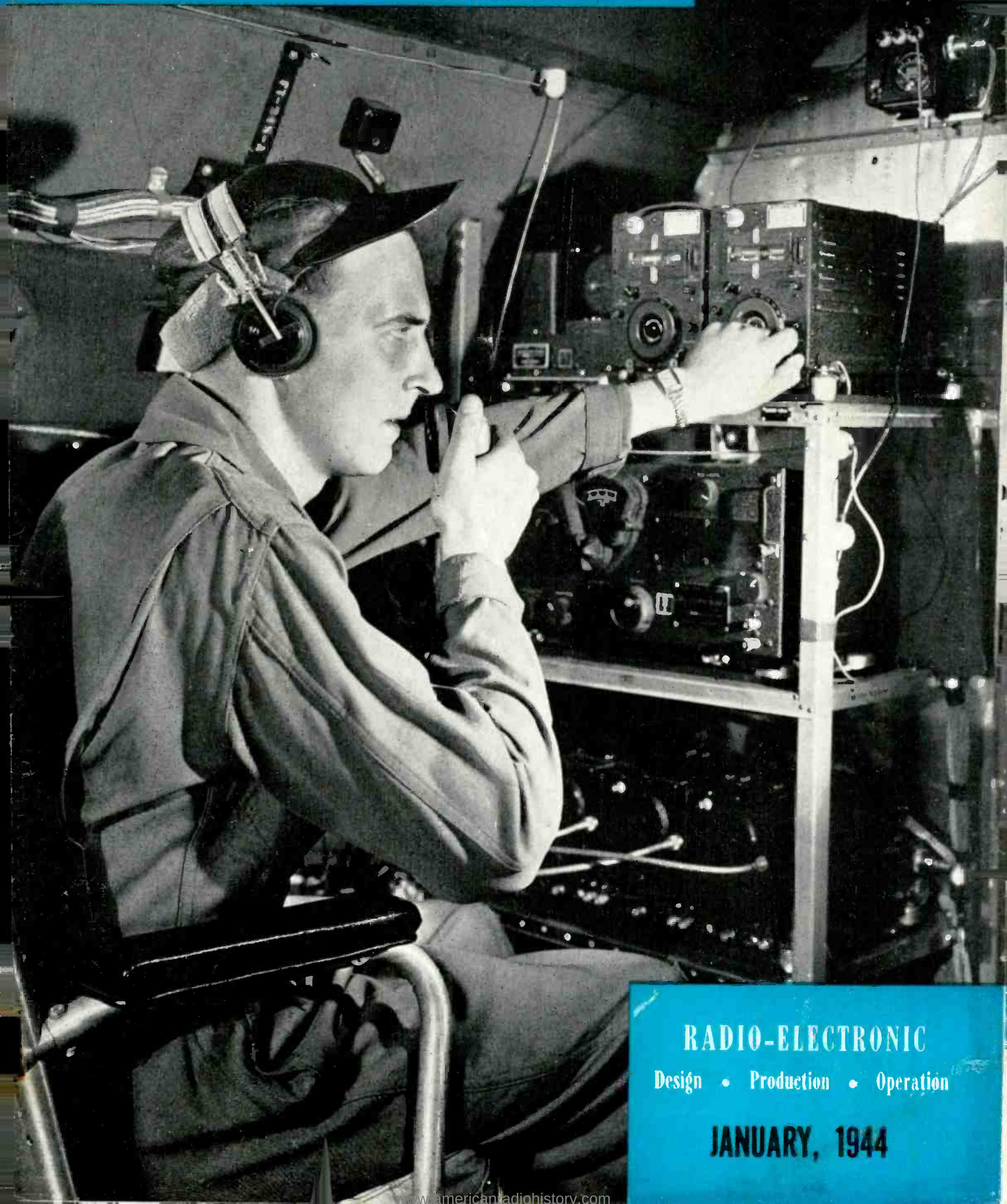
RADIO

ESTABLISHED 1917



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JANUARY, 1944

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We want letters telling of actual experiences with this equipment. We will give $100.00 for the best such letter received during each of the five months of November, December, January, February and March! (Deadline: Midnight, the last day of each month.)

We will send $1.00 for every serious letter received so even if you should not win a big prize your time will not be in vain.

