, it became necessary to provide a two-way-conversation broadcast between a remote, or quite inaccessible point, from an ordinary telephone connection and a broadcast studio. Engineers at the National Broadcasting Company, over whose networks these broadcasts were to be transmitted, devised a method permitting this type of broadcast. The system not only proved satisfactory for this particular occasion, but emergency conditions as well. For it is possible with this system to put on a two-way broadcast successfully in the event that the telephone company is not able to provide the customary lines. In view of those effective properties, particularly insofar as emergencies are concerned, it was improved upon until today the system is a vital accessory to the emergency broadcasting service format.

Standard Equipment Not Adaptable

As we know, the standard radio equipment generally available is not adaptable to permit broadcasting of a program from limited facilities described above, due to level difficulties. The sound of audio level received at the studio from a remote point is very low and the level transmitted to a distant point over the same line must be high. Obviously a program cannot be broadcast until the two levels are the same.

The system devised at NBC compensates for a difference in one line level up to 40 decibels. In Figure 1 we see the level equalizer schematic diagram indicating all of the resistance values.

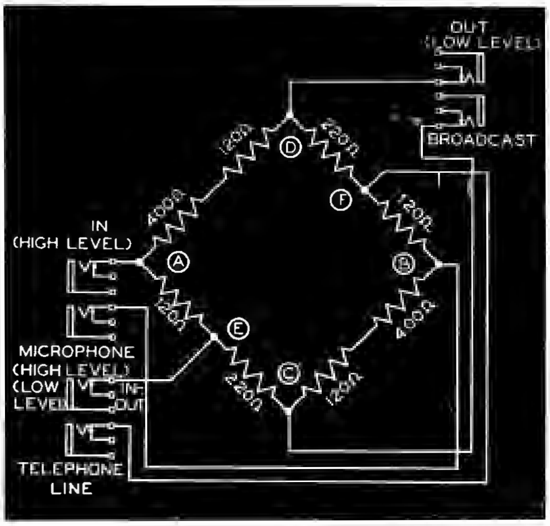


Figure 1
The basic circuit of the level equalizer system with the adopted resistance values.

Theory of Operation

Let us assume that a telephone line is connected to the level equalizer terminal marked "in" and "out" with a microphone signal connected to the "in" jack and that the output is being fed to a broadcast network or transmitter. The signal received from a remote point passes through the equalizer to the output. The microphone signal then passes through the equalizer to the line and also to the output. The dual resistances are adjusted so that the microphone level on the output terminal is the same as that of the incoming signal. Thus, on the level equalizer output the two signal levels are the same and can be fed to a network or transmitter. The equalizer is most effective, or has the best "bucking out" effect if the unit is connected as shown in Figure 2. In Figures 3 and 4 appear single line schematic diagrams showing the approximate program levels and two possible uses. The operation of these circuits are self-explanatory.

In Figure 1, the 120-ohm resistor linked to the 400-ohm unit in A-D leg and likewise the 120-ohm unit in the B-C leg, are variable and connected in tandem.

A regular microphone and either a monitoring speaker or pair of headphones must be used in place of a standard telephone transmitter and receiver. To accomplish this the feedback microphone used on special events is used. However, if desired, the feedback equipment may be operated from any broadcast studio by utilizing spare trunks and a special microphone receptacle and relay control.

After the equipment is connected and the P B X line is available, a short test period before attempting to go on the air to permit proper level adjustments is required. (Fig. 5.) It is suggested the actual test start by party at end of the P B X line giving test talk only. The variable pad marked "2" and the automatic audio gain control amplifier should then be adjusted so that plus 4 V U is obtained on the output with about 6 d b of gain control. Then the variable gain amplifier (number one) is fed between 0 and plus 10 V U to the P B X line. Then

(*Continued on page* 33)

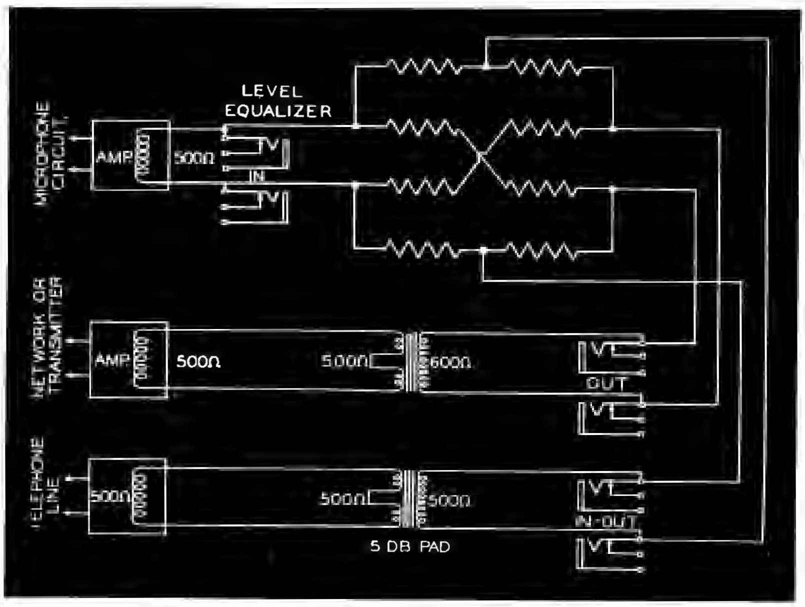
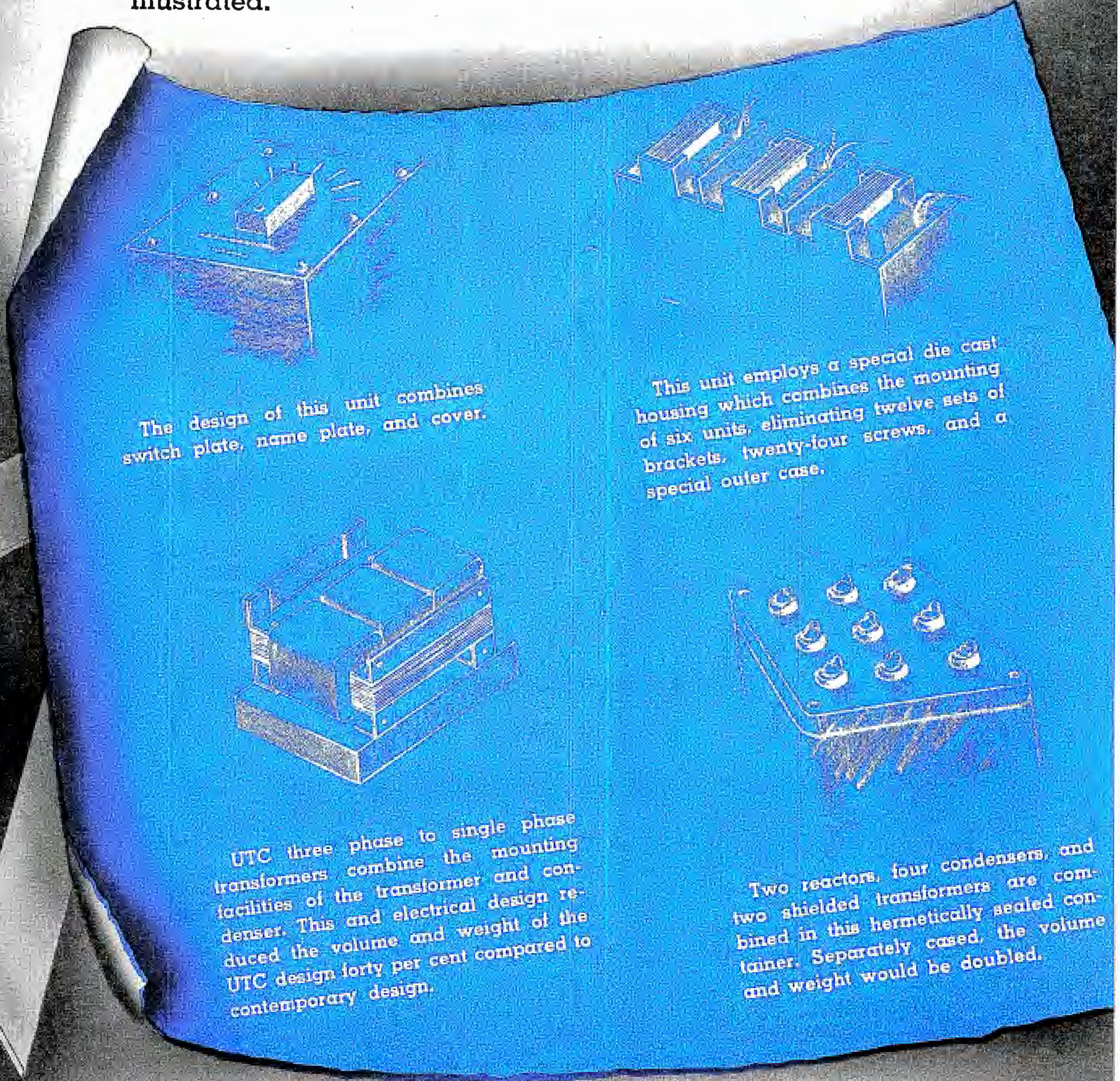


Figure 2

Combinations for Victory

Savings in materials and machine time are vital to victory. Substantial savings can frequently be effected by combining elements. Typical UTC design refinements of this type are illustrated.



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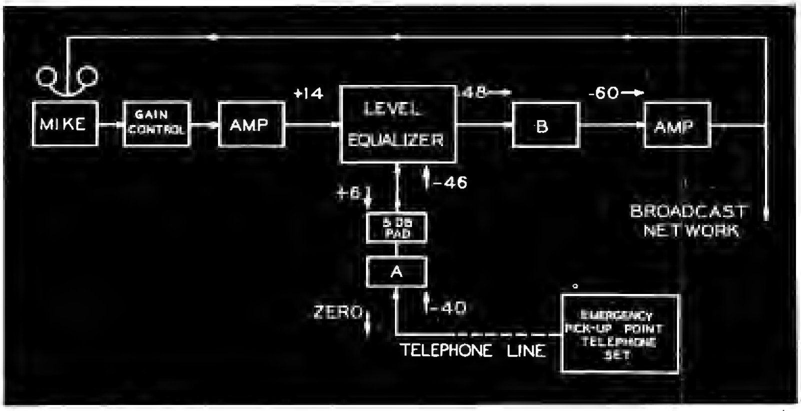
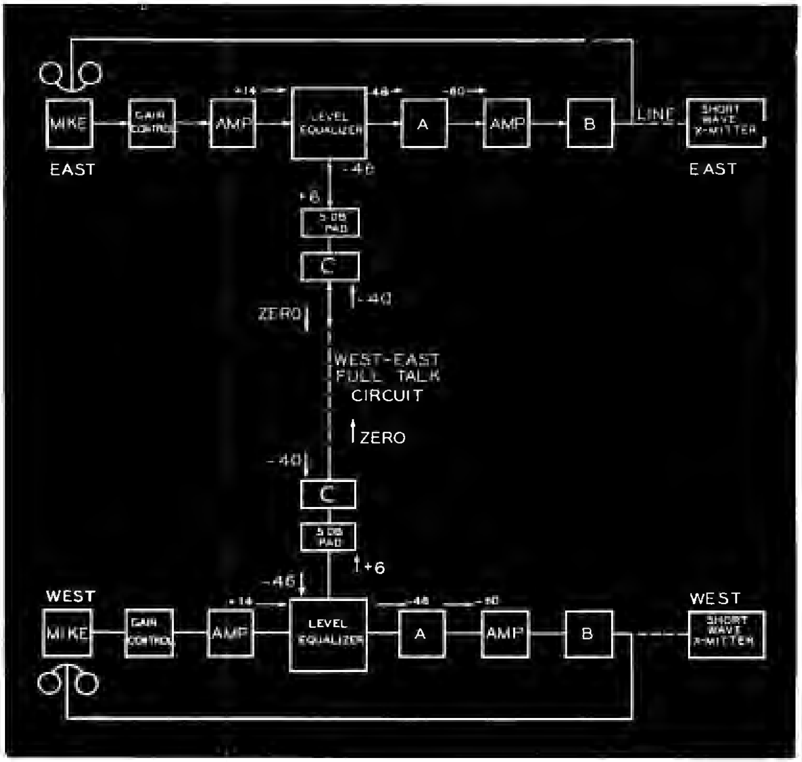


Figures 3, 4 and 5

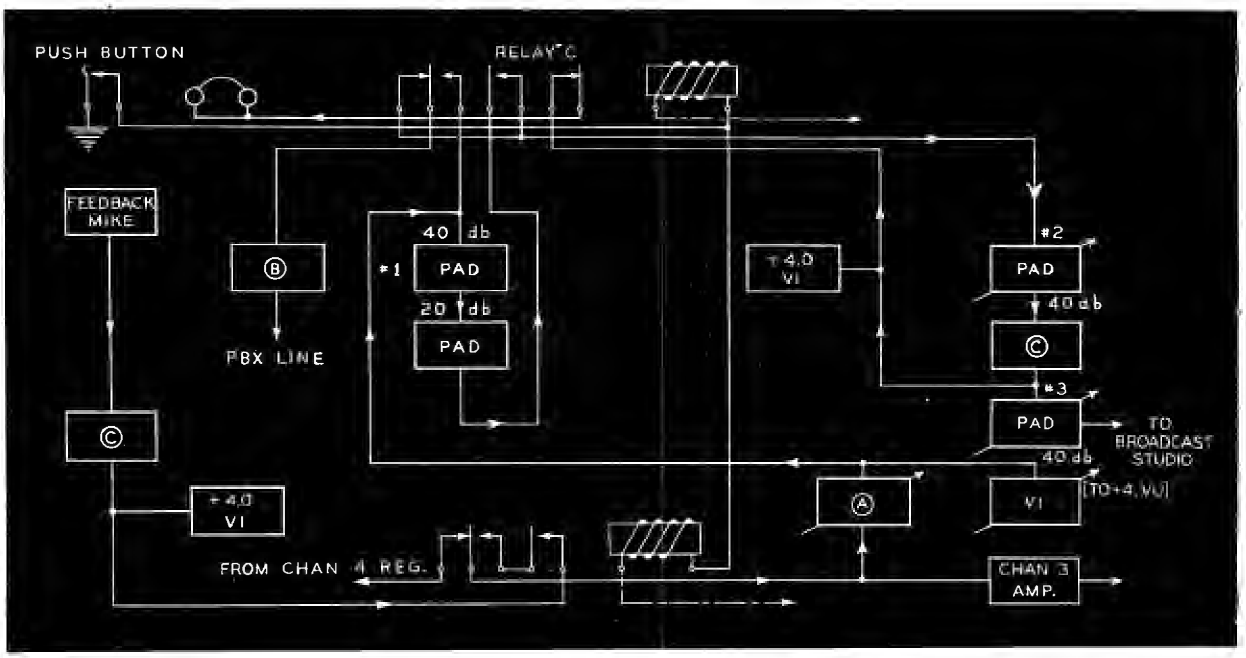
Figures 3 (left) and 4 (below), circuits for approximate program levels. In Figure 3, (A) is a split winding coil for circuit isolation, (B) a bridging coil. In Figure 4, (A) is a bridging coil, (B) an automatic gain control amplifier, and (C) an isolating unit. Figure 5 (bottom), a very long-line relay setup. Here (A) is an a-c line amplifier, (B) an isolating unit, and (C) an automatic a-f gain amplifier.

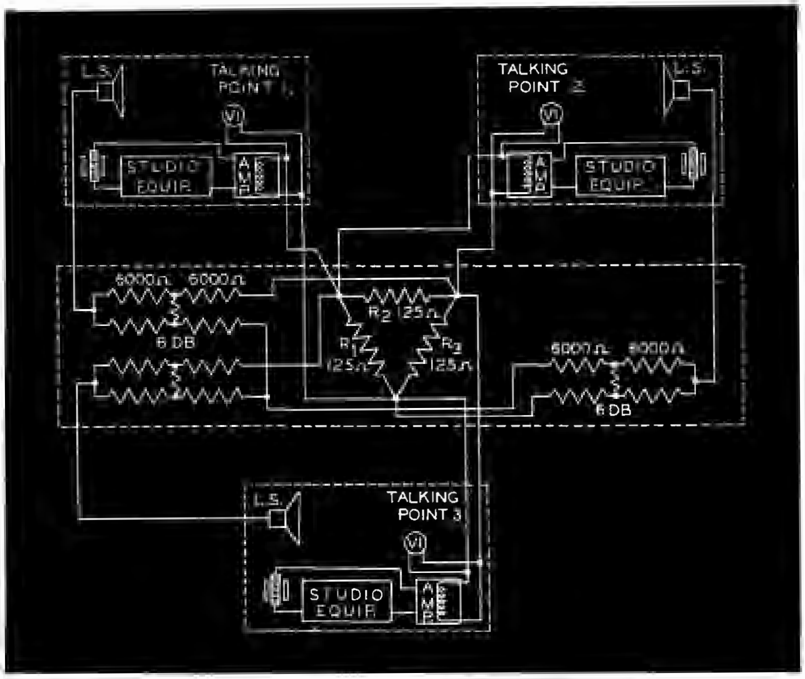


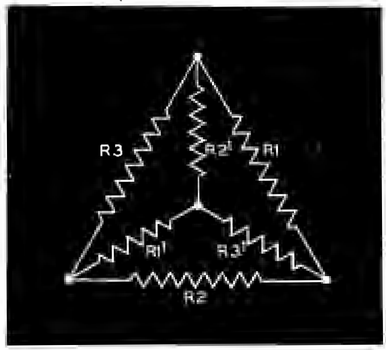
the feedback microphone should be push-button operated to obtain a normal level test talk from the feedback microphone. The variable pad (number one) is then adjusted so that the same level is obtained on the output of the gain control amplifier as that received with the P B X line but with practically no gain control action since there is already one gain control amplifier in this circuit. The variable pad (number three) can then finally be set to feed any desired level to the broadcast studio, minus 32 V U for nemo and minus 16 V U for a fader input.

Another NBC Emergency Development

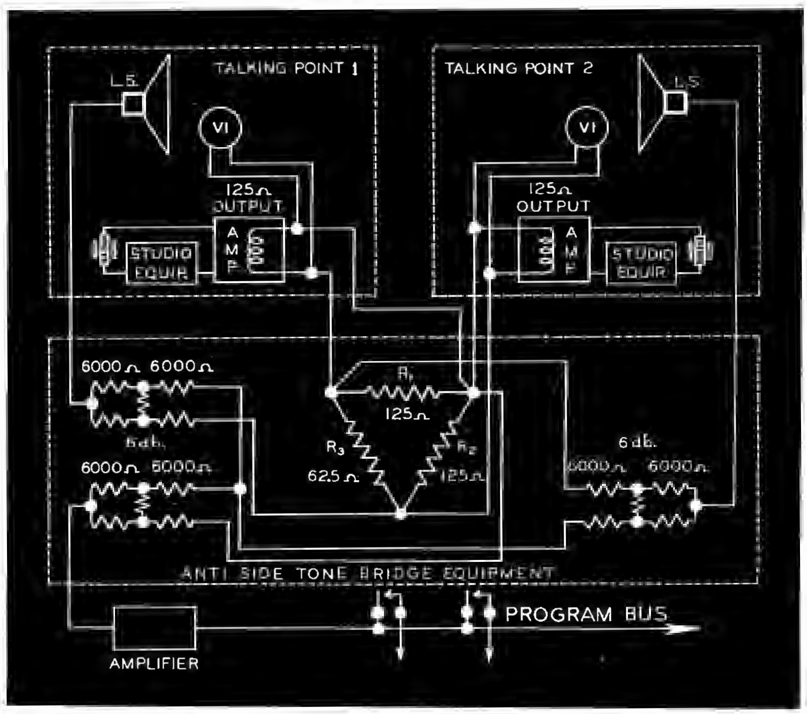
Another unique N B C development predicated by an odd situation similar to the stratosphere condition, and now a companion unit to the special equipment facilities, is the anti-side tone circuit. This unusual development was designed to provide a two-way conversation on the air or a three-way conversation with loud speakers at all points; the loud speakers and microphones being open at all times. This is made







Figures 6, 7 and 8
Figure 6 (above), circuit basis on which the anti-side tone system is based, wherein the resistances represent the output of microphone amplifiers or input of loudspeaker amplifiers, requiring an accurate balance. In Figure 7 (left) we have a typical three-way talking circuit with loud speakers at all talking points. In Figure 8 (below) we have a two-way talking circuit feeding a program bus for network or local station feed.



possible without a cut-off or switching systems.

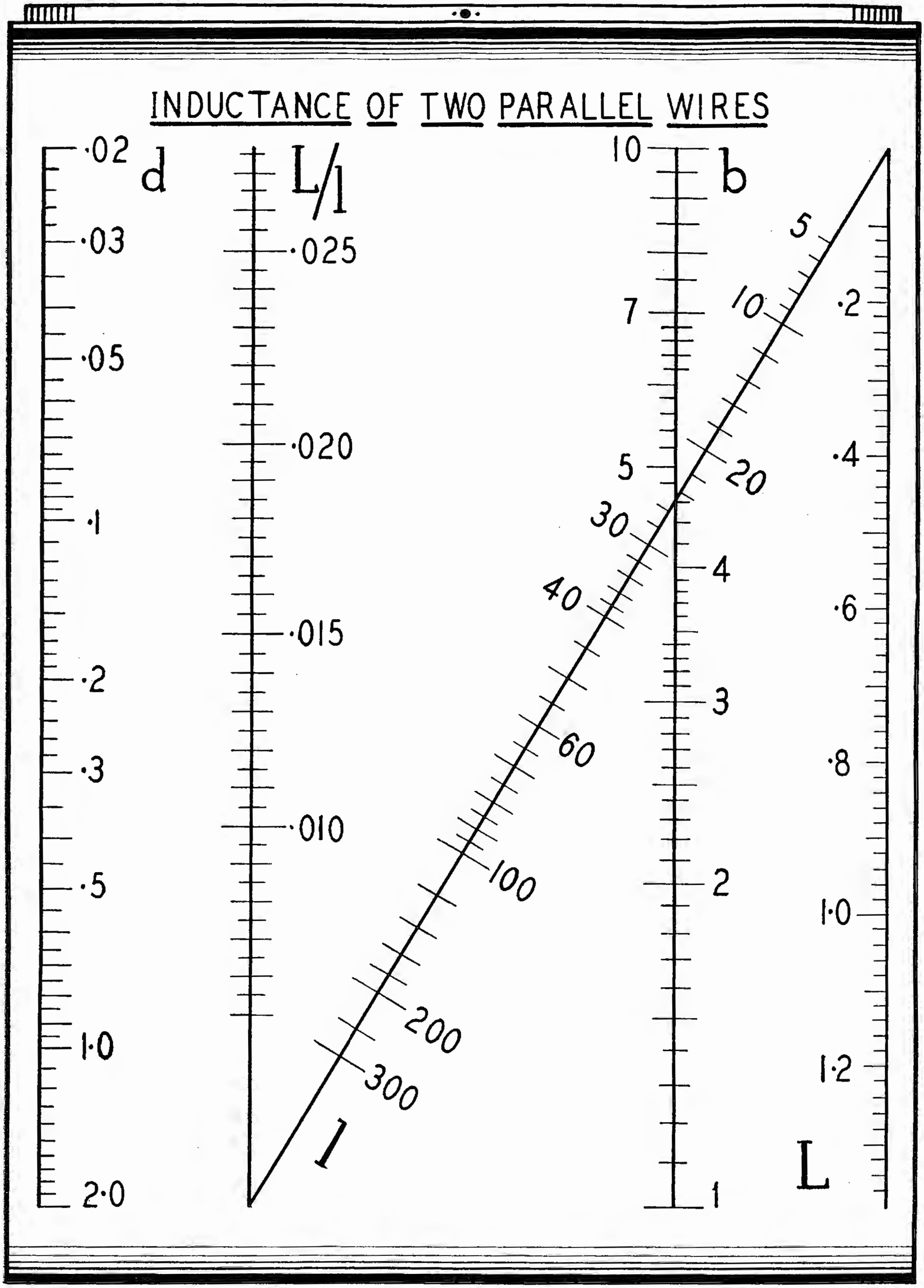
Circuit Theory

If we assume that R1, R2 and R3, as shown in Figure 6 are all of equal value, and $R1^1$, $R2^1$ and $R3^1$ are of equal value, then if a voltage is applied across R1, a voltage will be observed across all other resistances of the network except $R1^1$. This will be apparent if we refer to the Wheatstone Bridge circuit theory. If now the resistance R1 represents a microphone output and the resistance $R1^1$ the loudspeaker input, then when the microphone represented by R1 is spoken into, no feedback will be noted from the adjacent loudspeaker represented by the resistance $R1^1$. In a similar way, R2 and R3 may be microphones and $R2^1$ and $R3^1$ may be adjacently mounted loudspeakers. Accordingly, a full three-way conversation may be held. If it is desired to communicate between two points and have the resulting conversation transmitted to local or network channels, then we assume that R1 and R2 be the two sources of program, and $R1^1$ and $R2^1$ be the adjacently located loudspeakers. Thus R3 becomes a pure resistance and $R3^1$ will be the input to the outgoing line or channel amplifier.

It will be obvious that for the proper operation of this circuit all other resistances shown in Figure 6, representing as they do the output of microphone amplifiers or input of loudspeaker amplifiers, must be accurately balanced against each other. This means that R1, R2 and R3 must have very nearly the same values within close limits and the same will be true of $R1^1$, $R2^1$ and $R3^1$. To accomplish this exceptionally close balance, it is necessary in some instances to isolate the circuits by the use of balanced H pads.

It is most convenient in this connection to arrange the output of the microphone amplifiers for a 125-ohm operation and to terminate the same in a 125-ohm resistor. The variation in balance with this arrangement is reduced to a satisfactory minimum. The loudspeaker amplifier input is usually of a high impedance, subject to some variation with a change in the volume control. It has been found, therefore, best to isolate the inputs to these loudspeakers with suitable H pads. A six-decibel, 6000-to-6000 ohm pad is generally sufficient isolation. In Figure 7 appears a typical three-way talking circuit with loudspeakers at all talking points. In Figure 8 appears a two-way talking circuit feeding a program bus for network or local station feed.

No appreciable frequency discrimination has been noted by the use of this bridge circuit.



[See page 57 for explanatory data]

OPERATIONAL CALCULUS METHODS

For Transient Circuit Problems

by I. QUEEN

Western Electric Company

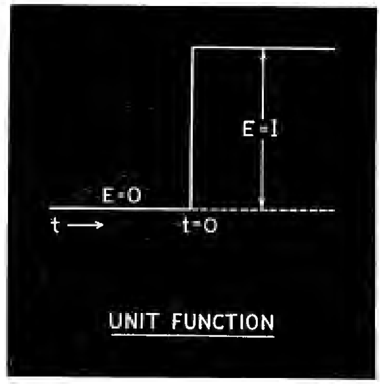


Figure 1
Step or unit function, wherein value of disturbance is assumed to be zero.

TO obtain instantaneous current and voltage values in many transient circuit problems, operational calculus may be used to advantage. This branch of mathematics was developed by Oliver Heaviside, the famous English scientist and engineer and presented in his historic "Electromagnetic Theory."

In many cases, other mathematical means of attacking the problems might lead to highly impractical and hopelessly involved calculations. This paper provides an analysis of the Heaviside method for cases where the mathematics involved may be followed without great difficulty.

Development of Operational Formulae

We will first discuss the development of operational formulae for given circuits and then we shall show how these formulae may be interpreted to obtain values of current or voltage as a function of the time.

Operational calculus methods apply generally to electrical circuits where a sudden e-m-f or current is applied to any network. The value of the disturbance is assumed to be zero from time equals $-\infty$ up to time equals zero, suddenly rising to a unit value and remaining thus indefinitely. This is known as a step or unity function and is illustrated in Figure 1. Obviously any value other than unity will give a result proportionally larger or smaller. This state of affairs takes place when a switch controlling a d-c potential is suddenly closed, or where a charged condenser is suddenly caused to be discharged through a circuit.

Heaviside used the symbol "p" to designate differentiation with respect to time (d/dt) and its reciprocal "1/p" to signify integration with respect to time ($\int_0^t dt$). This symbol parallels in some ways the use of the symbol "D" as a differential operator. It can be shown that the symbol "p" will obey the ordinary rules of algebra, such as those of multiplication, addition, partial fractions and determinants, etc., so that in any case, the problem will be . . . first, to obtain the proper operational formula, and second, to interpret it.

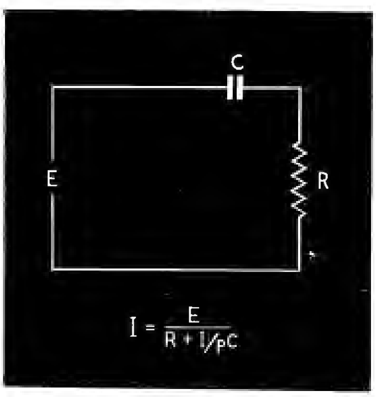


Figure 2
Usual formula, shown in this diagram, that is used in operational formulae analysis.

Operational Formulae

The usual formula for the circuit in Figure 2 gives us $E = IR + \frac{1}{C}\int_0^t I\,dt$. Substituting "p" for differentiation and "1/p" for integration (with respect to time) we readily obtain $E = IR + \frac{I}{C_p}$. It is important to note that the limits of integration are always "t" and "0," since the disturbance did not exist prior to $t = 0$. The symbol "p" can only operate on a sudden disturbance, so we proceed to rearrange the above formula, associating the operators with the disturbance, resulting in $I = \frac{E}{R + \frac{1}{C_p}}$ or for ease of manipulation, $I = \frac{E_p C}{R_p C + 1}$.

Figure 3 gives us the formula $I = \frac{E}{R + pL}$, obtained from $E = IR + L\frac{dI}{dt}$. Figure 4 leads to

$$I = \frac{E}{R + pL + 1/pC} \text{ or}$$

$I = \frac{EpC}{R_pC + p^2LC + 1}$. In a like manner, it is possible to deal with any circuit or combination of circuits.

The Resistance Operator

The above shows that the "resistance operator" for an inductance is Lp, and is 1/pC for a condenser. These operators may be treated otherwise just as though they were ordinary resistors. For example the voltage across the capacity in Figure 2 becomes current multiplied by resistance operator or $E_c = \left(\frac{EpC}{RpC + 1}\right)\left(\frac{1}{pC}\right) = \frac{E}{R_pC + 1}$. The charge on the condenser is $E_cC = \frac{EC}{RpC + 1}$.

Coupled Circuit

The coupled circuit of Figure 6 is similarly handled. We obtain the two equations $\left.\begin{matrix} I_1K_1 - I_2pM = E \\ I_2K_2 - I_1pM = O \end{matrix}\right\}$ where K_1 is the sum of the resistance operators in circuit 1, etc. Since "p" obeys the rules of determinants, E may be readily obtained. The series-parallel circuit of Figure 5 gives

$$I = \cfrac{E}{pL_1 + \left[\cfrac{\left(\cfrac{1}{PC} + pL_2\right)(R)}{R + pL_2 + 1/pC}\right]} \text{ and so on.}$$

Other types of transient circuits might include the sudden opening or closing of switches where a steady or varying current is already flowing (Figure 7). A steady voltage E is applied at $t = 0$ and the switch is closed at $t = z$. Before z, the equation is $I = \dfrac{E}{pL + R + 1/pC}$. As will be shown presently, this equation is transformed into a function of time, let us say, $\phi(t)$. The switch may be assumed to possess the property of having a potential pLI across it, and when it is closed this added voltage causes a current to flow into two circuits. One current $(-I)$ flowing through the coil cancels the previous coil current, while the other flows round the external circuit and is of magnitude $\dfrac{pL \cdot \phi(t)}{R + 1/pC}$. It must be remembered that the latter current is a function of $(t - z)$ and *not* of t, because the switch was closed at $t = z$. The sum of $\phi(t)$ and $F(t - z)$ is the total current.

Simplified Solution Afforded

The operational method thus permits a solution whereas the classical differential method would prove far more difficult. With the substitution of numerics for the general equations, this simplicity would be more readily apparent. It now remains to show how the above operational equations may be interpreted.

Expansion of Operators

It will first be shown how to solve $p/(p - a)$, since this is the basic term from which most other operators may be derived. We transform to $\dfrac{1}{1 - \dfrac{a}{p}}$ which gives the infinite series

$$1 + \frac{a}{p} + \frac{a^2}{p^2} + \frac{a^3}{p^3} \ldots.$$

Integrating as indicated we obtain

$$1 + at + \frac{a^2t^2}{2!} + \frac{a^3t^3}{3!} \ldots.$$

and thus discover that the operator $p/(p - a)$ equals ε^{at}, an important result. Integrating partially with respect

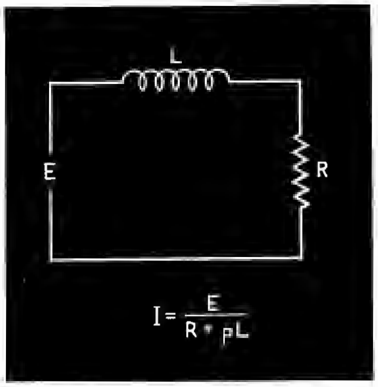


Figure 3
Formula shown here is derived from
$E = IR + L\dfrac{dI}{dt}$

to "a" we get

$$\frac{\partial}{\partial a}\left[\frac{p}{p - a}\right] = \frac{p}{(p - a)^2} = t\varepsilon^{at}$$

and continued partial differentiation shows that

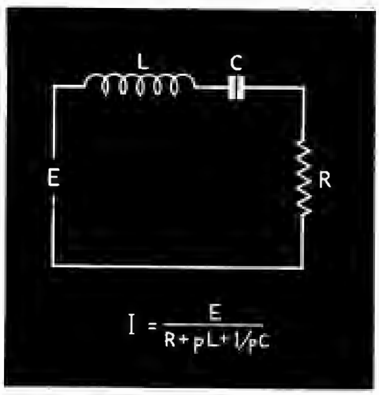
$$\underline{/n - 1}\; \frac{p}{(p - a)^n} = t^{n-1}\varepsilon^{at}.$$

It is convenient to have some direct rule whereby a general function of "p" may be transformed into a time function. This is the purpose of the *expansion theorem* which will now be developed.

Expansion Theorem

As with any algebraic quantity, the function is first reduced to the sum of an integral function and a proper fraction (if it is not already a proper fraction). We have seen how to handle an integral "p" function so we need only concern ourselves with the proper rational fraction.

Figure 4
Another step illustrating how it is possible to deal with any circuit or combination.



We now resolve into partial fractions. If "a," "b," "c," etc., are the roots of the denominator, we may assume

$$\frac{N(p)}{D(p)} \equiv \frac{A}{p - a} + \frac{B}{p - b} + \frac{C}{p - c} \ldots$$

or

$$\frac{N(p)}{D(p)} \equiv R + \frac{Ap}{p - a} + \frac{Bp}{p - b} + \frac{Cp}{p - c} \ldots,$$

where N is the numerator as a function of "p" and D(p) is the denominator. Now the operator $p/(p - a) = \varepsilon^{at}$, a pure transient, while operators of the form

$$1/(p - a) = \frac{1}{p} \cdot \frac{p}{p - a} = \int_0^t \varepsilon^{at} = \frac{1}{a}(\varepsilon^{at} - 1),$$

the sum of a transient and a constant term. Obviously it is to our advantage to use the second identity, since the constant term will be the sum of all the d-c components which are thus separated from the transient or time-varying terms. It will not be necessary to follow any special procedure in the case of imaginary roots, jK being treated under the same rules as K and suitably interpreted in the result. (The expansion cannot be used where multiple or zero roots are present.)

To continue then

$$\frac{N(p)}{D(p)} \equiv R + \frac{Ap}{p - a} + \frac{Bp}{p - b} \ldots$$

or

$$N(p) \equiv D(p)\left[K + \frac{Ap}{p - a} + \frac{Bp}{p - b} \ldots\right]$$

As usual, substitute "p" = 0, giving $N(0) = D(0) \cdot R$ or $R = \dfrac{N(0)}{D(0)}$ where N(0) is N(p) with 0 substituted for "p," etc. Now substitute p = a which gives $N(a) = \left[\dfrac{D(a) \cdot A \cdot a}{p - a}\right]$ all other terms vanishing. However, the latter equals the indeterminate 0/0, so we differentiate numerator and denominator and

$$N(a) = \frac{D'(a) \cdot A \cdot a}{1} \text{ or } A = \frac{N(a)}{a \cdot D'(a)}.$$

The other constants are likewise determined and finally we get the *expansion theorem*

$$\frac{N(p)}{D(p)} = \frac{N(0)}{D(0)} + \Sigma \frac{N(K)}{K \cdot D'(K)} \varepsilon^{kt}$$

(since $P/p - a = e^{at}$), where the Σ term is the sum of all terms with the proper root substituted for the general root K.

Numerical Example

A simple numerical example in the use of the above theorem will demon-

(*Continued on page* 40)

25 MILES—on a Still Night

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OPERATIONAL CALCULUS

(*Continued from page* 38)

strate the ease of calculation. Take the operator $\frac{(4+2p)E}{p^3-6p^2+11p-6}$. The roots of D(p) are 2, 1, 3. The complete expansion gives

$$E\left[-\frac{2}{3}-\frac{8}{2}\varepsilon^{2t}+\frac{6}{2}\varepsilon^{t}+\frac{10}{6}\varepsilon^{3t}.\right.$$

Now we are ready to solve some of the equations previously derived. Let us examine $I=\frac{EpC}{RpC+1}$. Here $\frac{N(0)}{D(0)}=0$ and the root of D(p) is $-1/RC$. The derivative of D(p) with the root substituted for "p" is $-1/RC\cdot$ Therefore

$$I=\frac{(EC)\left(-\frac{1}{RC}\right)}{\left(-\frac{1}{RC}\right)(RC)}\varepsilon^{-\frac{t}{RC}}$$

The formula $I=\frac{E}{R+pL}$ becomes

$$I=\frac{E}{R}+\frac{E}{\left(\frac{-R}{L}\right)(L)}\varepsilon^{-R/L\,t}$$

$$=\frac{E}{R}(1-\varepsilon^{-R/L\,t})$$

For $F_c=\frac{E}{RpC+1}$ we obtain

$$E_c=\underline{F}+\frac{E}{\left(\frac{-1}{RC}\right)(RC)}\varepsilon^{-t/RC}$$

$$=E(1-\varepsilon^{-t/RC}).$$

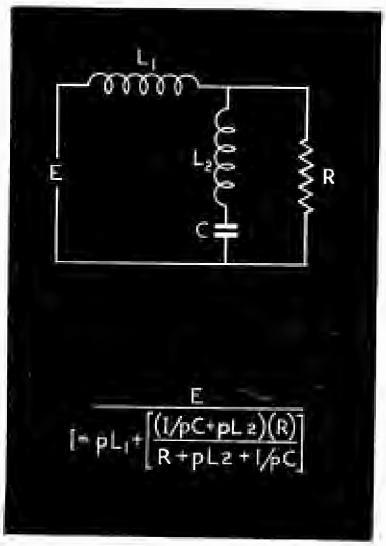


Figure 5
A series-parallel circuit.