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W. J. Halligan

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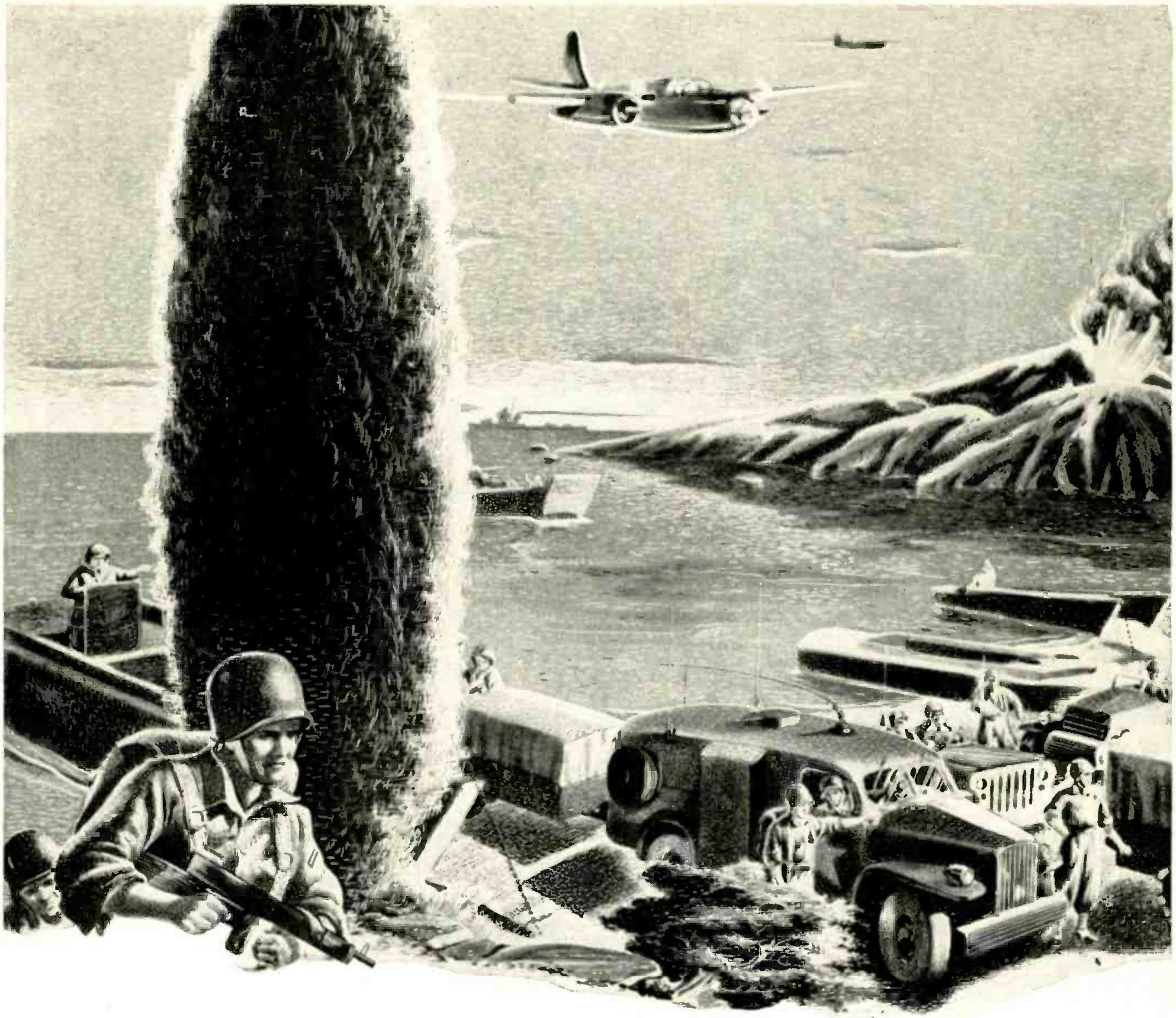

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JANUARY 1944 Vol. 28, No. 1

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Compact and versatile, the Western Electric command set, shown here in detail for the first time, is the vital airborne radio link between planes in flight and between planes and ground forces. Used in both Army and Navy planes, the comamnd set is notable for its small size, light-weight and ease of operation.

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TRANSIENTS

WALKING ZOMBIES

★ If the small number of people we recently questioned on the subject of their post-war desires represents a good cross-section of national thought, then the broadcast-receiver manufacturers may be in for a rude jolt. These people are definitely thinking of dream models, and if the dream fails to materialize the industry may face a buyer's strike.

An interesting, though disheartening, aspect of the situation is that the people with whom we discussed the matter, have no such expectations from the automotive industry. Good publicity has promoted the conviction that it will be some time before post-war cars assume the delightful characteristics of a mechanical dream, with the result that people are resigned to the fact that post-war cars for some time to come will be approximations of pre-war models. But there is no such conviction with regard to radios, for the simple reason that there has been too much talk about the wonders that will be incorporated in future sets and very little talk outside the industry as to *when* these wonders may be expected.

The National Association of Manufacturers has estimated that there will be a potential post-war market for 20 million radio receivers. This is a reasonable estimate, provided the public shows a willingness to accept pre-war designs. If our little survey is any criterion, the public won't. At least, not if they deduce that dream models will be forthcoming in a year or two. In that event the old radio, patched up, will do very nicely until such time as the radio industry makes good on its promises.

We believe the industry should do one of two things; either parallel the course taken by the automotive people and make it clear to the consumer that the dream held out is a distant one, or prepare to offer a reasonable facsimile of a dream model from the word go. Otherwise the industry may see a dream walking—in the wrong direction.