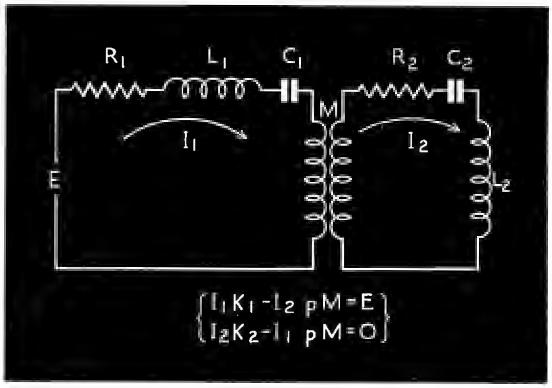


Figure 6
A coupled circuit wherein K_1 is the sum of the resistance of the operators in circuit I.

It is seen that these familiar formulae may in some cases be obtained on inspection. The difficulty will lie mainly in determining roots of D(p) when it is of high degree. This occurs only in highly intricate circuits where the differential equations would no doubt become hopeless of solution. Rigorous methods for determination of all roots (real and imaginary) of any equations are available.

The equation $I=\frac{Ecp}{p^2LC+pRC+1}$ (Figure 4) may be rewritten as

$$I=\frac{E}{L}\left[\frac{p}{p^2+p\frac{R}{L}+\frac{1}{LC}}\right]$$ and gives

two roots $-\frac{R}{2L}\pm\sqrt{\frac{R^2}{4L^2}-\frac{1}{LC}}$

Assume the radical to be negative (the usual oscillatory circuit case). Put

$$\frac{R}{2L}=A:\ \sqrt{\frac{1}{LC}-\frac{R^2}{4L^2}}=B:$$

root $[-A+jB]=M$:
root $[-A-jB]=N$.

Then $$I=\frac{E}{L}\left[\frac{M}{M(2M+2A)}\varepsilon^{Mt}+\frac{N}{N(2N+2A)}\varepsilon^{Nt}\right]=\frac{E}{2L}\left[\frac{\varepsilon^{-At}\varepsilon^{jBt}-\varepsilon^{-At}\varepsilon^{-jBt}}{jB}\right]$$

$$=\frac{E}{BL}\varepsilon^{-At}\sin Bt$$

(since $M+A=jB$:
$N+A=-jB$:
$\sin Bt=\frac{e^{jBt}-e^{-jBt}}{2j}$

Multiple Roots

Note that in the above problem if B were zero, we would have the double root $-A$. Now $\frac{\sin^{Bt}}{Bt}$ approaches unity as B approaches zero. Therefore we would have $\frac{tE}{L}\varepsilon^{-At}\frac{\sin Bt}{Bt}=\frac{E}{L}t\varepsilon^{-At}$.

In general we would follow the usual algebraic rule for partial fractions where multiple roots are involved. We have the identity

$$\frac{N(p)}{D(p)}\equiv R+\frac{Ap}{p-a}+\frac{Bp}{(p-a)^2}\ldots\frac{Mp}{(p-a)^m}+\frac{Np}{(p-b)}\ldots$$

where "a" is the multiple root and appears m times. The constants are found as usual by means of substitution or by the equating of similar powers of "p" after the elimination of the denominators, or their general form may be found directly.[1]

Should one of the roots of D(p) be zero, that is "p" be a factor, we could expand the other roots as usual and then treat 1/p as $\int_0^t dt$.

"Shifting" Theorem

The reader can easily evaluate that

$$\frac{1}{p-a}\varepsilon^{bt}=\frac{1}{p-a}\cdot\frac{p}{p-b}=\frac{a}{a(a-b)}\varepsilon^{at}\frac{b}{b(a-b)}\varepsilon^{bt}.$$

But this equals $e^{bt}\left[\frac{1}{(p+b)-a}\right]$ by the usual expansion. To operate on an exponential time function ε^{bt}, we change "p" to "p + b" and shift the function to the left as a coefficient. Likewise $p\varepsilon^{bt}=b\varepsilon^{bt}=\varepsilon^{bt}(b+p)$, for "p" acting on unity is zero. Now when

$$\frac{p^n}{(p-a)^n}=p\cdot p\cdot p\cdot\frac{1}{p-a}\cdot\frac{1}{p-a}\cdot\frac{1}{p-a}\cdot\ldots$$

(*Continued on page* 69)

NEWS BRIEFS OF THE MONTH...

WPB AUTHORIZES 40% TIN FOR SOLDER AND WIRE COATING

Manufacturers of military radio and radar, including parts, have been authorized to use 40 per cent tin for solder, hardware, and wire coating, under an interpretation of the tin Conservation Order M-43-a, just issued by WPB. The WPB action follows submission by many RMA members of information that lower-quality tin solder and wire coating previously permitted was not satisfactory.

A special RMA committee, headed by Raymond G. Zender of Lenz Electric Manufacturing Co., Chicago, was instrumental in securing the modification of the tin conservation order. Under special appointment by chairman Ray F. Sparrow of the RMA Parts Division, Mr. Zender assembler from many RMA members much actual manufacturing data regarding the unsatisfactory use of lower-quality tin. The RMA members' data was submitted to J. M. Lowenstein, chief of the Materials Section, WPB Radio and Radar Division, and by him to the WPB Tin-Lead Division.

Originally the tin content for solder and wire coating was restricted to 12 per cent. Under official Interpretation No. 1, military radio and radar were exempted from the tin conservation order, but the requirements for the lower quality of tin solder and wire coating remained.

* * *

"E" TO DEJUR-AMSCO CORPORATION

The Army-Navy "E" award for outstanding war production has been won by the DeJur-Amsco Corporation, Shelton, Conn.

* * *

DORIS EVANS REJOINS G. E.

After an absence of twenty years, Doris Evans, one of the first women assistants in the original radio department of General Electric's research laboratory, has returned to the laboratory.

When her husband, Col. Delbert Ausmus, was reported missing on Corregidor, presumably a prisoner of the Japanese, she offered her services once again to General Electric.

In the early 1920's she joined the G. E. as a secretary. Later, after transferring to the research laboratory, she took a special four-year course in mathematics at Union College, becoming one of the first women to study at that men's college. She thus qualified as a laboratory assistant, making wiring diagrams for radio equipment, then testing and keeping data on the equipment.

SHURE REACTANCE SLIDE RULE

A new reactance slide rule providing the solution of reactance and resonant frequency problems has been devised by Shure Brothers, 225 West Huron Street, Chicago, Ill.

On one side of this slide rule, resonant frequency problems are solved with one setting of the slide, using

$$\omega^2 LC = 1$$

with ranges of 5 cycles to 500 mc, .001 mmfd to 1,000 mfd, and .00001 mh to 10,000 henries.

On the other side of the slide rule, reactance, dissipation factor and coil "Q" problems are solved with one setting of the slide, using the following formulae:

$$X_C = \frac{1}{2\pi fC}$$

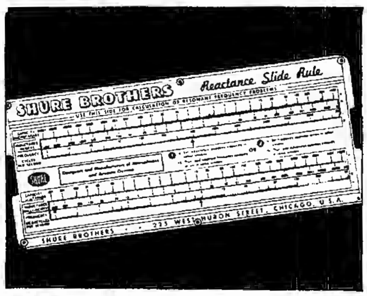
$$X_L = 2\pi fL$$

$$Q = \frac{2\pi fL}{R}$$

$$D = 2\pi fCR$$

The ranges on this slide are 0.1 cycle to 10,000 mc, 1 mmfd to 100 mfd, and .001 mh to 100 henries.

This slide rule is available at a cost of ten cents.



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GENERAL RADIO WINS "E"

The General Radio Co., Cambridge, Massachusetts, has been awarded the joint Army-Navy "E" production award.

* * *

OHIO BROADCAST CONFERENCE CANCELLED

The annual Ohio State Broadcast Engineering Conference, usually held in the latter part of February, has been cancelled this year, due to the war.

The director and originator of the conference, Dr. W. L. Everitt, is on leave from Ohio State to the Signal Corps. Lynne C. Smeby, former NAB director of engineering, who cooperated with Dr. Everitt in handling the sessions, is now associated with Dr. Everitt in the Signal Corps.

* * *

A. J. "NICK" CARTER DEAD

Alva J. Carter, president of the Carter Motor Company, Chicago, Illinois, died suddenly on January 24. Mr. Carter entered the parts manufacturing business in 1922, and in 1928 organized the motor manufacturing unit.

FIELD SERVICE FOR RADIO AND RADAR DIVISION

Eighteen field officers have been appointed to the newly organized field service for radio manufacturers of the WPB Radio and Radar Division, according to Frank S. Horning, chief of the Field Operations Section. Known as "radio industrial specialists", the field officers have been assigned to the WPB regional offices, but their activities, directed by the Field Operations Section, will be confined exclusively to the assistance of radio and radar manufacturers.

In region one, Boston, will be Michael Scott and John A. Fletcher. New York (region 2), will have Frank Misterly, Vernon M. Bugg, Frederick J. Kahn, Samuel D. Barr, Robert E. Schwarting and Wm. D. L. Starbuck. Philadelphia (region 3), will have Frank Aiken and Charles Boice. In Cleveland (region 5), Howard J. Shartle, Karl J. Banfer and M. G. Thomas will preside. Chicago (region 6), will have Raymond H. Woodford, George Lonergan, A. E. Klein and Carl E. Sartoris. In Kansas City (region 7) will be Fred H. Larrabee.

* * *

HALLICRAFTERS TO OCCUPY COMPLETE BUILDING

The Hallicrafters will soon occupy the entire building at 2611 Indiana Avenue, Chicago, Ill.

When the Hallicrafters moved to Chicago from Marion, Indiana, on August 15, 1936, they occupied but one floor in the 2611 Indiana Avenue building.

* * *

RCA SERVICE COMPANY FORMED

A separate subsidiary, RCA Service Company, Inc., to handle the technical servicing and installation activities of the RCA Victor Division of the Radio Corporation of America, has been formed.

Edward C. Cahill, manager of RCA Victor's sound equipment activities is president of the new company. He will also retain his other responsibilities with the RCA Victor Division. W. L. Jones, former manager of RCA Victor's service and installation division, is vice president and general manager of the new company. There are no changes in either the managerial or the technical staff of the RCA Victor service organization, which is now incorporated in its entirety within the new company. The new company will also continue to conduct its training school for technicians in Philadelphia for the U. S. Signal Corps.

(*Continued on page* 54)

W. L. Jones

E. C. Cahill

BOOK TALK . . . —

MANUAL OF SIMPLIFIED RADIO SERVICING

By Major J. G. Tustison, U. S. Army Signal Corps . . . 44 pp. . . . Chicago, Ill.: Allied Radio Corp. . . . $.10

A pocket-sized manual, with practical field-tested, short-cut methods for servicing electronic and radio devices. Contains data on general servicing hints, voltage and current readings, impedance measurements, inductance and capacity, transmitters and signal tracing. In addition, there are data on resistor and condenser color codes, power transformer, audio transformer, i-f transformer leads, etc.

Engineers, maintenance and service men can obtain this booklet free by sending in requests on firm letterheads.

This is a handy little book to have around the shop and office.—*O. R.*

• • •

THE INDUCTANCE AUTHORITY

By Edward M. Shiepe, B.S., M.E.E. . . . 50 pp. . . . New York: Gold Shield Products . . . $2.50

In this new edition, Mr. Shiepe provides 38 inductance charts, of which 36 cover the numbers of turns for wire sizes ranging from 14 to 32, as well as different types of coverings including single silk, cotton-double silk, double-cotton and enamel. Data covers diameters of from three-quarters of an inch to three inches. Each turns-chart for a given wire has a separate curve for each of thirteen form diameters shown.

A straight line inductance-capacity-frequency (5 to 50,000 kc) chart is also provided.—*O. R.*

• • •

A GUIDE TO CATHODE RAY PATTERNS

By Merwyn Bly, Associate Engineer (Radio), Navy Department . . . 37 pp. . . . New York: John Wiley & Sons, Inc. . . . $1.50

An interesting compilation of patterns, that can be used effectively in development work, are presented in this unusual book. The patterns shown are the result of studies of phase determination, frequency-determination, modulation, sine-wave and square-wave testing, resonance curves, vacuum tube characteristics, and other miscellaneous allied subjects.

The patterns shown are clearly drawn and as such are excellent for teaching and training work as well as for engineering references.

A very simple graphic analysis for those who have had no previous knowledge of the subject is also offered.

This book is highly recommended to everyone from beginner to professional. —*O. R.*

• • •

TELEVISION STANDARDS AND PRACTICE

Edited by Donald G. Fink, with the cooperation of the N. T. S. C. Editorial Advisory Board . . . 405 pp. . . . New York: McGraw-Hill Book Company . . . $5.00

The meetings of the National Television System Committee from August, 1940, to March, 1941, provided an invaluable record of television data. This record totaled some 2,000 pages and covered 11 volumes. It constituted a thorough and authoritative examination into the technical basis of a public television service. So vital were these data that a decision was made to provide a condensed, or edited, version of this material for study by everyone.

This volume is the result of that decision. It is an outstanding contribution and too much praise cannot be given to the many who contributed to it and to Donald G. Fink, who edited it.

In this volume will be found data covering television standardization in America, the National Television System standards, television systems, the subjective aspects of television, the television transmitter and the channels required, the transmitter-receiver relationship, scanning specifications, synchronization of the picture, and horizontal as against vertical polarization.

In the appendix appears the FCC standards of good engineering practice concerning television broadcast stations and the FCC rules governing commercial and experimental television stations. A bibliography of technical papers presented in the N.T.S.C. proceedings is also included.

Dr. W. R. G Baker has provided the foreword to this interesting book.—*O. R.*

• • •

PRINCIPLES OF AERONAUTICAL RADIO ENGINEERING

By P. C. Sandretto, formerly Superintendent of the Communications Laboratory, United Airlines Transport Corporation and now a Major in the Air Corps of the U. S. Army . . . 414 pp. . . . New York: McGraw-Hill Book Company . . . $3.50

This is a most topical book and one of the most authoritative ever presented.

The complete story of the problems, and their solutions, of aeronautical radio engineering is most effectively treated in this volume.

Subjects discussed include the radio range, ultra-high-frequency radio range, aircraft direction finders, markers, instrument landing, absolute altimeters, medium and ultra-high-frequency communication systems, power supplies, etc.

There are 228 illustrations and diagrams, most of which have never appeared elsewhere before.

A worthwhile book for every engineer.—*O. R.*

• • •

ASPECTS OF MODULATION SYSTEMS

By James Robinson, M.B.E., D.S.C., Ph.D., M.I.E.E. . . . 39 pp. . : . London: The Journal of the British Institution of Radio Engineers.

Appearing in the 1942-43 issue of the British I. R. E. Journal, is this comprehensive modulation system paper, which was read before the London section of the Institution at the Federation of British Industries, London. Dr. Robinson discusses the characteristics of amplitude modulation and his famous "stenode" method. In his exposition of the stenode system he tells of the effect of the rectifier on interference, interfering program de-modulation and the stenode single-side-band operation and stenode transmission. Continuing his analysis, he compares the virtues of the stenode and frequency modulation. Discussed, too, are the subjects of interference with frequency and phase modulation systems, and the limitations of frequency and phase modulation.

In his summary, he points out that his inverse stenode method of transmission provides further progress in transmission since . . . "we can apply a correction factor at the transmitter and transmit the higher side frequencies at a much greater level with regard to the lower side frequencies than normally. . . . Then reception is simple and we obtain a very considerable improvement in the signal to noise radio."

"Further," he adds, "this method gives a gain in the efficiency of the transmitter, for we need transmit only a low percentage of the normal carrier,

(*Continued on page* 63)

Wheezes, Wows, Squeaks, Noises, are out because there are

NO GREMLINS

in GOULD-MOODY'S sensational "Black Seal" GLASS BASE *Instantaneous* RECORDING BLANKS

Gremlins are those pesky little pixies who annoy pilots of the RAF and the U. S. Air Force. They're also present in many recording blanks, causing wows and rumbles, squeaks and noises. But, there are no Gremlins in "Black Seal" Glass Base Instantaneous Recording Blanks. They're the talk of the industry...giving a wide frequency range, true and beautiful reproductive qualities, and absolute freedom from noises—you hear only the performance itself ! Try these Gremlin-free "Black Seal" blanks at our expense—if they don't come up to your expectations, send them back and we'll stand the entire tariff.

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IMMEDIATE DELIVERY! Styli and shipping cartons supplied at cost.

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THERE ARE HUMAN GREMLINS, TOO!

They're well-meaning, but kind of careless, people who buy things they don't need, who spread rumors, who throw away scrap and rags, who waste fuel, who drive their cars too fast, who aim to but don't invest in War Bonds.

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V.W.O.A.'S EIGHTEENTH CRUISE

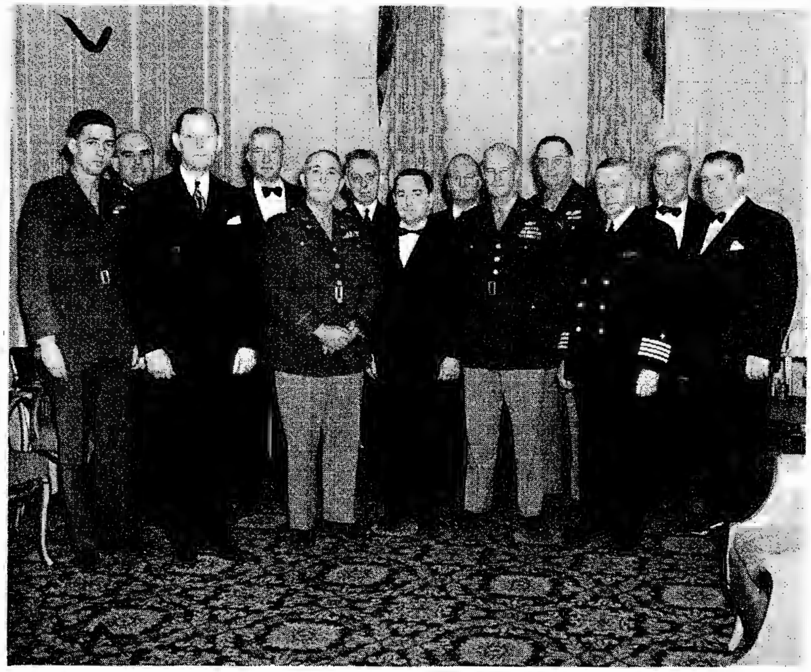
THE Veterans Wireless Operators Association celebrated its eighteenth anniversary with a dinner cruise at the Hotel Astor, on February 11th, 1943. Marconi Memorial honor award plaques were presented to Major General Dawson Olmstead, Chief Signal Officer of the U. S. Army; Captain Carl F. Holden, Director of Naval Communications; Captain E. M. Webster, Director of Coast Guard Communications; Colonel A. W. Mariner, Director of Air Corps Communications; Colonel Wallace, Director of Marine Corps Communications, and Captain Thomas Blau, Commandant, United States Maritime Service. The presentation of the plaques to the Directors of Communication was broadcast over WEAF and a coast-to-coast NBC network.

A special commemorative medal was presented to Major General Follett Bradley, Commanding General, First Air Force, as a pioneer in the use of wireless communication from an airplane for artillery spotting in 1912. A special broadcast of the award to General Bradley was presented over WHN with General Mauborgne, the man responsible for the installation of the radio equipment on the plane in 1912 participating.

A third broadcast over WOR featured the radio installation of the last war, in both Army and Navy. General J. O. Mauborgne, USA, retired, spoke of the work done in the Signal Corps during World War I, and Rear Admiral S. C. Hooper, USN, retired, gave a graphic account of the building up of Navy radio just in time for the last conflict. A lighter touch was given by a short talk by a WAVE speaking in general terms of the position of women in the war today. This program was announced by the first civilian radio aide in the Navy, who was assistant to Admiral Hooper during the entire war.

Among the honored guests at this eighteenth anniversary dinner cruise was C. J. Pannill, VWOA life member, who received a Marconi Memorial Medal of Achievement as a former wireless operator, and whose organization last year was awarded the Army-Navy "E" pennant for achievement. W. J. Halligan, also a life member, also received a similar medal on behalf of his company, the Hallicrafters in Chicago, also recipients of the Army-Navy "E." In attendance also were E. A. Nicholas, president of Farnsworth Television and Radio Corporation; Commanders Muller, Wallis and Boucheron; General J. O. Mauborgne, an honorary member of the association, and former Chief Signal Officer; Admiral Luke McNamee, president, Mackay Radio Telegraph Company; Commander R. B. Howley, general manager, Tropical Radio Telegraph Company; E. H. Rietzke, president, Capitol Radio Engineering Institute, who kindly consented to the presentation of scholarships in the home study division of the Institute to the WAVES, WAACS and the SPARS; K. B. Warner, secretary and general manager of the American Radio Relay League, upon whom our association conferred honorary membership; W. F. Aufenanger, general superintendent of RCA Institutes, who was inducted into the association as a life member; James Francis Rigby, person-

(*Continued on page* 62)



At the eighteenth anniversary VWOA dinner-cruise (left to right, front row) . . . Colonel Berkley, Commissioner Fly, General Olmstead, W. J. McGonigle, General Bradley, Captain Blau, T. R. McElroy. At rear, left to right . . . George Bailey, General Mauborgne, Captain Webster, Captain Holden, Colonel Mariner and C. J. Pannill.

W. J. McGonigle presenting commemorative medal to General Bradley.

REPORT ON IRE WINTER CONFERENCE

(*Continued from page* 16)

up of a committee to determine the status of the registrant. If in the opinion of the committee the individual possesses the requisite training, qualifications or skill, a stamped endorsement of this fact is filed with the original form and supplied to the local draft board. In addition, explained Mr. Miles, this committee also has the prerogative of appealing the local board's decision. It is believed that this plan, which now exists only in the physics field, will be extended to other scientific and specialized fields, according to Mr. Miles.

The qualifications unit of the National Roster has been serving American industry in a very effective manner, said Mr. Miles. Since its inception, some 25,000 jobs have been filled through these facilities. There were over 100,000 engineers registered in this Roster. Unfortunately, only a small percentage of these are radio engineers and practically all of them are already engaged in war work.

The occupational questionnaire is serving to provide the Roster with additional engineers. Registration blanks are sent to all individuals who indicate their engineering qualifications.

Only 7,000 Radio Engineers

Mr. Miles pointed out that of the 280,000 professional engineers, but 20% are electrical engineers, and only about 7,000 of this entire group are radio engineers.

Fortunately, said Mr. Miles, a larger percentage of the recent graduates have been electrical and radio engineers. There is the hope, he said, that this proportionate increase will continue.

LLOYD ESPENSCHIED'S PAPER

One of the most illuminating papers of the session was that presented by Lloyd Espenschied, consultant for the Bell Telephone Laboratories. His paper covered an analysis of the various branches of electrical communications.

The obtaining of an electric current free of the shackles of ponderous matter, as is done in the space of a vacuum tube, said Mr. Espenschied, gives a new latitude in the kind of intelligence pattern that can be picked up and delivered. In this respect, he pointed out television as an example.

In the transmission over an intervening medium the dimension of time is involved in three senses, said Mr. Espenschied. The first is the rate at which the intelligence pattern is picked up at the transmitting terminal and reproduced at the receiving end. The second is the time of transit across the intervening space, and the third is the rate of recurrence, or the frequency of oscillation of the carrying wave itself.

Ultra-high-frequency transmission has provided a new conception of the relationship of electrical communications to three-dimensional space, said Mr. Espenschied. Not only can such radiation be narrowed down into beams, but also into pipes or tubes that are protected and guided to particular destinations, related Mr. Espenschied. This latter point of "pipe transmission" was discussed by Dr. George C. Southworth, whose paper will be commented on later.

An interesting pictorial representation of the history of communications shown by Mr. Espenschied appears in figure 4.

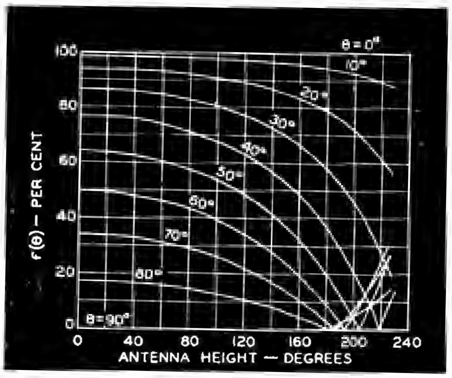


Figure 5

Curves representing the vertical radiation characteristic as a function of electrical height, as prepared by Smith-Gove, in their paper on the Electromechanical Calculator for directional antenna patterns. (See page 48.)
(*Courtesy AIEE*)

DR. SOUTHWORTH ON MICRO-WAVES

The advantages of micro-waves and their usefulness today was explained by Dr. George C. Southworth, Bell Telephone Laboratories, in his paper on "Beyond the Ultra Shorts". Briefly outlining the conquest of the frequencies from the sixty-cycles per second of the power lines through the 15,000 of speech and music, the 1,500,000 of broadcasting and the 10,000,000 of the short-wave range, Dr. Southworth mentioned the need of television and communication in general for more and wider channels as one of the prime forces in the advance into the micro-waves. Other desirable features of the "micro" region, above a billion cycles per second, are the small size of antennas and their high directivity; and the fact that the waves follow the line of sight and thus do not interfere with signals beyond their own useful range.

Some method of conducting waves from generator to antenna, and from antenna to receiver is obviously necessary, he said. While ordinary insulated

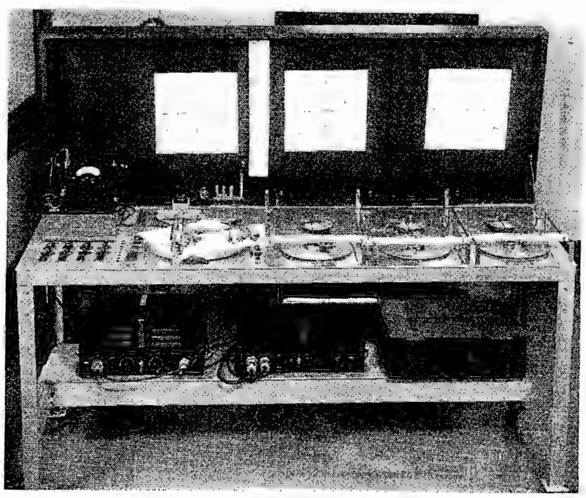


Figure 6 (left) and 7 (right)

Figure 6, the electromechanical antenna pattern calculator. At left of the unit appears the magnitude controls, followed by the turntable and cosine wave generator panels. In Figure 7 we have a closeup of the magnitude controls and the turntable.
(*Courtesy AIEE*)

wires can be used through the broadcast range and beyond, in the short wave range special attention must be given to losses in the insulation, to radiation into space and into nearby conductors, and to the effects on tuning produced by stray capacity and inductance. The coaxial line, in which one conductor is formed into a tube, and the other is enclosed in it, is an excellent expedient. If the central conductor is completely removed, it is still possible to transmit energy down the tube which then becomes a wave guide. If the tube is filled with insulating material, even the outer conductor can be removed. The coaxial and the conducting tube or wave guide are the most promising of these various arrangements.

Wave Guide Superiority

Compared from the standpoint of attenuation losses, the coaxial is better at the lower frequencies; but in the microwave region, which is of most importance at the moment, the wave guide has decided advantages.

Wave guides are decidedly useful for conveying micro-waves from their generator to the place where they will be used. For one reason, they contain no insulating material and so are entirely immune to moisture. Moreover their waves can be radiated by simply flaring out the tube into a horn. A wave guide may also be made into a resonant chamber by blocking one end with a metal plate and closing the other partially by a plate with a hole in it, explained Dr. Southworth. By varying the length of the chamber, it can be tuned to the precise frequency desired; with a small hole, if the chamber is ½, 1, 1½ of a wavelength, it will admit energy readily; if ¼, ¾, 5/4 wavelengths, it will repel energy . . . that is, be anti-resonant. Since the wave pattern in a resonator is fixed, it is possible to locate a detector at precisely the right spot in the pattern to get maximum response.

Because they, too, can be guided down a tube, sound waves are strikingly analogous to electric waves in some of the properties just described; for example in radiation from a horn and resonance in chambers, said Dr. Southworth. However, any hole in the tube will let out some of the sound energy. One of the most useful forms of the electric wave, on the other hand, can be so oriented to a hole in the tube, or even to a long slot, that no energy escapes, and hence it is possible to insert an electrical probe and move it along the tube. That procedure makes possible the detection of any irregularities in the flow of power.

Wavelengths of a Foot

Somewhere along the frequency scale in the neighborhood of a billion cycles per second—wavelength about one foot — micro-wave technic undergoes a marked change, continued Dr. Southworth. Methods using the conventional go-and-return-conductor type of circuit give way to the somewhat simpler hollow pipe, or wave guide circuit. These newer methods seem to be at their best in the centimeter wavelength range. At the longer wavelengths, the component parts become inconveniently large. For shorter waves, it would appear that ability to manufacture small parts would become an important limitation.

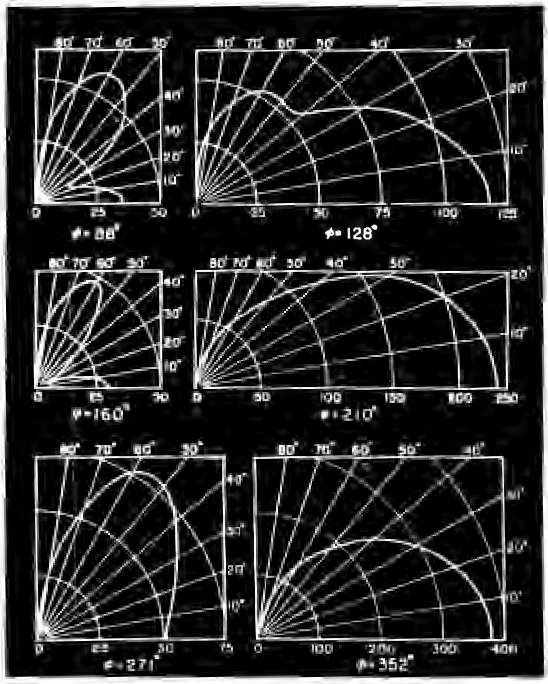


Figure 8
Vertical-plane radiation patterns produced by Smith-Gove on their electromechanical antenna pattern calculator. Vertical patterns are important when considering sky-wave interference problems between radio stations. On page 48 appear the highlights of the Smith-Gove paper describing this effective calculating device.
(Courtesy AIEE)

To illustrate the progress of u-h-f study, Dr. Southworth presented the chart, shown in Figure 1.

DIRECT-READING WATTMETERS

In an extremely interesting paper on "Direct-Reading Wattmeters for Use at Radio Frequencies," prepared by George H. Brown, J. Epstein and D. W. Peterson, all of RCA, and presented by Dr. Brown, wattmeters for use in the frequencies between 500 and 2,000 kilocycles and in the neighborhood of 50 megacycles, were described.

Direct and Indirect Methods

The power output of a radio broadcast transmitter in the past has been determined by either one of two methods, the direct and the indirect methods, said Dr. Brown. In the indirect method, which is not too accurate, according to Dr. Brown, the plate input power of the last stage of the transmitter is multiplied by a stated factor so as to obtain the output power. In the direct method the antenna resistance or the resistance at some point in the feed system is measured. Then, said Dr. Brown, an ammeter is inserted at this point and the power is determined from the I^2R formula. This method of power determination, said Dr. Brown, assumes that the antenna resistance or the feed point resistance does not change. If such a change occurs, due to climatic conditions, or due to intentional or accidental circuit changes, explained Dr. Brown, the mere fact that the current at the measuring point remains constant does not assure a constant power.

Identical Thermocouples

Two identical thermocouples are the prime factors in the operation of these wattmeters. These thermocouples, said Dr. Brown, are of the vacuum type with a heater insulated from the junction.

The low frequency wattmeter can be calibrated with ordinary laboratory instruments. The power source does not have to have sufficient power to deliver more than a couple of watts, according to Dr. Brown.

Operated Between 500-2000 KC

The meter can be calibrated to read 100 microamperes when the power into the load is 1,000 watts.

This instrument has been operated successfully at frequencies between 500 and 2,000 kilocycles and although no attempt has been made to operate outside this band of frequencies it is believed that a much wider frequency range is feasible.

U-H-F Wattmeter

The principle of paired thermocouples is also employed in the ultra-high-frequency wattmeter. The difference in the

(*Continued on page* 48)

IRE WINTER CONFERENCE

(*Continued from page* 47)

two instruments, according to Dr. Brown, lies in the method of coupling the thermocouples to the transmission line. The thermocouples used in this instrument, explained Dr. Brown, had a maximum allowable meter current of one ampere. This, said Dr. Brown, allowed the use of a heater resistance so low that the thermocouple placed across a concentric transmission line became a very effective short circuit. The thermocouples in this instrument were mounted in a specially bored brass block in which the necessary transmission lines terminated so that as much lead inductance as possible was eliminated, explained Dr. Brown. This mounting, he continued, as well as a shielded case around the meter, was used to eliminate undesirable radio frequency currents which might endanger the junction of the couples. A low power oscillator having but 50 watts can be used to make a preliminary calibration of this instrument.

U-H-F Wattmeter Tests

This ultra-high-frequency wattmeter, after preliminary adjustments, was tested with a 1,000 watt frequency modulation transmitter operating on 44.9 megacycles. The calibration was checked against a flowmeter operating on a water-cooled resistor, explained Dr. Brown. There was a small error with reactive loads which was corrected by adjusting the length of the line Y between the points T and V, said Dr. Brown. Phase shift in this line should be 90°, he said. The terminating impedance was made very nearly equal to the characteristic impedance of line Y so that the phase shift would be close to linear with the length, continued Dr. Brown.

Since the operation of the wattmeter depends upon the properties of quarter and half-wave transmission lines, said Dr. Brown, the instrument is inherently a single frequency device. Tests made with frequencies between 40 and 50 megacycles, said Dr. Brown, show that the instrument develops errors of 5% when the carrier frequency is more than .5 megacycle away from the calibrating frequency.

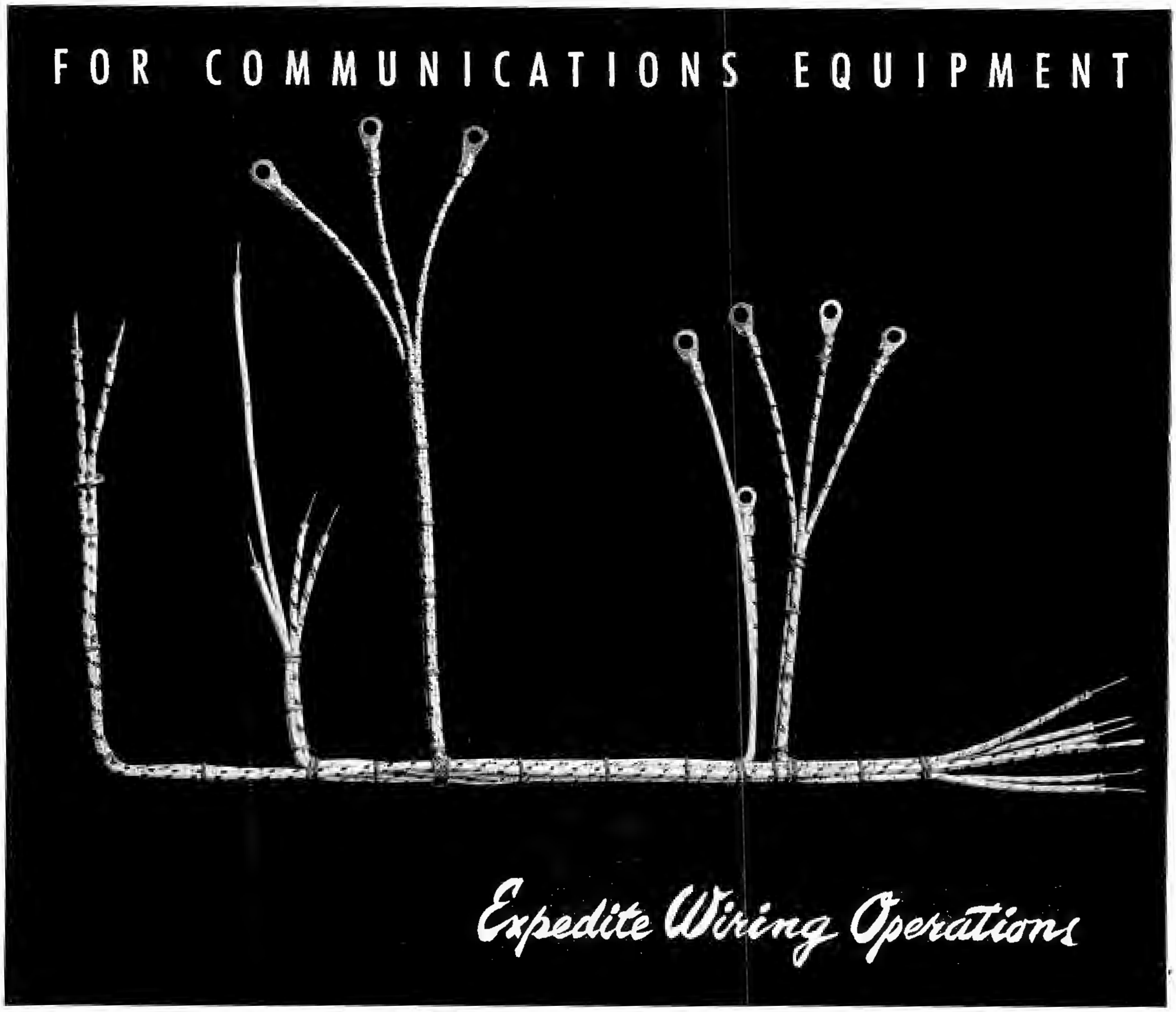
This invaluable instrument should find many applications not only for transmitter measurement service but also for development and laboratory work. Undoubtedly it will become an important measurement standard for broadcast service.