MILITARY SURPLUS

★ Our editorial titled "Competition", in the November issue, brought forth a number of letters, both pro and con. Of particular interest is a letter from *McMurdo Silver*, Vice-President of The Grenby Manufacturing Co. Mr. Silver is of the opinion that the dumping of surplus radio-electronic equipment, no matter how accomplished, will damage the future prospects of the entire industry. It is his conclusion that it might be far better in the long run to scrap the equipment. His expression is well summed up in the following paragraph taken from his letter:

"Awful as is the thought of total destruction, it may be the best answer. The cost in material and man-hours of this potential military surplus is already on our tax bill—and on the tax bill of our children's children. If we could significantly reduce this burden by dumping, that would be wise. But past experience is that dumping will yield only the tiniest fraction of the original cost—maybe not enough to leave any net cash salvage after handling and selling costs to the government. But the tax bill *must* be paid if we are to escape ruin as a nation. If the price of dumping is to even partially reduce new production, to reduce continuing employment, to diminish individual purchasing power and hence to reduce taxable income, is it not better to destroy the past to preserve the future?"

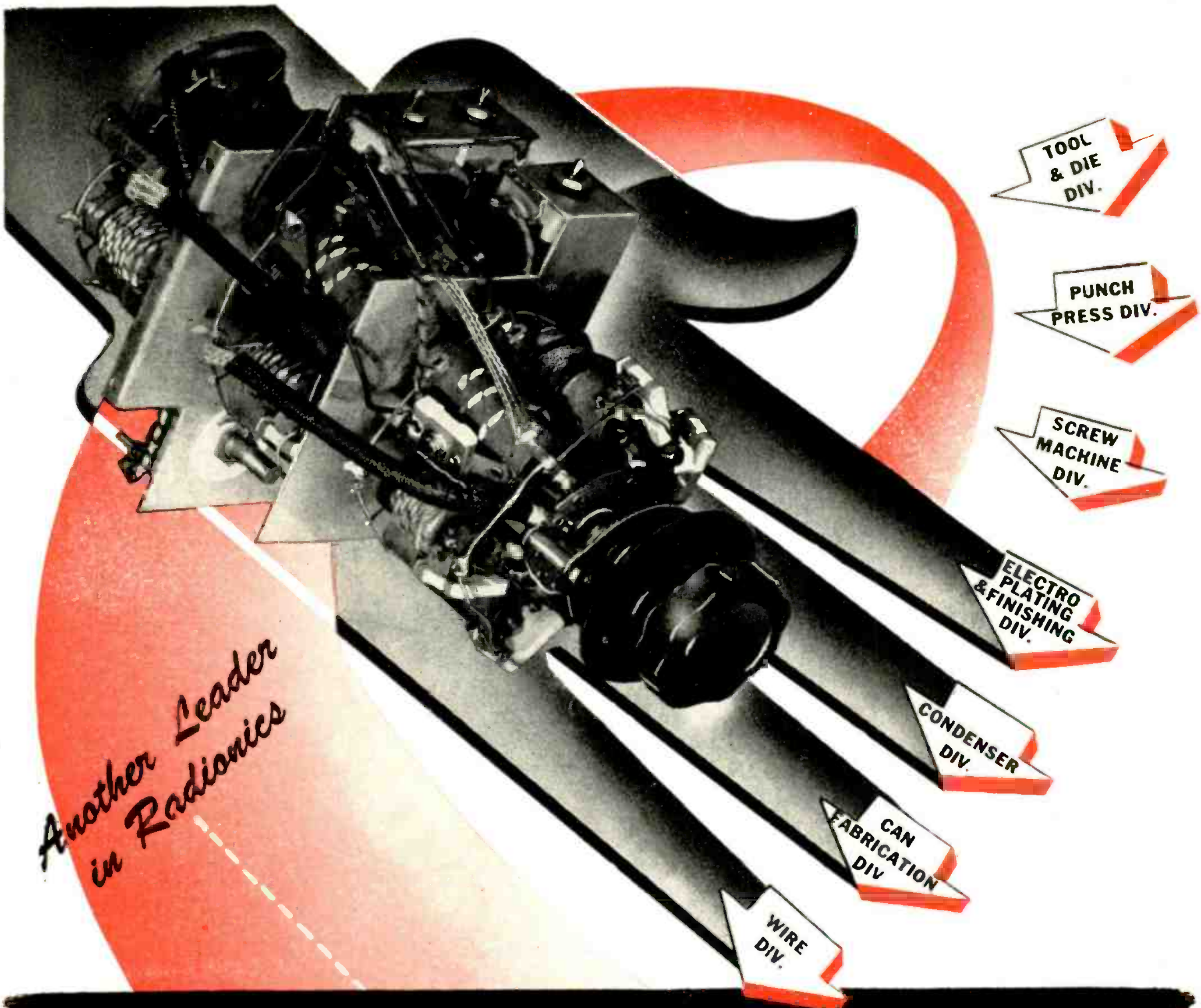
We have since learned that the Government is giving the problem serious consideration, and that a bill will be introduced in the Senate proposing that the disposal of military surplus be administered by industry. In that case, each industry would be in a position to protect its own interests.

POST-WAR JOBS

★ Outstanding experts in manufacturing, marketing, sales, finance, management and engineering have organized to make available to American business during 1944 the latest practical knowledge needed to help them effect an expansion of post-war production and employment to unprecedented peacetime levels, it was recently announced by Marion B. Folsom, Chairman of the Field Development Division of the Committee for Economic Development. Eleven Action and Advisory Committees will make this knowledge freely available to all American businessmen in publications and by direct consultation through the 1100 community committees of CED now at work in all 48 states.

"The most pressing job of the CED in 1943," said C. Scott Fletcher, Director of the Field Development Division, "was to organize businessmen at the community level to study conditions in their own businesses and to take responsibility for devising bold plans for reducing post-war unemployment to the bedrock minimum. On New Year's Day, 1943, we had exactly three pins in our organizational map. Today we have more than 1300 representing regional, state, district and community committees, and more are being inserted every week.

"In 1944 the CED's most urgent task will be to make available to the nation's 2,000,000 business employers the best American managerial science, imagination and know-how, in such practical form that it can be applied effectively to their own post-war planning problems. Our Research Division advises us that 55,000,000 post-war civilian jobs in business, agriculture and government, producing 142 billion dollars of goods and services is a reasonable and achievable goal to aim at. Compare that with 46,000,000 and 97 billion in 1940—our banner peacetime year hitherto—and one can appreciate the size of the job which confronts America in the post-war period. Business is determined to make its contribution to meeting this challenge."



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For many years before the war, Edwin I. Guthman & Co. was especially known for manufacturing better coils. With war came greater demands upon our facilities . . . U. S. Army and Navy orders for many diversified radio parts . . . expansion of our plant . . . the addition of many new manufacturing departments. All manufacturing and assembling of these many units was done in our own completely equipped plant. Thus, our engineers and skilled personnel gained a broader experience in modern radionics. Now, we are concentrating all this technical experience in the engineering and production of Guthman Super-Improved Coils . . . promised leaders in peacetime radionics.

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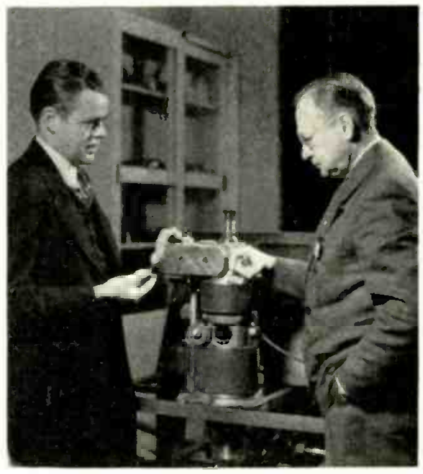
PRECISION MANUFACTURERS AND ENGINEERS OF RADIO AND ELECTRICAL EQUIPMENT

TECHNICANA

ELECTRON MICRO-ANALYZER

★ An instrument which will enable the identification of the chemical elements in ultra-microscopic particles no larger than 1/100,000th of an inch in diameter has been developed experimentally by Dr. James Hillier of RCA Laboratories and is described in a letter published in the November 15th, 1943, issue of the *Physical Review.*

In operation, the micro-analyzer uses an "electron needle" to knock loose other electrons in their parent atoms in the specimen, measures the amount of energy lost by the incident electrons in the process, and thereby reveals the specimen's chemical content.