ELECTROMECHANICAL CALCULATOR

For the rapid solution of directional antenna patterns, Carl E. Smith, chief

(*Continued on page* 64)

LACED WIRING HARNESS



A sure cure for wiring "headaches." Constructed entirely of wires with approved types of color coded insulation, assembled exactly in accordance with your specifications, Lenz Laced Wiring Harnesses will speed up your wiring operations and permit the release of some of your labor to other assembly tasks.

Make the Lenz organization a part of your factory. A Lenz Wire engineer will be glad to consult with you on your requirements. Quotations will be gladly furnished on receipt of specifications and sketch.

IN BUSINESS SINCE 1904

LENZ ELECTRIC MANUFACTURING CO.

1751 NORTH WESTERN AVENUE • CHICAGO, ILLINOIS

R-F TRANSMISSION LINES

(*Continued from page 28*)

$$R_M R_m = R_0^2 \tag{43}$$

whence

$$P = \frac{V_M V_m}{R_0} \tag{44}$$

Thus to find the power to a load, we need only to know the two voltages V_M and V_m. Their product divided by R_0 is the power sought.

Example 2. Stub Matcher: Find the location and length of stub to match a load to a line.

Referring to Figure 8, we see that in general the curve R_p crosses the R_0 line. We first wish to find the distance from R_m to this point. Thus we set $R_p = R_0$ and solve for s′ which will be the distance desired. Letting the value of s′ be S, we have

$$R_0 = \frac{1 + K^2 - 2K\cos 2\beta S}{1 - K^2} = R_0 \tag{45}$$

which yields

$$\cos 2\beta S = K \tag{46}$$

or

$$S = \frac{\cos^{-1} K}{180} \times \frac{\lambda}{4} \tag{47}$$

At this position, we will now resonate X_p with a short-circuited section of line placed in parallel with the line. If this line section has the same R_0 as the main line, we may write

$$X_p = R_0 \left[\frac{1 + K^2 - 2K\cos 2\beta S}{2K \sin 2\beta S} \right] = R_0 \tan \beta l \tag{48}$$

where l is the unknown length of the stub. We know from the above that $\cos 2\beta S = K$, and from trigonometry we have $\sin 2\beta S = \sqrt{1 - K^2}$. Then equation (48) reduces to

$$\tan \beta l = \frac{1 - K^2}{2K\sqrt{1 - K^2}} = \sqrt{\frac{1 - K^2}{4K^2}} = \frac{\sqrt{q}}{q - 1} \tag{49}$$

The second of these expressions is easier to use in computations. With its aid, we get

$$l = \frac{\tan^{-1} \sqrt{q}/q-1}{90} \times \frac{\lambda}{4} \tag{50}$$

Equations (47) and (50) have been computed and the results are shown in Figure 10. If S is taken towards the load from R_m, the value of X_p is capacitive, so the stub should be inductive, and should have the value shown in Figure 10. If S is taken towards the source from R_m, then X_p is inductive and the stub should be capacitive. In this case,

(*Continued on page 52*)

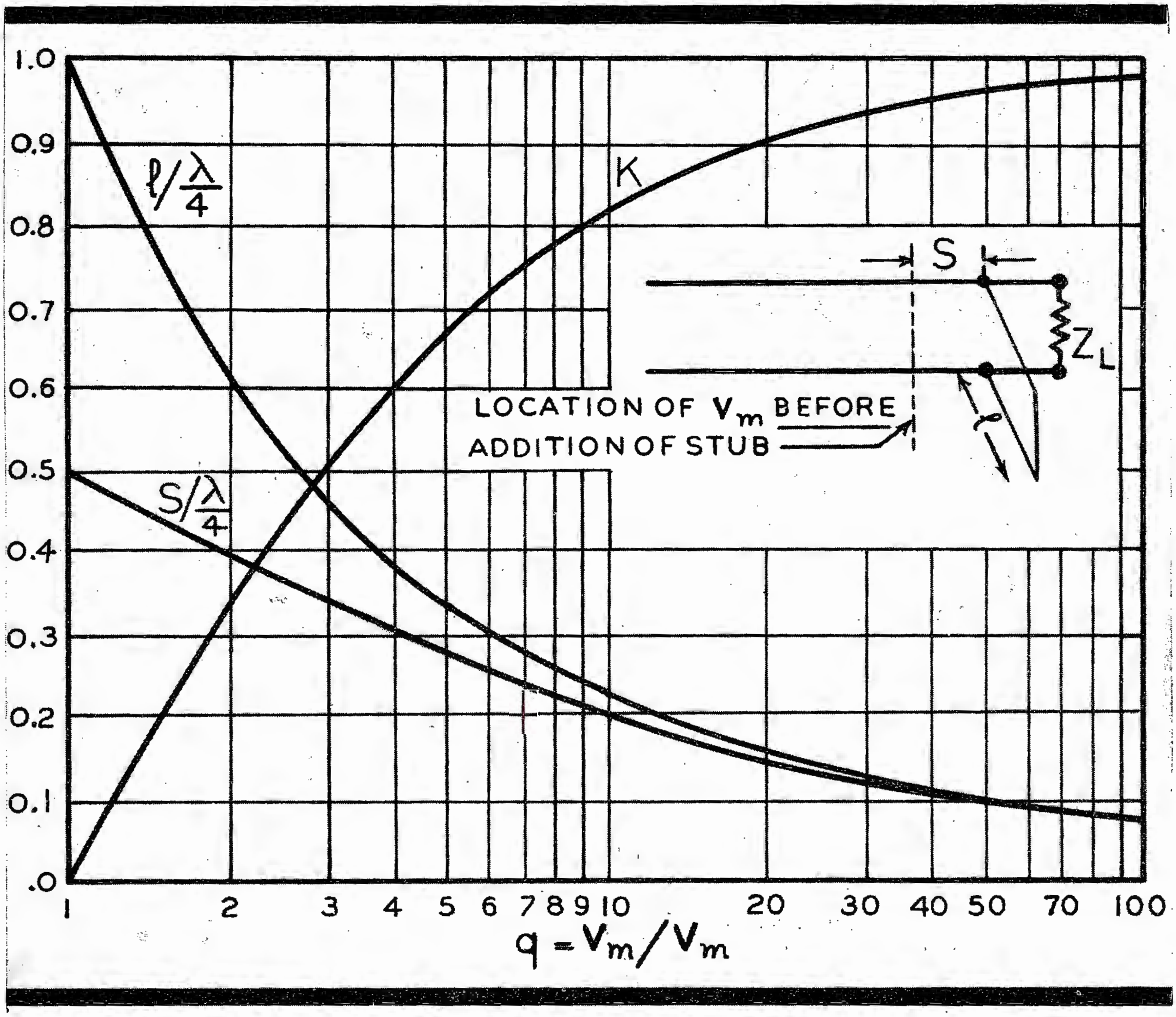


Figure 10
Length and position of a matching stub in terms of the standing-wave ratio. S is the location of the stub, measured from the voltage minimum towards the load; l is the length of the short-circuited stub, provided it has the same R as the line. If properly interpreted, the curves can be used with the other stub location also.

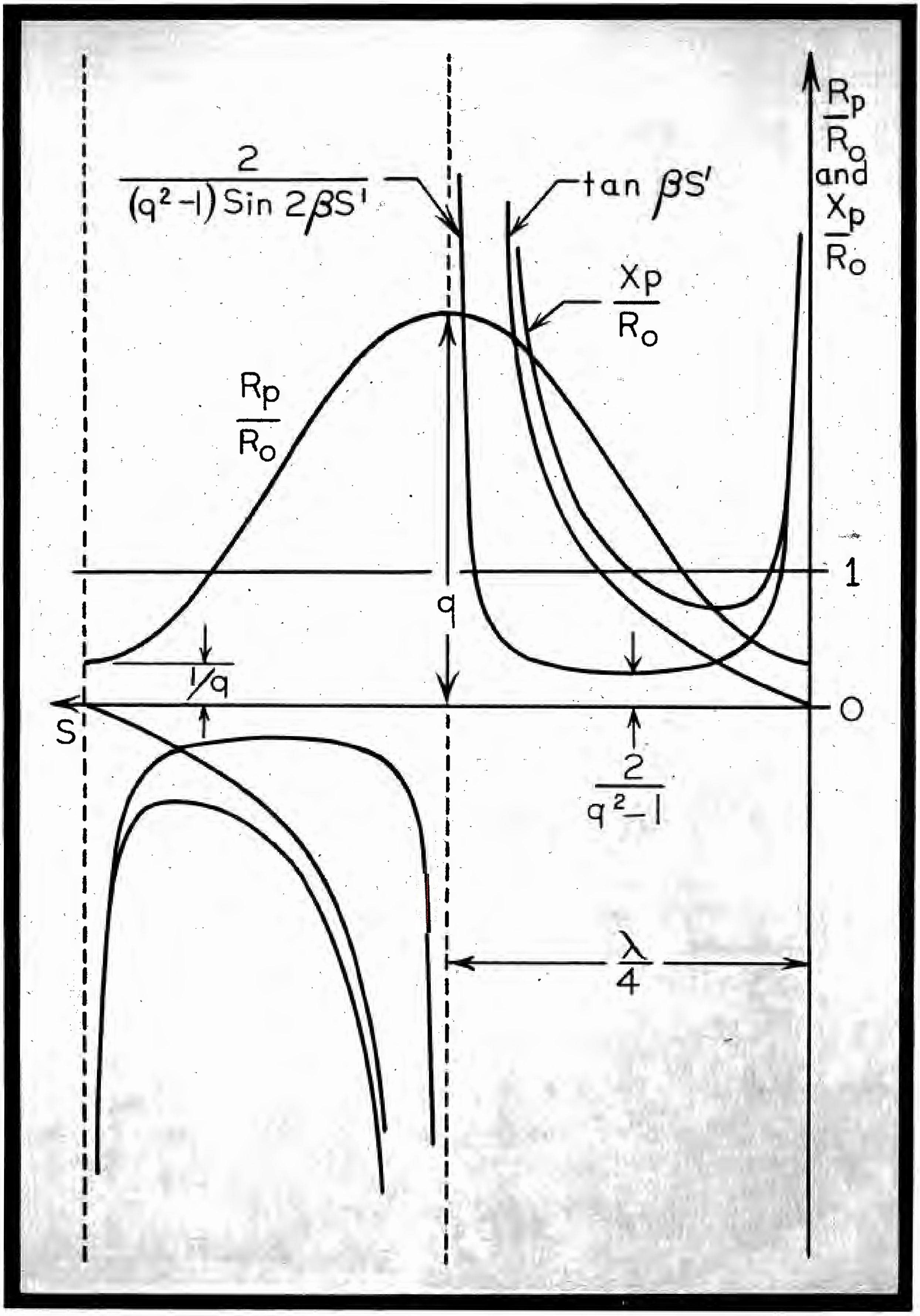
"UNITED" skills operating within this organization are devoted exclusively to the designing and manufacturing of electronic power tubes. This intensive degree of specialization is reflected in tubes achieving an amazing record of performance through the gruelling punishments of war.

"UNITED" skills, cooperating hand in hand in this plant, include eminent engineers recognized by the industry as pioneers in development of electronics. On the grounds of priceless, time-tested experience alone, the products of these pioneers inspire confidence.

"UNITED" skills in electronics may be identified by the name "United" on each tube. Look for it when peace permits the enlarged use of electronic power tubes for radio, industrial and an ever-growing number of applications.

UNITED ELECTRONICS COMPANY • NEWARK, N. J.

UNITED *Skills in* ELECTRONICS



(*Continued from page* 50)

l is the length by which the stub falls short of a half wavelength.

This example has, of course, used some equations in its solution. However, at all times, we had a simple physical picture of reactances and resistances in parallel.

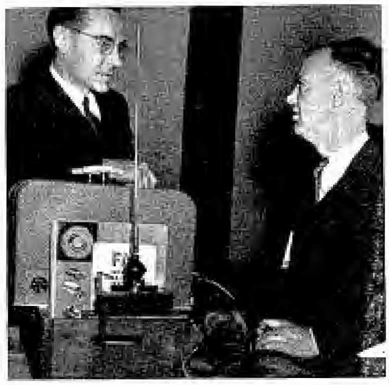
Figure 11
The variation of R_p and X_p with distance along the line towards the generator from the virtual load. The tangent and secant components of the reactance curve are shown.

NEWS BRIEFS

(*Continued from page* 41)

RESERVE POOL DISCUSSED

D. L. Chestnut of General Electric discussed the WPB radio reserve pool, recently at the New Jersey section of the International Municipal Signal Association. A new two-way f-m emergency unit, being manufactured for this pool, was exhibited.



W. E. Dunleavy (right), deputy fire chief, Belleville, N. J., and D. L. Chestnut

* * *

FOURTH EDITION OF DI-ACRO CATALOG

A revised 36 page edition of the Di-Acro catalog has been published by O'Neil-Irwin Manufacturing Company, Minneapolis, Minn.

Included are an improved Di-Acro shear and an improved and revamped Di-Acro brake.

An entirely new model is also shown. It is the Di-Acro shear No. 3, of 12 inch, in a maximum material thickness of approximately 22 gauge cold rolled steel sheet or heavier materials in narrower widths or of greater ductility. All bearing surfaces of this new shear are adjustable for wear and alignment and rifle drilled to provide lubrication to all bearing surfaces.

* * *

JOBBERS HAVE VITAL WARTIME JOB, SAYS GOLENPAUL

There's a wartime job for every parts jobber provided *he goes after that job*, said Charles Golenpaul, jobber sales manager for Aerovox Corporation, recently in a report. This statement was based on a review of reports Mr. Golenpaul received from jobbers throughout the nation. The reports indicated, according to Mr. Golenpaul, that existing stocks should be made available to Government agencies. Complete inventories should be submitted with selling prices. Wonderful cooperation has been forthcoming from jobbers in this connection. Weeks and months have been saved in the most crucial days of our war efforts, before factories could swing into production. Most jobbers freeze merchandise deemed essential to the war effort, even at the sacrifice of immediate turnover and taking care of civilian needs.

The contacting of wartime activities, in the local territory . . . training camps, posts, fortifications, bases; university, college and training schools; research and engineering groups; local radio and electronic equipment manufacturers and sub-contractors, and other war workers is also an important step, according to Mr. Golenpaul. The jobber's stock is of tremendous importance in providing perhaps small quantities but certainly *large varieties* of needed components, particularly for experimental assemblies and models that must precede actual production, and for urgent maintenance.

Many jobbers have been found functioning as radio and electronic manpower recruiting agencies, unofficially, but nevertheless very helpful, said Mr. Golenpaul. Jobbers know the local Service Men, experimenters, amateurs and other radio workers. The jobber can supply information to radio workers as to wartime opportunities. Names can be sent to the proper authorities seeking specialized manpower.

In addition, said Mr. Golenpaul, the jobber has been providing much needed engineering service to local manufacturers, sub-contractors, engineers, research workers and others. In most instances the circuits and problems are highly confidential. Data cannot be taken out of given premises. Having access to such data, the jobber can suggest parts and substitutions, helping convert ideas into working models and even production efforts.

* * *

DU MONT CATHODE-RAY TUBES RE-NUMBERED

To provide standardization of cathode-ray tube types, Du Mont have given all of their tubes the RMA type numbers. These changes are explained in a four-page folder just released by Du Mont. Copies of the folder (Vol. 5, No. 10) are available for the asking.

* * *

R. F. FIELD EXPLAINS DIELECTRIC BEHAVIOR TO RADIO CLUB

At a recent meeting of the Radio Club of America, Robert F. Field, engineer for the General Electric Company, discussed the behavior of dielectrics over wide ranges of frequency and temperature.

He showed that two types of polarization, the dipole and interfacial, are responsible for the changes of dielectric constant and loss factor. These polarizations, he said, are defined by three parameters whose values are found either from plots of loss factor against dielectric constant or by a graphical analysis of the current-time curves of the dielectric.

* * *

CORNING GLASS PERFECTS NEW GLASS FABRICATING PROCESS

A new method of fabricating glass pieces known as the "Multiform Process" has been announced by the Corning Glass Works, Corning, New York. This new process is particularly applicable to the manufacture of coil forms, tube sockets, coaxial line beads and many other parts that require precision production.

The process differs from the older process by using a combination of cold-molding batch materials with subsequent fusing to provide grooves, threads, shapes and perforations, that cannot be obtained by the hot-molding process. The resultant product is still glass resembling, however, articles made by the conventional pressing, drawing, or hot-blowing processes.

Four basic types of glass are being used at present in this new process. Featured characteristics of this glass are low dielectric loss, low thermal expansion, etc.

* * *

CANNON "A N" CONNECTOR BULLETIN

A new and revised type 82-page electrical connector bulletin has just been issued by the Cannon Electrical Development Company, 3209 Humboldt Street, Los Angeles, Calif. This new bulletin is well illustrated and contains, in addition to the type A N general information and tabular matter, pages on junction shells, A N cable clamps, dust caps, dummy or stowage receptacles, and Cannon bonding rings. The Cannon catalog condensed supplement is also included in a separate section. A total of 167 insert arrangements with wire data are also included.

* * *

STAFF CHANGES ANNOUNCED BY CANADIAN MARCONI

Ralph Letts has been appointed manager, Engineering Services of Canadian Marconi.

Eric Farmer will serve as assistant and M. J. Mercier as chief draughtsman.

F. A. Barrow assumes the positions of manager of the Crystal Laboratory and supervisor of quality control.

* * *

ELECTRONIC LABORATORIES WINS "E"

For excellence in war production, Electronic Laboratories, Inc., Indianapolis, Indiana, has been awarded the Army-Navy "E" award.

* * *

FORMEX MAGNET WIRE BOOKLET

The interesting story of Formex magnet wire appears in a new 28-page booklet, just released by the General Electric Company, Schenectady, New York.

Data covered in this booklet, include properties, types available, applications, and gage tables.

For a copy, simply address the company, and ask for GEA-3911.

* * *

GOTHARD ISSUES PILOT LIGHT ASSEMBLY LEAFLET

A variety of pilot light assemblies are described and illustrated in a four-page leaflet, released by the Gothard Manufacturing Company, 1300 North Ninth Street, Springfield, Illinois.

* * *

REFERENCE BOOK AND BUYERS' GUIDE

An attractive buyer's guide listing thousands of radio and electronic items is now available from Terminal Radio Company, 85 Cortlandt Street, New York City; Walker-Jimieson, Inc., 311 South Western Avenue, Chicago, Ill., or Radio Specialties Company, 20th and Figueroa Streets, Los Angeles, California.