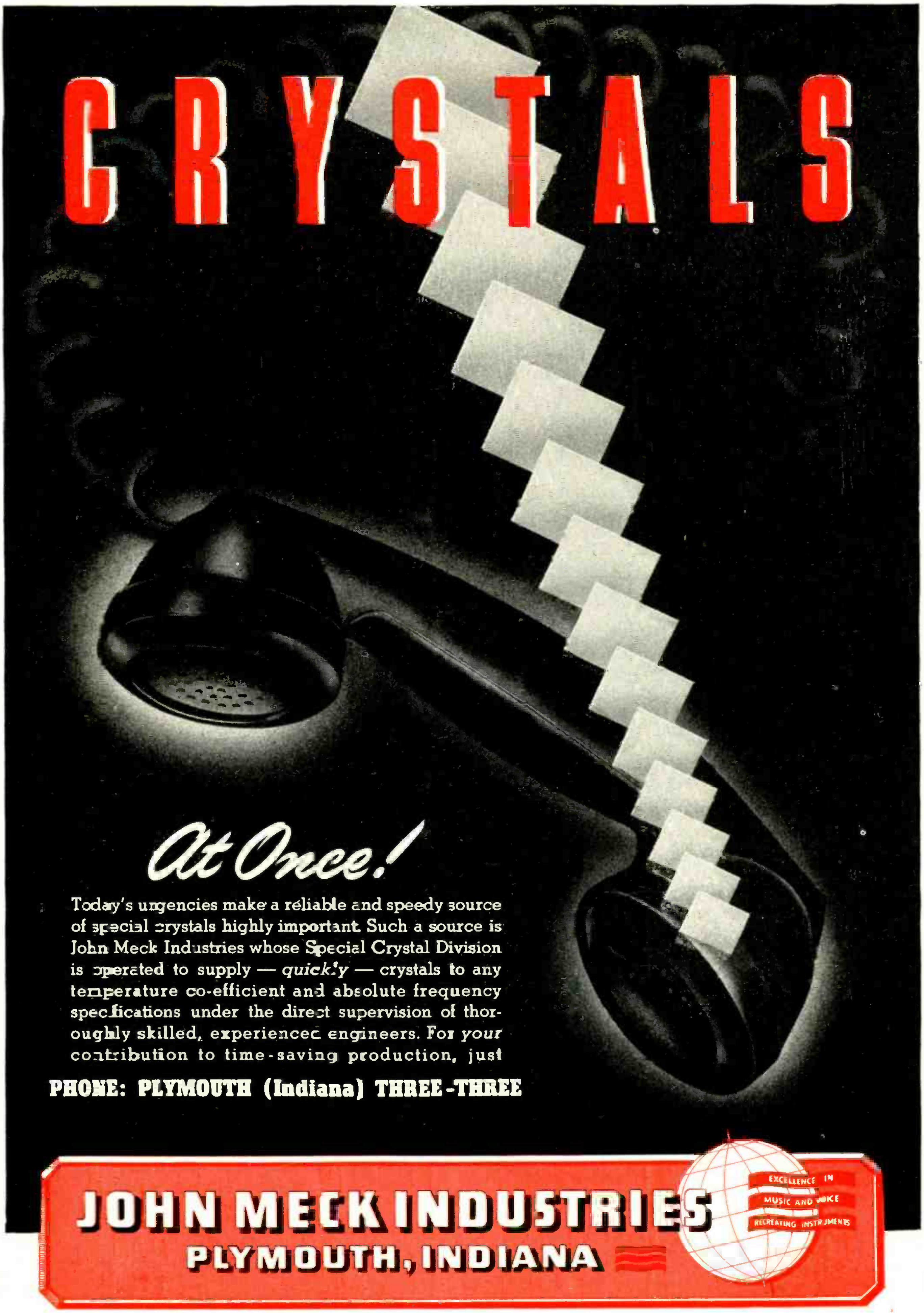


Dr. Hillier (left) and Dr. V. K. Zworykin, Associate Research Director, RCA Laboratories, with an experimental model of the electron micro-analyzer

According to Dr. Hillier, the electrons of the "needle" that strike the selected area of the specimen are all moving with the same velocity, say 50,000 volts. After they have passed through the specimen area, those electrons which have struck atoms are traveling with less velocity. Because the energy loss suffered by the speeding electron is different for each chemical element, it is possible, by measuring the energy loss, to determine the kind of atom which has been struck. An energy loss of 298 volts, for example, indicates that a carbon atom has been struck; a 400-volt loss identifies the element as nitrogen, etc.

An electron microscope is incorporated as a part of the micro-analyzer. After a selection has been made of the exact portion to be analyzed, a photographic exposure is made, showing the electron velocity distribution. This re-

[*Continued on page 8*]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TECHNICANA

[Continued from page 6]

sults in a series of small marks on the photographic plate, each of which indicates the presence of a chemical element in the specimen. Thus, with one exposure, information is obtained which would have taken weeks or months to secure by present indirect methods, Dr. Hillier points out.

An incidental development made by Dr. Hillier in designing the microanalyzer was an improvement in the resolving power of the electron velocity analyzer. In the experimental model of this instrument it is now possible to measure electron velocities to 1 part in 4300, whereas formerly 1 part in 200 was considered good.

NEW THERMOCOUPLE STANDARD

★ The American Standards Association has just announced approval of the new American war standard, Dimensions for External Radio-Frequency Thermocouple Converters (120 ma. to 10 amps., inclusive), designated as C39.4-1943. This standard has been adopted for procurement purposes by the Signal Corps Standards Agency and the Radio Division, Navy Dept., Bureau of Ships.

It has been estimated that this standard covers 90 per cent of the thermocouple converters used in radio and electronic equipment. Designers of equipment should utilize this standard as extensively as possible to aid in securing maximum production and to simplify repairs of equipment in the field.

Copies of this and other war standards may be obtained from the American Standards Association, 29 W. 39th St., New York 18, N. Y.

VOICE-POWERED TELEPHONE

★ A sound-powered telephone operated without batteries proved one of the most useful pieces of equipment on Guadalcanal, the War Department has been advised by Lieutenant-Colonel R. B. H. Rockwell, Signal Corps, who served as division signal officer on the South Pacific island.

Power in the telephone is generated by the human voice. It is capable of carrying its message as far as ten miles under favorable conditions and has a normal range of five miles under almost any circumstances. Commercially developed, the sound-powered telephone has been adapted to war communications by the Signal Corps.

This equipment was found particu-

[Continued on page 10]

TECHNICANA

[*Continued from page 8*]

larly advantageous on Guadalcanal because of the lack of batteries, which have been found susceptible to deterioration from the humidity and dampness of the South Pacific. In addition, it is considerably smaller, more compact and durable than battery-powered telephones. In size and appearance it similar to the handset in use in American homes. Signaling is accomplished by whistling into the transmitter.

VIBRATION INDICATOR

★ The design and application of a simple instrument for checking vibration displacement is described in an article by H. M. Dimond in the December, 1943, issue of the *General Electric Review*.

The construction of the instrument is indicated schematically in *Fig. 1*. The small mirror is rotated by movement of the stylus, and this movement is magnified by the reflected light beam,

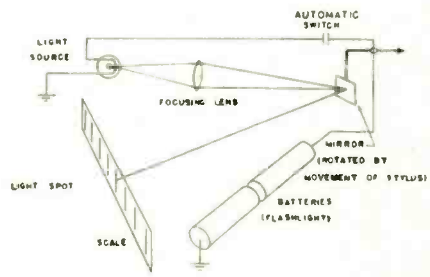

Fig. 1. Vibration-indicator diagram

which is projected on the calibrated glass screen. Rapid motion of the light spot thus formed causes it to appear as a band. The length of the band indicates the magnitude of the vibration. Loose bearings and couplings, and resonant vibrations of attached equipment give distinctive indications which can be readily identified by an operator familiar with the instrument.

This device was developed by the Mechanical Investigation Section of the General Electric Research Laboratory.

IMPROVED AC-DC SET DESIGN

★ An improved method of eliminating undesired interstage coupling in ac-dc receiver design is described in a patent abstract published in the December, 1943, issue of *Wireless World*. Be-

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TECHNICANA

[*Continued from page 12*]

assigned to the Philco Radio and Television Corporation.

TELEVISION PROJECTION

★ New RCA developments in the application of aspherical optics to television projection make possible the economical production of projection-type television receivers that reproduce images up to full theater-screen dimensions.

According to an article by I. G. Maloff of RCA, appearing in the January, 1944, issue of *Radio Age,* a large gain in light with ample resolution and contrast is obtained in the projected image through the use of aspherical

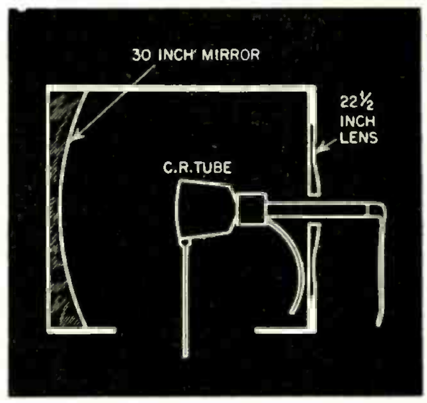

Fig. 3. The projection system

lenses. These are produced by a special RCA process at low cost by molding plastic, methyl methacrylate, in the form desired. After molding, the lens is extracted and the hole for the protruding cathode-ray tube is bored out. The lens is then ready for use, no polishing or finishing of any sort being required.

A sketch of the system, which was demonstrated in New York, is shown in *Fig. 3.* A 30-inch spherical mirror is used in conjunction with the lens. This mirror gathers the light emanating from the tube and reflects it through a 22½-inch lens onto the theater screen. All the light (except for slight losses in the reflection and transmission) which the large mirror gathers, finds its way to the screen, and this accounts for the superiority of the new optical system over conventional projection lenses.

In working with large spherical mirrors, a very interesting effect is often observed. It is well known to op-