* * *

N. U. APPOINTS ED DE NIKE TO PUBLIC RELATIONS POST

Ed DeNike has been named public relations director of National Union Radio Corp., Newark, N. J.

Mr. DeNike was formerly advertiisng manager of National Union from 1931 to 1940, at which time he left to become district sales manager at Geneva, New York.

* * *

A. H. REIBER, DEAD

Albert H. Reiber, vice president in charge of development and research for the Teletype Corporation of Chicago, died recently.

Mr. Reiber was employed as a development engineer in the Western Union Telegraph Company from 1916 to 1920, and in sales and engineering work in the Kleinschmidt Electric Company of Long Island City from 1920 to 1925 when this company was merged to form the Morkrum-Kleinschmidt Corporation of Chicago.

* * *

ARMY-NAVY "E" TO THERMADOR ELECTRIC

The "E" pennant has been won by the Thermador Electric Manufacturing Company, Los Angeles, California.

* * *

McCANNE ELECTED S-M CLUB CHAIRMAN

Lee McCanne, secretary and assistant general manager of Stromberg-Carlson Telephone Mfg. Co., Rochester, New York, has been elected chairman of the Sales Managers' Club of the Rochester Chamber of Commerce. He was also elected vice presi-

(*Continued on page* 58)

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INDUCTANCE OF TWO PARALLEL WIRES

(Reprinted by Request)

(*See page* 36)

by T. S. E. THOMAS

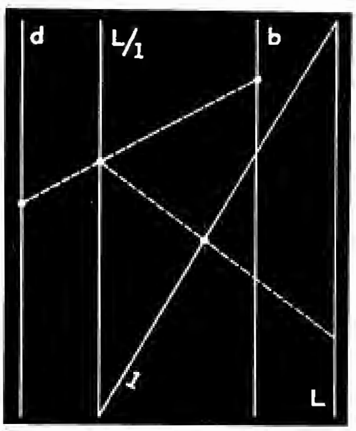
IN radio-frequency engineering it is sometimes necessary to know the inductance of a pair of parallel leads such as the feeder to an aerial or the connections to a condenser or inductance coil.

The high-frequency inductance of two parallel wires is given by

$L = 0.004\, l \log_e 2b/d$ microhenry

where l is the length, d the diameter (circular section) and b the distance between centers, all dimensions being in centimeters. The formula does not take into account the effect of the end connections and it also becomes inaccurate when the wires are almost in contact.

The method of using this nomogram (page 36) is shown in diagram below. There are two alignments . . . the first gives the relation between L/l, l and d; the second, the relation between L, l and L/l.



dent of the Rochester Electrical Association.

* * *

KEN GARDNER PRESENTS F-M PAPER

Ken Gardner, chief engineer of WHAM and W51R, recently discussed the results of extensive transmission field tests made at W51R, and other f-m operating problems before the Engineering Society, at the Sagamore Hotel, Rochester, N. Y.

* * *

CAPLAN JOINS IRVINGTON VARNISH

S. Caplan, who for the past nine years has been associated as research chemist with the Harvel Research Corporation, has become the research manager and acting technical director of the Irvington Varnish and Insulator Company, Irvington, N. J.

Mr. Caplan succeeds C. F. Hanson, who has been appointed chief consulting engineer.

* * *

JUDSON C. BURNS DIES AT 72

Judson C. Burns, pioneer G. E. electric appliance distributor, died recently of a heart ailment after a short illness. He had been in appliance business in Philadelphia since 1910.

* * *

ELECTRONIC CORPORATION MOVES

The Electronic Corporation of America, formerly Transformer Corporation of America, has moved its offices and plant to 45 West 18th Street, New York City.

* * *

G. E. PROMOTES KENNY AND BRADLEY

W. G. Bradley has been appointed assistant to the auditor, and K. E. Kenny has been named accountant of the transmitter division, at General Electric in Schenectady, N. Y.

Mr. Bradley has been a G. E. employee for 12 years. A native of Asheville, N. C., he was graduated in 1930 from the University of Maryland and in that year joined the General Electric appliance and merchandise department in its accounting section at Bridgeport, Conn.

Mr. Kenny graduated from Franklin College in 1927, and joined G. E. upon graduation.

* * *

JORDAN JOINS I. T. & T.

Arthur C. Jordan, formerly sales manager of Garrett, Miller and Company, Wilmington, Delaware, a Philco distributor, has joined the selenium rectifier division of Federal Telephone and Radio Corporation, 1000 Passaic Avenue, East Newark, in the Commercial Engineering Department.

* * *

DR. A. W. HULL NEW PHYSICAL SOCIETY PRESIDENT

Dr. Albert W. Hull, assistant director of the General Electric Research Laboratory, was elected president of the American Physical Society at its recent meeting in New York. The society, which numbers about 4,000 members, includes the nation's physicists, as well as scientists working in allied fields.

Dr. Hull received the Morris Liebmann prize in 1930 for his work on vacuum tubes. Many types of electronic tubes, some of which have important war uses, are credited to Dr. Hull. The magnetron, dynatron and screened-grid tube for r-f amplification were among his developments.

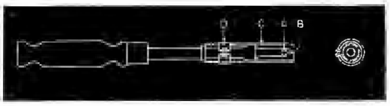
* * *

SIMPLIFIES SMALL WIRE SOLDERING

The job of soldering small wire connections has been simplified at G. E. by making the iron stationary and dipping the connections into a small hole filled with solder near the tip of the iron.

As shown by the drawing, the soldering iron can be fixed for use in this manner by drilling a hole (A) into the tip (B). A nickel steel tip will last longer than other types.

The drip and splash guard (C) catches surplus or drips of solder coming off the iron. It is made of 1/32-inch steel and is fastened to the iron with a hose clamp (D).



* * *

AKEROYD NOW IN RAYTHEON SPECIAL EQUIPMENT DIVISION

A. E. Akeroyd, manager of replacement sales, Raytheon Production Corporation, Newton, Massachusetts, has been assigned to special work in the electrical equipment division of the Raytheon Manufacturing Company, Waltham, Massachusetts.

It is expected that this special assignment will result in a full time application of Mr. Akeroyd's efforts at Waltham, and, therefore, R. O. Lund has been transferred from the Raytheon warehouse and office at Chicago to Newton to take on the replacement sale assignment.

* * *

BATTERY ORDER AMENDED

An amendment to battery limitation order L-71 was made recently. The continuation of present production of radio and hearing-aid batteries is authorized, but the production of flash-light and other dry cell batteries has been cut. Flash-light cells are cut to about 35% of 1940 production.

* * *

BATTERY CONSERVATION BULLETIN

Batteries for farm radios are vital. The Consumers Durable Good Division has thus issued a bulletin to advise consumers regarding conservation of radio batteries. The bulletin known as WPB-2332, contains interesting data, and should be studied.

* * *

MORELAND NOW WESTINGHOUSE X-RAY PRODUCTS MANAGER

Henry D. Moreland, since 1938, x-ray division manager at Portland, Ore., has been advanced to the position of manager of the x-ray products, agency and specialties department of the Westinghouse Electric & Manufacturing Company, Baltimore, Maryland.

* * *

SYLVANIA ISSUES FIFTH EDITION OF MANUAL

The 5th edition of the Sylvania Technical Manual is now ready for distribution.

One section of the Technical Manual has been devoted to listing all new types of tubes released since the previous issue, and a section pertaining to panel lamps has also been added.

* * *

LEWIS NOW IN OWI PRODUCTION BRANCH

William B. Lewis, chief of the Domestic Radio Bureau of the Office of War Information, has been named an assistant director of the Domestic Branch, in charge of plans and production.

To assist him in the planning function, the Bureau of Campaigns will become a division in Mr. Lewis' office with Drew Dudley as chief. Mr. Dudley has been assistant chief of the Campaigns Bureau.

James Allen continues as assistant director of the Domestic Branch of OWI with full authority under Mr. Cowles except for the duties specifically assigned to Mr. Lewis.

* * *

FORMICA WINS "E"

The Formica Insulator Company, 4620 Spring Grove Avenue, Cincinnati, Ohio, has been awarded the Army-Navy "E" pennant.

The pennant was presented to D. J. O'Connor, president of Formica by Colonel Alonzo M. Drake, Army Air Force Central Director Procurement Supervisor.

Also present at the ceremonies were W. J. Donald, executive director of the National Electrical Manufacturers' Association; Commander B. H. Bowman, Navy Department Inspector, and Russel Wilson, former Mayor of Cincinnati, and present Councilman.

* * *

GOULD-MOODY OFFERS FREE ANALYSIS SERVICE ON WPB RULINGS

To assist broadcast stations, commercial recording studios, and others interested in assistance on WPB limitation, priority, etc., rulings, The Gould-Moody Company, 395 Broadway, New York City, now offers the services of their legal department to explain and clarify such rulings. This assistance is available gratis to all recognized companies provided that they specifically set forth the questions to be answered on their official letterhead.

* * *

CINAUDAGRAPH CORPORATION WINS "E"

The Army-Navy Production Award has been awarded to the Cinaudagraph Corporation, Stamford, Connecticut. Sherman R. Hoyt, president of Cinaudagraph, received the award from Captain F. D. Woods, U. S. Army Air Corps.

* * *

AT THE STROMBERG CARLSON "E" AWARD

Left to right, Lee McCanne, assistant general manager; Major William L. G. Winter, telephone plant division of the Signal Corps; Dr. Ray H. Manson, and Bishop James E. Kearny.

NOTICE

Inductions into the armed forces and demands of war production industries have created shortages of labor necessary in the printing, handling and mailing of publications.

If your monthly copy of COMMUNICATIONS should be late in reaching you — remember that the delay is due to war conditions and the war effort must come first.

Please bear with us.

Thank You!

HAZELTINE CHANGES NAME

The name of the Hazeltine Service Corporation has been changed to Hazeltine Electronics Corporation, according to an announcement by W. A. MacDonald, president. This step follows the completion of a program of plant expansion providing additional facilities for electronics research and development.

* * *

I. R. BAKER DEAD

Irvin Ray Baker, former head of the broadcast transmitter sales division of RCA and recently engaged in electronic developments at RCA, died suddenly while at work on February 9th.

* * *

AMERICAN CORPORATION OF SCOPHONY TELEVISION FORMED

The patent rights of Scophony, Ltd. of London have been purchased by a newly formed group in America, the Scophony Corporation of America. Head of the new corporation is Arthur Levey. Affiliated with the company is the General Precision Equipment Corporation (formerly General Theatres Equipment Corporation) and Television Productions Inc., a subsidiary of Paramount Pictures. The five directors of the company are . . . Joseph E. Swan, a partner in E. F. Hutton and Company; Franklin Field, director of Piper Aircraft Company; Paul Raibourn, president of Television Productions Inc.; Earle G. Hines, president of General Precision Equipment Corporation, and Mr. Levey.

* * *

FANSTEEL ELECTRICAL CONTACT MANUAL

A 36-page manual containing vital data on contacts and contact materials has been published by the Fansteel Metallurgical Corporation, North Chicago, Ill.

Charts, tables and other valuable information on alloys, rivets, contact disks, screws, bimetals, etc., are included in this new guide.

Copies are free for the asking.

* * *

NELSON AWARDED MEDAL

Donald M. Nelson of WPB at the exhibit of International Resistance Company, prior to receiving the Poor Richard Gold Medal of Achievement at the banquet tendered to him in Philadelphia.

VWOA NEWS

(*Continued from page* 44)

nel director of RCA Communications, also made a life member; J. O. Smith, one of the first amateurs; Guy R. Entwistle, president, Massachusetts Radio and Telegraph School, who received his life member certificate at the Boston Dinner on February 6th of this year; Francis C. W. Lazenby, now Warrant Electrician USNR, a pioneer of 20 years standing; Charles D. Guthrie, one of the first official radio inspectors in the United States Government Service, and an officer and director of the association for many years.

Others in Attendance

Also in attendance were: F. A. Kolster, inventor of the modern direction finder; George Lewis, of I. T. & T.; "Johnny" Johnstone of the Blue Network, who used to be famous for the fact that he was VWOA's only piano player (he is today a life member); Dave Driscoll, in charge of special events for WOR-Mutual, and Tom Slater; Jack Popelle, chairman of the scholarship committee, secretary and chief engineer of WOR-Mutual, who announced at the dinner that we are awarding scholarships to the top ranking girls in the WAVES, WAACS and the SPARS; A. J. Costigan, traffic manager, Radiomarine Corporation; C. S. Anderson, editor of the Year-book, who has done a splendid job, even more extensive than usual; George H. Clark, VWOA's secretary; George W. Bailey, our special Washington representative, to whom all credit is due for the success of this dinner; F. P. Guthrie, who also is a Washington representative and is chairman of the Washington Chapter of VWOA; T. R. McElroy, the world's champion and outstanding telegraphist, who unveiled his "chart of all charts," including every known code, the Arabic, Russian, International Morse, American Morse, Japanese, Spanish, Flag Signals, "Q" Signals, "Z" Signals, and all others; John Cose, superintendent, RCA Institutes, New York, who has done a swell job in educating our scholarship students under the Marconi Memorial Scholarship Plan; Haraden Pratt, vice-president and chief engineer of the Mackay Radio Telegraph Company; W. S. Fitzpatrick of Radiomarine, one of the real pioneers in the wireless operating art, and one of the founders of the association (he gave ye prexy his first job as a wireless operator); J. B. Duffy, assistant traffic manager, Radiomarine Corporation of

America; O. B. Hansen, vice-president and chief engineer of the National Broadcasting Company, and Charles W. Horn, NBC director of development.

Benjamin F. Miessner, whose first invention was the cat-whisker detector and who later has become one of the foremost inventors in the radio art, was also present, along with John V. L. Hogan; Arthur Van Dyck, executive engineer, RCA Patent Department, and past president of the Institute of Radio Engineers; H. J. Scroll, vice president, New York Telephone Company; Colonel Bender, Signal Officer, Second Corps Area; Major Moody, in charge of communications, Second Corps Area, Governors Island, N. Y.; Gerald F. J. Tyne, Bell Laboratories, a well-known collector of data on the vacuum tube; Stuart Ballantine, of the Ballantine Research Laboratories, Boonton, N. J., who did yeoman work for Uncle Sam in the last war in the development of the radio compass; Elmer Bucher, whom everyone knows as the author of Practical Wireless Telegraphy and other books; T. D. Haubner, the man who first used the signal S O S as a distress signal; "Bill" Dubilier, who made the mica condenser possible, and Carl Dreher.

Lieut. Commander W. A. Eaton, formerly Officer-in-Charge of the Radio Test Shop, Washington Navy Yard, was at the dinner, too. And others present were: R. H. Frey, one of VWOA's best loved members, who handles radio for A. H. Bull and Company; Colonel Moore, Signal Officer of the First Army; Colonel Schute of the Western Union; Frank Hinners, an old timer of the previous war, now with the Hazeltine Corporation; Larry Horle; Paul Trautwein; R. M. Keator, who supplied motor generators from the Crocker Wheeler Company when the Navy needed them badly in 1917; T. E. Niverson, general superintendent, Mackay Radio Telegraph Company; E. K. Cohan, technical director, Columbia Broadcasting System; Roger B. Lum, an announcer of note in the early days of broadcasting and now in business for himself; J. V. Maresca, our first secretary; J. F. J. Maher, one of our first presidents; George Crouse, who built radio sets for the Sperry Company in the previous war and should be building them now, and all our directors.

An inspiring message was read from our honorary president, Dr. Lee deForest, stressing the devotion of the radio operators in all branches of the military service and the merchant marine in the present war.

Undoubtedly this dinner-cruise was one of the most unusual we have ever had. And next year we will try and top it.

BOOK TALK . . .

(*Continued from page* 42)

and we can rely on the fact that the high selectivity of the receiver will accentuate it, thus making it very strong."

In the appendix to this paper appears an analysis of phase modulation produced by heterodyne; Appleton and Boohariwalla's explanation of de-modulation, and the production of phase modulation from amplitude modulated waves.

Dr. Robinson, in 1931, talked on the stenode system before the Radio Club of America. This presentation contains an elaboration of his presentation and includes many new and unusual applications of the system.—*A. L.*

• • •

ELEMENTS OF RADIO

By A. Marcus and William Marcus, prepared under the editorship of Ralph E. Horton. . . . 700 pp. . . . New York: Prentice-Hall, Inc. . . . $4.00.

For the real beginner, this is an appropriate text. An exceptionally lucid presentation of all of the fundamentals, without the use of mathematics is provided. Suitable summaries, questions and glossaries supplement forty-two chapters.—O. R.

IRE WINTER CONFERENCE

(*Continued from page* 48)

engineer of Stations WHK and WCLE, and Edward L. Gove, formerly with the same stations, devised an electromechanical calculator. This device was described by Mr. Smith during a special radio engineering morning session that followed the one-day conference.

In this device, after the desired antenna parameters have been set up, the field intensity curve is automatically drawn to any desired scale on a sheet of polar co-ordinate paper. It indicates the rms value for drawing a circle of the equivalent non-directional pattern.

Any number of antennas can be used in the directional array with this calculator. As the number of antennas is increased, the greater the degree of control is possible to mold the radiation pattern into the desired shape. Not only is it possible to obtain the horizontal directional field-intensity pattern, but also the field-intensity contours at any elevation angle with this instrument. It is possible to select the vertical radiation characteristics of several antennas at will, thus making it possible to explore the solid contour surface of the whole hemisphere in a relatively short time. It is also possible in this way to determine the total power radiated from the directional-antenna system. And, in addition, it is also possible, with this instrument, to calculate the solid contour surface of the radiation pattern from a parallel horizontal antenna array.

These calculators have been put into operation at the transmitting plant of WHK-WCLE to automatically draw the horizontal pattern of a four-element array.

POWER CIRCUITS AND RADIO RECEPTION

Since electrical power apparatus and allied circuits may under certain circumstances influence radio reception, many manufacturers and power companies have been cooperating for several years on a control of this influence. Measurement equipment and methods have been established. The results of practical experience with standard equipment and methods for the measurement of such radio influence factors were discussed in a paper by C. M. Foust and C. W. Frick of the general engineering laboratory of General Electric Company, as the second paper in the morning session succeeding the I R E Conference.