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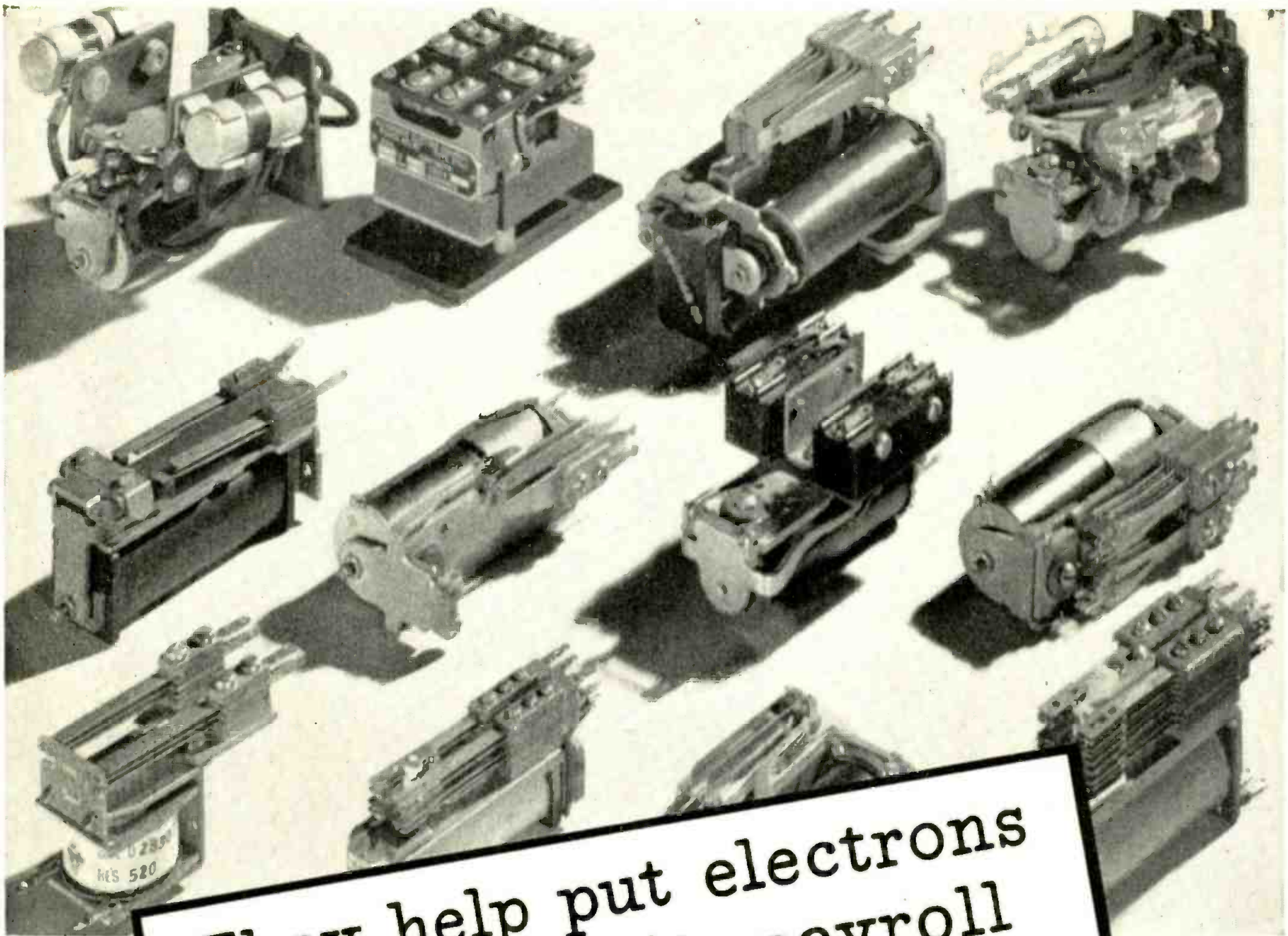

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MUSCLES FOR THE MIRACLES OF ELECTRONICS

Production Speed-Ups

ELECTRICAL TAPE SUBSTITUTE

By ALZEOR I. BEAUNE
General Electric Company, Cleveland Plant

★ In case it becomes impossible to get friction tape or rubber tape, a satisfactory substitute is ¾-inch cotton tape, painted with Ajax Black Air Drying Varnish made by the Sherwin-Williams Company.

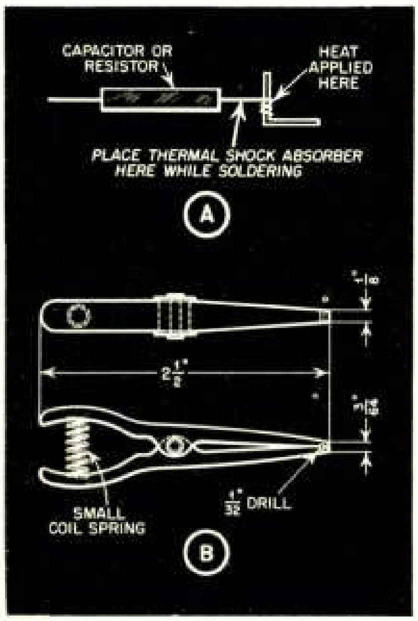
After submersion in oil for 48 hours, connections made with ordinary friction tape became loose, gummy and saturated, while those made with the substitute as described above remained firm and hard.

It has also been found that cotton tape, painted with G. E. Glyptal varnish, makes very satisfactory connections. However, this varnish takes longer to dry than the Ajax type so connections cannot be pulled through conduit or be otherwise handled as quickly as when the Ajax varnish is employed. The latter has successfully withstood tests up to 440 volts.

THERMAL SHOCK ABSORBER

By R. C. MIDDLETON
Templetone Radio Co.

★ Heat conduction from the soldering iron often ruins delicate radio components when the soldering operations are performed by unskilled personnel, as is so often the case these days. This is especially the case when precision resistors, copper-oxide rectifiers and small capacitors are being soldered.