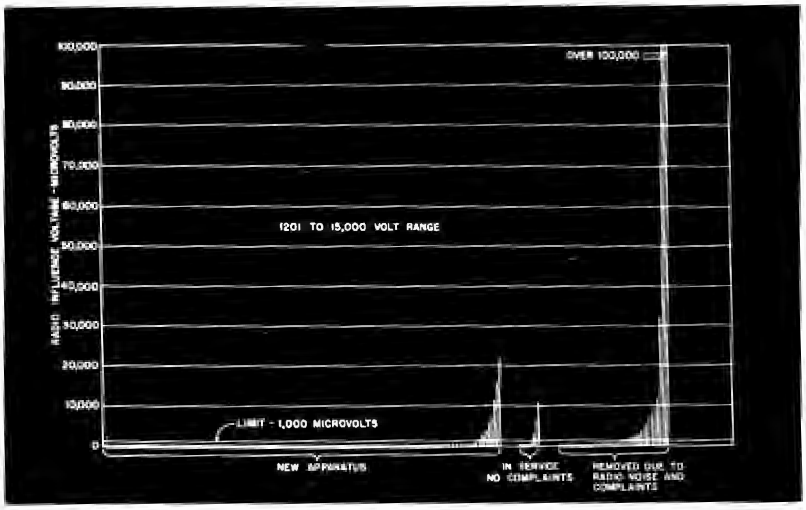


Figure 9

Summary chart of radio influence voltage data on high voltage apparatus. Each vertical line or dot represents five tests. These data were obtained by Foust and Frick in their study of power circuits and radio reception.
(*Courtesy AIEE*)

Eight Important Factors

There are eight factors to be considered in the problem of measurements of radio influence factors. The first involves the design, construction and calibration of instruments suitable for the measurement of the electrical characteristics of radio influence phenomenon. The second covers the measurement of radio influence characteristics of power apparatus of all types to indicate the relative influence possibilities when placed in service. In the third step we are concerned with the measurement of radio influence voltage on power lines to establish a relationship between the value existing on the line and the measured characteristics of the apparatus connected to it. The fourth factor concerns the measurement of radio influence voltage under the power line to establish the relationship between the radio influence voltage at some standard position adjacent to the line, but not connected to it and, in addition, the radio influence voltage on the line, as indicated in factor three. In the fifth point, we are concerned with the measurement of radio noise voltage on the receiver antenna to determine the relationship between its value and the radio influence voltage measured at the standard position under the power line established in factor four. Step six concerns the measurement of the susceptibility of the radio receivers and antennas to extra noise influence. In factor seven we are concerned with the determination of limiting values for the ratio of signal-to-noise for good reception and in factor eight it is necessary to establish the determination of limiting program signal strengths on which to base a criterion of good reception.

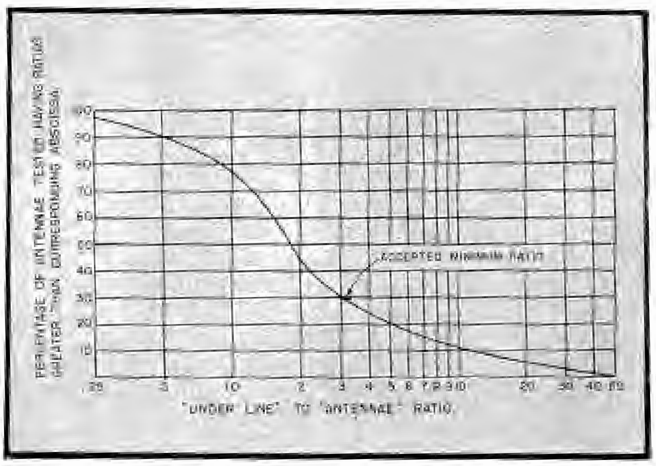


Figure 10

Under line to antenna radio influence voltage ratios, plotted by Foust and Frick in the power circuit survey.
(*Courtesy AIEE*)

Methods whereby these factors were determined were carefully explained. For instance, in the radio influence voltage of apparatus discussion, three voltage ranges were found to be fundamental factors of consideration. Some 950 individual tests were involved in plotting the results in the 1,201 to 15,000 volt range. In the 15,001 to 37,000 volt range 130 tests were necessary and in

(*Continued on page* 73)

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THE INDUSTRY OFFERS . . . — . . . — . . . —

CRAMER TIME DELAY RELAY

A new time delay relay designed to furnish maximum protection to vacuum tube equipment under unusual and difficult operating conditions has been developed by The R. W. Cramer Company, Inc., of Centerbrook, Connecticut.

Basically, the relay (type TD4), consists of a synchronous motor-driven timer which delivers an accurately measured but completely adjustable time delay prior to activation of a switch mechanism. As such, it is ideal for controlling application of plate voltage to mercury vapor rectifiers and other tube equipment.

A heavy steel base plate provided for mounting, is zinc plated. The cover is zinc plated and has a black crackle finish enamel over the zinc. The joint between cover and base plate is sealed by a compressible gasket. The entrance for control cables is sealed by a special grommet and by a sealing compound.

The entire mechanism is, therefore, protected against dust, moisture and air, with intent to eliminate any possibility of condensation inside the case. The wiring is protected against moisture by protective coating.

The relay provides the customary resetting action of its predecessors so that the full delay period is delivered in cases where circuits are re-energized after power interruptions of considerable duration.

In cases of momentary power failures the standard timer resets completely. This relay, however, is said to hold the time actuated switch in operating position for about 3/10 seconds after all power is cut off. Interruptions of less than 3/10 seconds, however, do not cause resetting of the timer and equipment functions normally with power restoration.

* * *

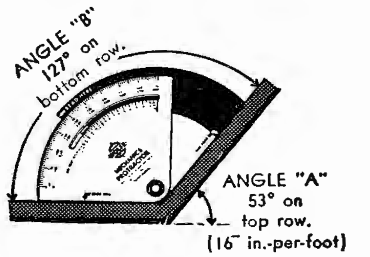
SOLDERLESS WIRE CONNECTORS

Solderless-tapeless screw-on wire connectors produced by Ideal Commutator Dresser Company, Sycamore; General Electric Co., Meriden, Conn.; Weiss & Biheller Mdse. Corp., New York, and Wiremold Company, Hartford, Conn., are said to be appropriate alternates for solder and tape joints. They consist of a cone-shaped spiral spring insert, imbedded in a molded insulation. The joint is made by stripping the wires about ½" and then screwing a "wire-nut" on the stripped ends.

The spring insert presses clean threads into the wires. A molded shell is said to eliminate any possibility of sharp wire ends protruding and piercing through as is common with solder and tape joints. Five sizes are available.

MECHANIC'S PROTRACTOR

A protractor that will measure a variety of angles up to 180° is now being made by the Interstate Sales Company, 1123 Broadway, New York City. Among the advantages that the protractor, known as the Mechanic's Protractor, is said to offer are . . . readings for outside angles, readings for inside (inclusive angles), and inches-per-foot against degrees up to 24" per foot (60° 26"). All of these readings can be taken with one setting. Difficult angles can also be measured with this protractor in conjunction with a bevel. Calibrations are at the extreme of the radius, enabling positive readings to a fraction of a degree.

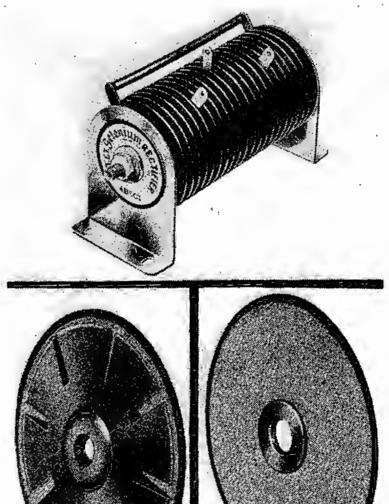


* * *

NEW I. T. & T. SELENIUM RECTIFIER

A new type selenium rectifier has been announced by the Selenium Rectifier Division of the Federal Telephone and Radio Corp. Protection against excessive humidity and moisture conditions, encountered particularly in marine service is provided for in this new unit. The standard petal-shaped brass contact washer and pressure-limiting fibre washer are not used in the assembly. Instead a single metal washer is employed, making it possible to apply the protective coating to all exposed surfaces.

Henry H. Scudder is manager of the selenium division.



RCP MULTITESTER

A multitester, type 419, featuring an a-c d-c voltmeter, milliameter, ammeter, capacitymeter, ohmmeter and inductance meter is now available from Radio City Products Co., Inc., 127 W. 26th St., New York City.

This model has a-c scales that are linear with d-c scales. The sensitivity of the meter is 2,000 ohms per volt, accurate to within 2%. Ohmmeter has self-contained power supply.

Ranges are . . . d-c voltmeter: 0-5-50-250-2,500-5,000 volts. A-c voltmeter: 0-10-100-500-1,000-5,000 volts. D-c milliammeter: 0-1-10-50-250-1,000 ma. D-c ammeter: 0-1-5-25 amps. Capacitymeter: 0-.03-.30-3.0-30-300 mfd. Low ohmmeter: 0-100-15,000-150,000 ohms. Megohmmeter: 0-1.5-15 megohms. Inductance measurements (chart reference): .25-1,000 millihenries; .25-100-1,000-10,000 henries.

Model 419 is available in three types . . . 419P, supplied in a hand rubbed natural finish maple case with cover and carrying handle; model 419C . . . an open face bench type instrument with a 4½" meter and model 519V-7, an upright instrument in a crackle finish steel case with a 7¼" rectangular meter.

* * *

ALLIED KEYING RELAY

A high speed keying and break-in relay for aircraft radio equipment, type AK, has been produced by Allied Control Company, Inc., 227 Fulton Street, New York City.

It has a push-pull magnetic arrangement providing magnetic holding pressure on both transmit and receive contacts. One pole is equipped with two windings, one of which is a holding winding connected directly across the battery supply. The other winding is connected in series with the single winding on the other pole and polarized so that when the circuit is completed through the key, the flux is neutralized on the holding or receive position pole and the armature pulls up to the transmit position. Opening the key cuts off the bucking flux and the holding flux pulls the armature back to receive position.

The arms are equipped with anti-bounce features. It is magnetically held in both

(Continued on page 68)

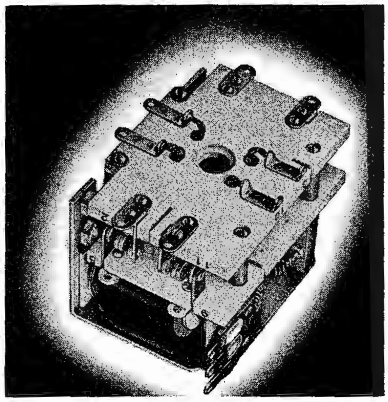
THE INDUSTRY OFFERS . . .

(*Continued from page 66*)

positions and does not rely on back spring pressure. It keys at 20 cycles and has a contact rating of 1,000 volts at 30,000 feet, 20 megacycles. It is insulated to sustain 10,000 volts at sea level, and said to withstand vibratory motion to better than 20 G.

It is of a 4-pole double throw type; has a wattage consumption of 5.5 in first position and 17.0 in second position; available fo- 12 and 24 volts d-c.

Size is 2 7/16x3½x2¼ inches. Weight is 17 ounces.



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EMBY RECTIFIERS

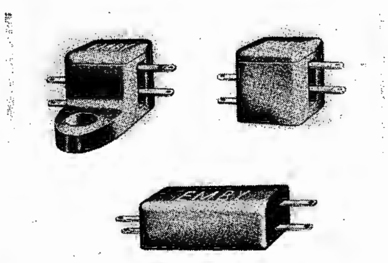
Instrument and relay rectifiers of the selenium type have been produced by the Emby Products Company, Inc., 1804 West Pico Boulevard, Los Angeles, Calif.

They utilize the unipolar conductivity of the metal to selenium junction for rectification purposes.

Eight sizes with output ranging from 8 to 120 milliamperes are available. Due to a special Emby process these rectifiers are said to have been made permanently stable and have unlimited life. They are said to withstand temperatures up to 70° C.

Due to their light weight no additional mounting brackets are necessary and the only assembly operation required is soldering of the terminals.

Series "L" rectifiers are supplied in well insulated metal cases; series "S" in unbreakable molded enclosures.



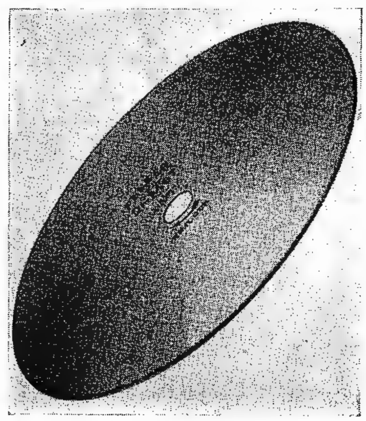
* * *

DI-MET RIMLOCK DIAMOND ABRASIVE WHEELS

Diamond impregnated cut-off wheels, for cutting all hard dense materials such as quartz, ceramics and vitreous products, are now being produced by the Felker Manufacturing Company, Torrance, California.

These wheels, known as Di-Met Rimlocks, are available in three-inch to twenty-four inch diameters, with thicknesses varying from .020" to .064".

Complete details appear in a four page leaflet, which is free for the asking.

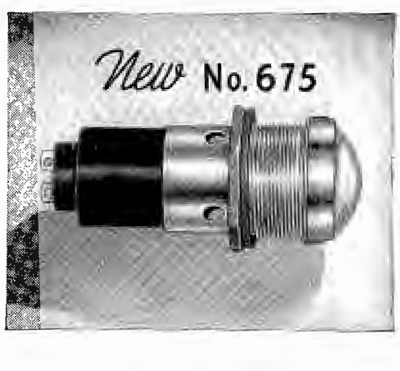


* * *

DRAKE'S PILOT LIGHT ASSEMBLY

A new heavy duty jewel type light assembly has been developed by the Drake Manufacturing Co., Chicago, Ill.

According to Ken Foute, sales engineer of Drake, jewels for this assembly may be of smooth, colorless frosted back glass, with removable color disc or diamond cut (faceted) colored glass. A slip-fit bezel, holding the jewel, permits easy removal of lamp from panel front. Metal parts are burnished cadmium plated, except the bezel, which has a highly polished chrome finish. Any double contact, candelabra sized bayonet base lamp with C7, G6, S6 or T4½ bulb size can be used.



OPERATIONAL CALCULUS

(*Continued from page* 40)

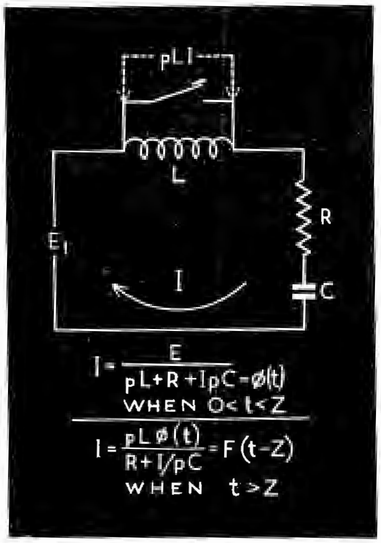


Figure 7

operates on ε^{bt} we may in turn place ε^{bt} to the left of each factor, changing "p" to "p + b" in each. Since any $\phi(p) = \Sigma \frac{K p^n}{(p - a)^n}$ plus a constant we have the "shifting" theorem $\phi(p)\varepsilon^{bt} = \varepsilon^{bt}\phi(p + b)$ or $\varepsilon^{bt}\phi(p) = \phi(p - b)\varepsilon^{bt}$.

Other Operational Operators

While the fundamental operation of the Heaviside mathematics is on the step function, it is by no means limited to such cases as the following will show. Assume ϕ to be some function of "p."

Then $\phi\left(\frac{P}{p^2 + \omega^2}\right) = \phi$

$$\left[\frac{1}{p - j\omega} \cdot \frac{P}{p + j\omega}\right] = \phi\left[\frac{1}{p - j\omega} \cdot \varepsilon^{j\omega t}\right]$$

By the "shifting" theorem we have

$$= \phi\,(\varepsilon^{-j\omega t})\left(\frac{1}{p - 2j\omega}\right)$$

$$= \phi\ {}^{-j\omega t}\ \frac{1}{2j\omega}\,(\varepsilon^{2j\omega t} - 1)\Big]$$

$$\text{so that } \phi\left(\frac{t}{p^2 + \omega^2}\right) = \frac{\phi}{\omega}\,(\sin \omega t)$$

Operating with "p," that is differentiating, we obtain

$$\phi\left(\frac{p^2}{p^2 + \omega^2}\right) = \phi\,(\cos \omega)\,.$$

In like manner we may obtain other useful and commonly used operators.

If we have a sine function instead of the step function to be operated on, for instance, we would simply proceed as follows:

$$[\phi(p)]\,[\sin \omega t] = [\phi(p)]\left[\frac{p\omega}{p^2 + \omega^2}\right]$$

$= F(p)$ and expand as usual.

Reflection Conditions

Of especial utility are the methods of operational mathematics in the treatment of transmission lines for the investigation of sudden disturbances such as lightning surges or of reflection conditions at junctions where the impedances differ. Elementary calculations on transmission lines parallel those of classical mathematics and give greatly simplified results in many complex situations.

Unit Length Constants

Basic results may be obtained from Figure 8. $\alpha E = -I(R + pL)\alpha x$ and $\alpha I = -E(G + pC)\alpha x$ where the circuit constants are for unit length of line as usual, and where distance (x)

(*Continued on page* 70)

OPERATIONAL CALCULUS

(*Continued from page* 69)

is measured from the receiving end. Further development shows $\frac{\alpha E}{\alpha x} = -IZ$

$$\frac{\alpha I}{\alpha x} = -EY \quad \text{where} \quad (R + pL) = Z$$

$$(G + pC) = Y.$$

Treating functions of "p" as algebraic quantities, we may solve the differential equations $\frac{\alpha^2 E}{\alpha x^2} = EZY \quad \frac{\alpha^2 I}{\alpha x^2} = IZY$

$$E = A_1 \varepsilon^{\sqrt{ZY}x} + A_2 \varepsilon^{-\sqrt{ZY}x}$$

and $$I = B_1 \varepsilon^{\sqrt{ZY}x} + B_2 \varepsilon^{-\sqrt{ZY}x}$$

where the constant A and B are evaluated from the line termination.

Conclusion

This paper has been written as an exposition of the basic utility of operational calculations. Although the full beauty and usefulness of this type of mathematics can only be appreciated when based on the theory of complex variables, it has been shown what remarkable results may be obtained by using the principle so that under certain conditions, functions of "p" may be treated practically as algebraic quantities. Advanced research in this field will well repay the physicist and engineer.

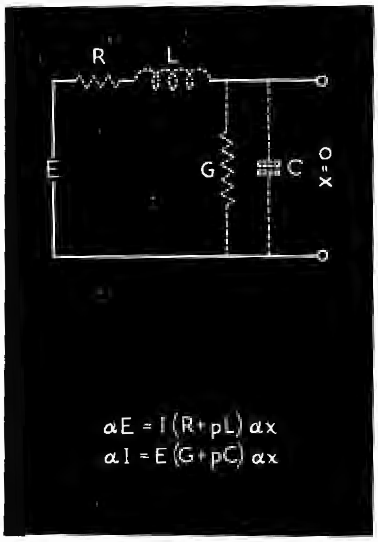


Figure 8
Basic results may be obtained from this circuit.

[1]"Peirce's Integrals," page 14.

U-H-F CIRCUIT CONTOURS

(Continued from page 21)

clearly the effectiveness of diffraction at 40 megacycles. A 50-watt transmitter in use in the C circuit lays down a field in excess of plus 40. A 10-watt transmitter would be perfectly satisfactory and would lay down a field of plus 33.

Channels Have Wider Applications

Due probably to lack of field experience and to misunderstanding of the behavior of the earth's surface to ultra-high frequency transmission, these channels are generally supposed to be applicable only for extremely local use within a radius of a few miles. On account of this, they have been put to the greatest use for police service within the bounds of cities and towns.

As has been indicated above, it is possible to predict from properly plotted contours what the transmission characteristics will be and reliable circuits can be installed on this basis covering areas state-wide in extent. Distances up to 100 miles or more can be spanned with reasonable low power very economically. Sections of a state may be segregated and inter-connected when desired to extend the peak traffic ability. Any number of stations can be provided with instantaneous communication.

Distribution of Mobile Units

The fixed stations can be distributed so that mobile units, necessarily of fairly low power and with low effective antenna height can communicate with at least one station from any point within the state-wide area. Messages from these points can be relayed either orally or automatically without the necessity of oral repetition with its attendant errors, into the entire system. A centrally located state headquarters can, in this manner, maintain communication to a mobile fleet thruout the area within its boundaries.

A system of this type with multiple stations of lower power represents a lower initial investment than the long wave high powered stations now in use for state police. It has the additional advantage of providing two-way communication under all types of weather conditions as against the one-way system using the longer waves with its attendant fading, varying skip distance and susceptibility to atmospheric disturbances.

Automatic Relaying

The establishment of such a system must be based on the choice of a suitable fixed station in each section which acts as an automatic relaying point. The remaining stations of that section will all transmit to this point on a single channel. Then a transmitter at this control tower operating on a second channel, will be received by all of the auxiliary points. A special type receiver at the control tower will then provide an output for actuating relays when a carrier is received which automatically turns on the transmitter and re-broadcasts the message.

In this way, any station can communicate with any other, and through them to the mobile units in the field through similar automatic relays at the auxiliary points if desired. Two channels only are necessary to cover any single section which can be linked with state headquarters directly or through a second automatic relay if the range is too great or the circuit contours are unsuitable.

System Now in Operation

A system, based on the foregoing data, has been in operation in the New Jersey Forest Fire Service for several years. Equipment especially designed to provide the results discussed has been developed and placed in operation.

Transmitters having very high stability employing crystal control which

(Continued on page 72)

(*Continued from page* 71)

will hold the frequency within .01% are available both in fixed and mobile units which will withstand the severe mobile and fixed usage incident to such service. Receivers meet rigid specifications of high sensitivity and selectivity in order to reject adjacent channels 40 kilocycles away in the newly allocated series used by other services. They are equipped with a silencing circuit which render the sets inoperative except when a carrier is received to eliminate the stand-by rush resulting from noise pick-up when no signal is being received. Limiter circuits are also a necessity especially in mobile units and at fixed locations having high noise level.

Compensated Type Receivers

Receivers of the fixed tuned type are crystal controlled and require no attention over long periods of time.

For relay towers, automatic control equipment which functions even on weak carriers has been perfected.

Suitable Antennae

The installation of suitable antenna systems to provide efficient radiation and of receiving antennae to provide non-directional reception and minimum noise pickup also comes in for its share of consideration. They must be installed with due regard for wind conditions and protected against electro-chemical action between dissimilar metallic contacts.

• • •

AIRCRAFT RECORDER

(*Continued from page* 14)

one-hundred per second with signals recorded on disc and film. Incidentally, these recordings may be made either simultaneously or the film may be re-recorded from the disc. A recorder-analyzer provides the decoding of the recorded film signals. It also provides an identification and plotting of the readings of each pick-up on a separate chart. All of this is done automatically.

The image of each instrument panel is projected through an optical scanning system which determines the frequency of the recorded signal and then plots the related amplitude on a pen and ink chart. The analyzer, in addition to converting frequencies to corresponding amplitudes, shifts the correct chart for each pick-up into the proper recording position when the filmed image of that pick-up is moved into the decoding system. In this way, the changes in the pick-up response are plotted on separate charts. To accomplish this automatic decoding and plotting operation, only approximately three seconds are required per indication.

This new recorder is extremely flexible. For instance, any desired continuity can be set up with the leads from the pick-ups, which are brought to the terminal board, where we have the scanning switch.

This is particularly important in dive and pullout studies where we have a terrific acceleration. This flexibility provides a reading of acceleration fifty times a second by an adjustment of a scanning switch.

This new instrument reduces the number of hours of test-flying required to obtain flight performance data on new type airplanes and engines, to a minimum. Engineering time consumed in plotting charts of flight data are also reduced by the automatic analyzer. Since as many as 260,000 amplitudes may be recorded on one disc, an effective, compact and permanent form of record is made available for future study and filing.

[*To Be Continued*]

IRE WINTER CONFERENCE

(*Continued from page* 64)

the 37,001 to 73,000 volt range 94 tests were required.

The effect of humidity and the porcelain insulators used on power equipment was also analyzed. An artificial test to establish a method of learning the results, was also disclosed. Such tests are made in a closed chamber in which the atmosphere can be artificially reduced by suitable dryers so that a range from .03 inch of mercury vapor pressure to .6 inch are obtained. The humidity was measured with a dew point potentiometer and data of radio influence voltage variations were obtained at 10 kv, 16 kv, 22 kv and 28 kv. It was noted, that a marked increase in voltage as the humidity decreased, was consistent at all voltage levels tested.

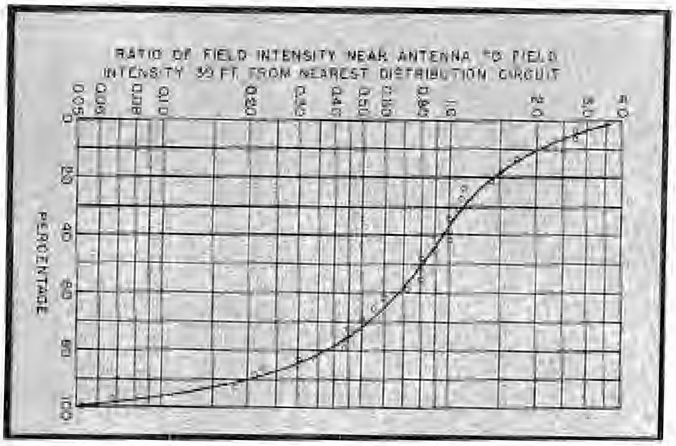
This report will be of material effect in providing a maximum of effective broadcasting service.

POWER EQUIPMENT AND RADIO NOISE

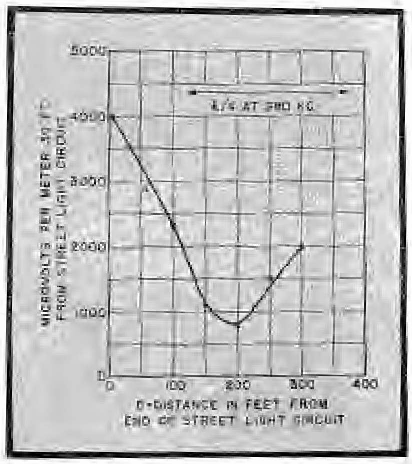
The influence of electrical apparatus and power systems on radio also served as a basis for a paper by C. V. Aggers, W. E. Pakala, both of Westinghouse, and W. A. Stickel of the West Penn Power Company, in the concluding period of the special radio engineering morning session succeeding the one-day conference. In this paper the effect of radio frequencies of a power system on radio receiving systems was discussed.

This paper was particularly concerned with the high voltage equipment affecting radio. Tests and methods for calculating the over-all effects on radio reception resulting from the radio frequency voltages produced incidentally by this power equipment were also described. To determine the coupling factor of the antenna to the power lines,

(*Continued on page* 75)



Figures 11 (left) and 12 Curves prepared by Aggers, Pakala and Stickel for their study of the influence power systems on radio. (*Courtesy AIEE*)



IRE WINTER CONFERENCE

(*Continued from page* 73)

field tests were made at radio frequencies in a city receiving power from 25 kv transmission lines and 4 kv distribution circuits. A radio frequency generator was connected to the 25 kv bus at the sub-station and field-intensity measurements were made near the power lines and at 29 receiver antennas located at various distances from the 25 kv lines. The coupling factors to the nearest power circuit and to the 25 kv line were obtained in this way.

Other information learned by these tests showed that 45% of the installations under study used water pipe for ground, 28% had no connections to ground and the remainder used ground rods which measured in some instances several hundred ohms with direct current.

It is possible, according to this paper, to establish perfect radio coordination of electrical equipment into two classifications; low voltage (consisting of apparatus operating below 1,200 volts and frequently operated on the premises of the radio listener), and high voltage (generation, transmission and distribution of electric power).

As in the previous paper the data supplied, again proves the tremendous strides made by power companies and broadcasting stations in effecting a coordinated policy of mutual assistance to afford improved reception for the listener.

These last three papers were A I E E presentations, and were presented as supplementary features to the one-day I R E Winter Conference.

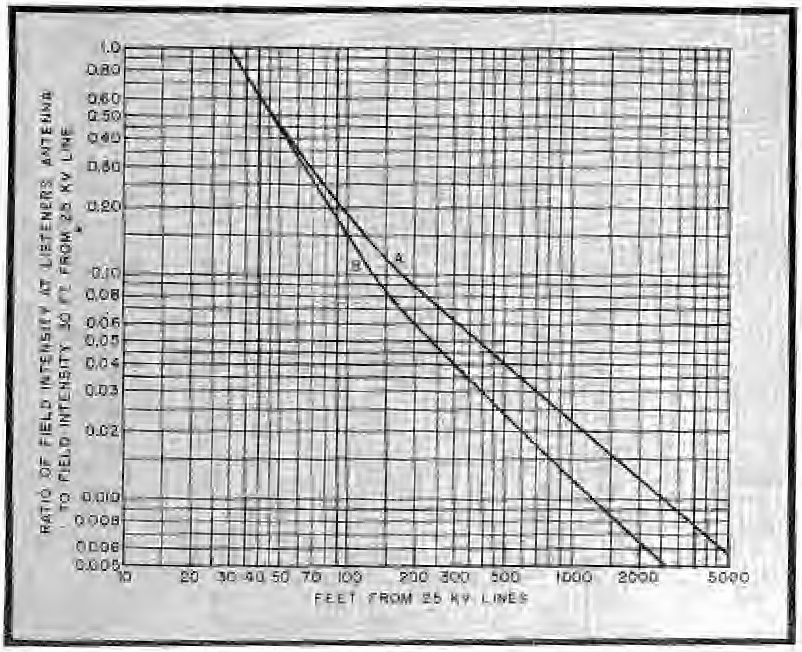


Figure 13
Coupling from high-voltage line to antenna as a function of distance from the line; "A" with distribution circuits over area and "B" with no distribution circuits . . . all transmission through space.

(*Courtesy AIEE*)

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COMMUNICATIONS—FEBRUARY, 1943

IRE WINTER CONFERENCE

(Continued from page 73)

field tests were made at radio frequencies in a city receiving power from 25 kv transmission lines and 4 kv distribution circuits. A radio frequency generator was connected to the 25 kv bus at the sub-station and field-intensity measurements were made near the power lines and at 29 receiver antennas located at various distances from the 25 kv lines. The coupling factors to the nearest power circuit and to the 25 kv line were obtained in this way.

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It is possible, according to this paper, to establish perfect radio coordination of electrical equipment into two classifications; low voltage (consisting of apparatus operating below 1,200 volts and frequently operated on the premises of the radio listener), and high voltage (generation, transmission and distribution of electric power).

As in the previous paper the data supplied, again proves the tremendous strides made by power companies and broadcasting stations in effecting a coordinated policy of mutual assistance to afford improved reception for the listener.

These last three papers were A I E E presentations, and were presented as supplementary features to the one-day I R E Winter Conference.

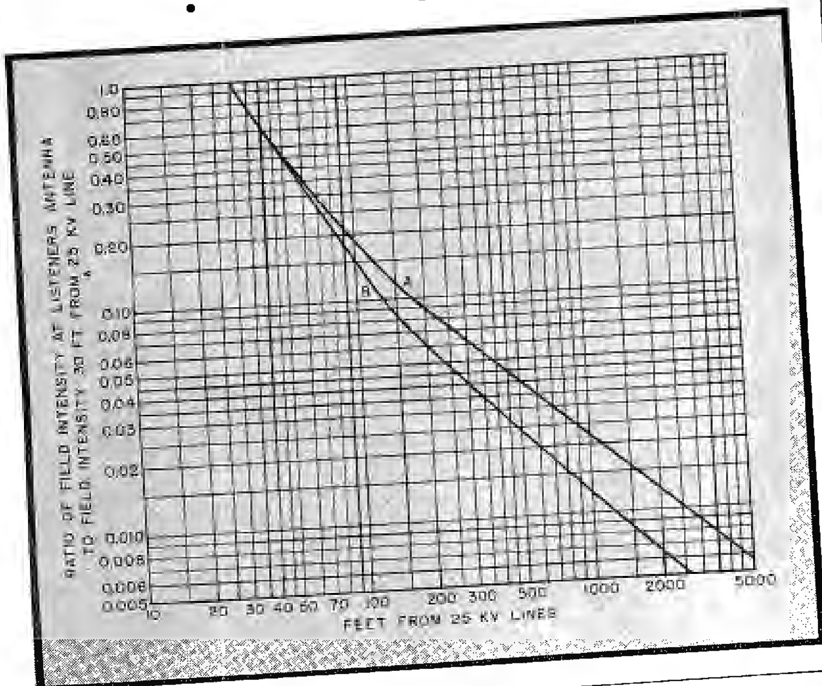

Figure 13
Coupling from high-voltage line to antenna as a function of distance from the line; "A" with distribution circuits over area and "B" with no distribution circuits . . . all transmission through space.

(Courtesy AIEE)

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IRE WINTER CONFERENCE

(*Continued from page 73*)

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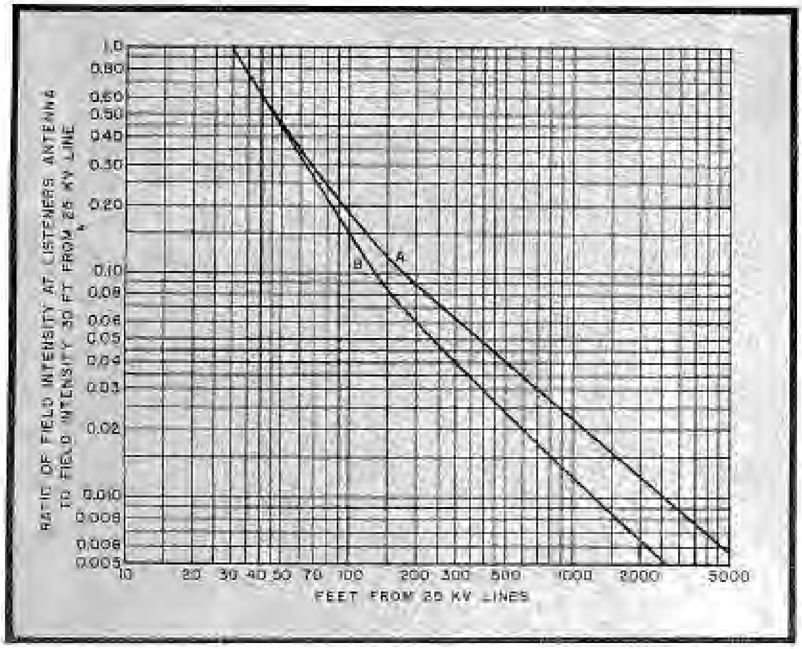

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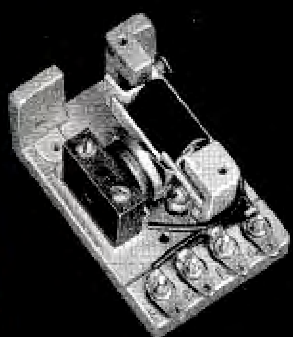

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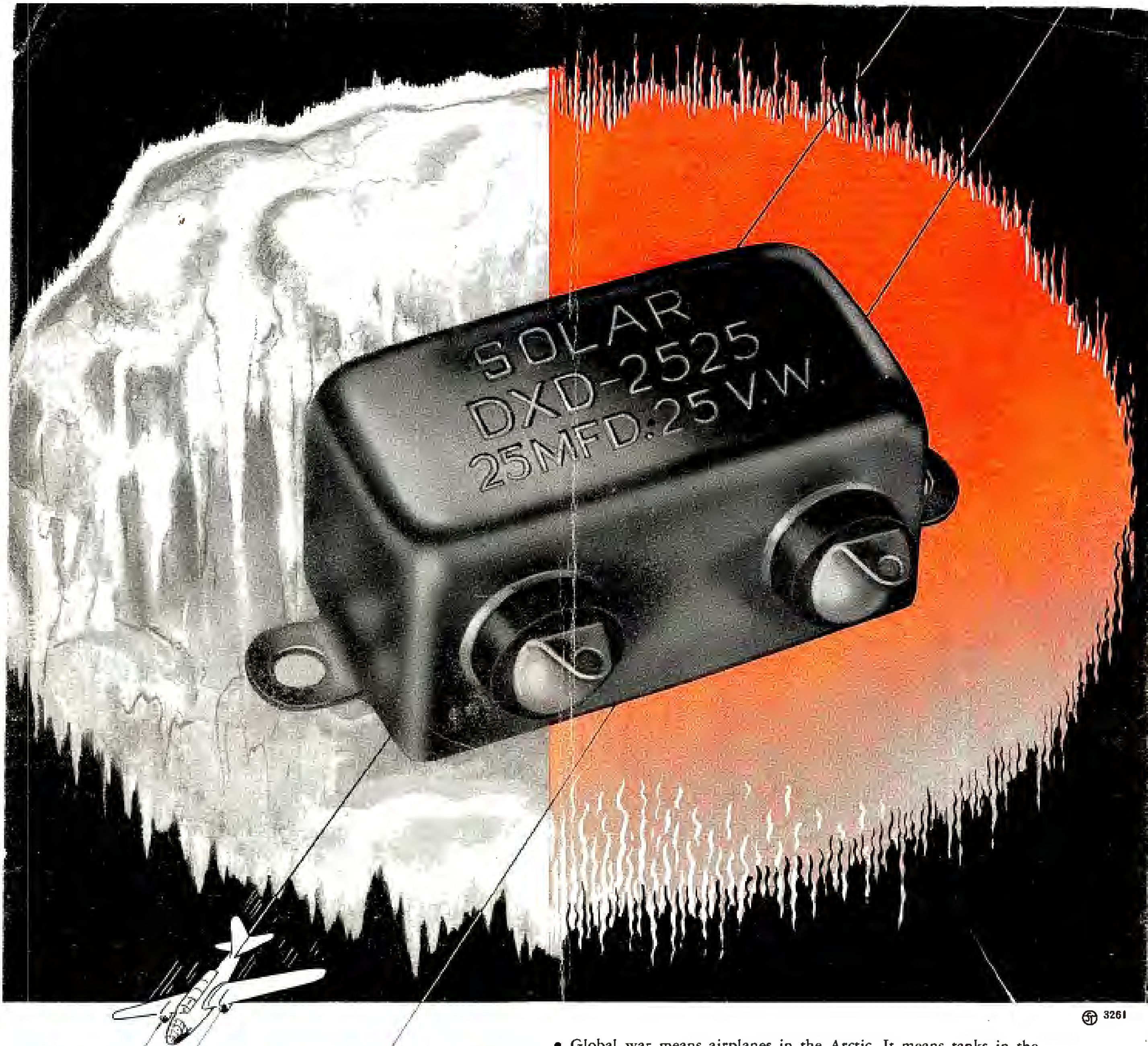

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