The thermal shock absorber practically eliminates rejects due to this cause. When this device is clamped on the lead, the heat from the iron is dissipated by the thermal shock absorber rather than by the item being soldered.

TRANSFORMER LID JIG

By D. SMITH
RCA Manufacturing Co., Inc., Camden Plant

★ This suggestion refers to a jig to hold hermetically sealed transformer can lids. The fixture is designed to construct two cover assemblies at one time.

Corprene washers are assembled over the studs, which are placed in their respective holes and the metal covers are mounted over the blocks on each side of the fixture. This operation is performed while the locating plate is pushed back to allow the operator more room. The operator assembles a large washer, bushing, and a small washer, respectively, on each of the eight extending studs. The locating plate is then moved down into position and terminals and lockwashers are assembled on top of the small washers. The operator inserts a nut into the end of an air-gun, which is suspended directly over the fixture, and tightens the assembly. When the locating plate is swung back, it automatically ejects the two complete assemblies.

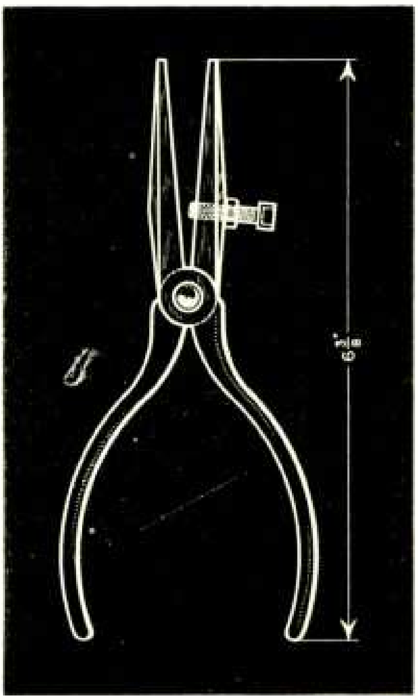
The ejector feature is necessary because the air-gun tightens the assembly enough to cause the washers below the cover to expand and press against the side walls of the holes. When the locating plate is pushed back it automatically moves the ejectors upward, catching each end of the cover, thus ejecting them. A steel clamp has been added to the fixture to hold the locating plate in place, as the air-gun vibrates enough to force the plate upward, leaving the terminals in position.

A drawing (Suggestion Serial No. 409) showing the design of this jig may be obtained from the War Production Board, War Production Drive Headquarters.

SPECIAL RADIO PLIERS

By JAMES DOUGHERTY
RCA-Victor Div., RCA, Camden Plant

★ It is suggested that standard pliers be modified as shown so that loose contacts on switch wafers may be tightened without damage to the wafers. Normally about 15 per cent of these wafers are not usable because of loose contacts, often caused by rough handling in transit. When this tool is properly adjusted contacts may be tightened without injuring the wafer.



Results: Practically eliminates rejects.

PRODUCTION TEST JIG

By R. C. MIDDLETON
Templetone Radio Co.

In designing test equipment for a certain job, the problem arose of speeding up testing on a nine-cord unit; that is, nine telephone jacks spaced on one-inch centers. The first thought was to gang the nine plugs in one jig, which would enable the nine tests to be performed in a single operation. This failed because the force required to re-

[Continued on page 59]

PAINTED FOR ELECTRONIC LABORATORIES, INC., BY BENTON CLARK

Can a Vibrator Power Supply Rescue a Boat-Load of Men?

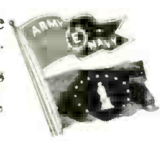
No . . . it can't! But it *can help* — and the rescue *might* be prevented and the boat lost forever, if just one vibrator power supply failed to do its job.

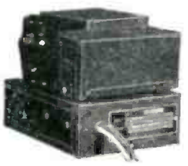
● The compact radio transmitter that is standard equipment in many lifeboats depends on a vibrator power supply . . . The patrol plane that picks up the SOS . . . spots the drifting boat, and summons surface ships with its own powerful transmitter, has a complex electrical system that includes many vibrator power supplies. And in the rescue ship itself are still other vibrator power supplies performing vital functions.

The dependability of *E·L* Vibrator Power Supplies under all climatic conditions — their amazing adaptability in meeting specific current requirements — have brought them into wide use for radio, lighting, communications and motor operation — on land, sea and air.

Electronic's engineers have specialized for years in the technique of vibrator power supplies. They have conducted the most extensive research ever known on power supply circuits. They have extended the practical application of vibrator-type power supplies far beyond previous conceptions.

In the electronic era of peace to come, the efficiency and economy of *E·L* Vibrator Power Supplies will find new applications wherever electric current must be changed, in voltage, frequency or type.





For Operating Radio Transmitters in Lifeboats — *E·L* Model S-1229-B Power Supply. Input Voltage, 12 Volts DC; Output Voltage, 500 Volts DC; Output Current, 175 MA; Dimensions, 7½" x 5½" x 6¼".

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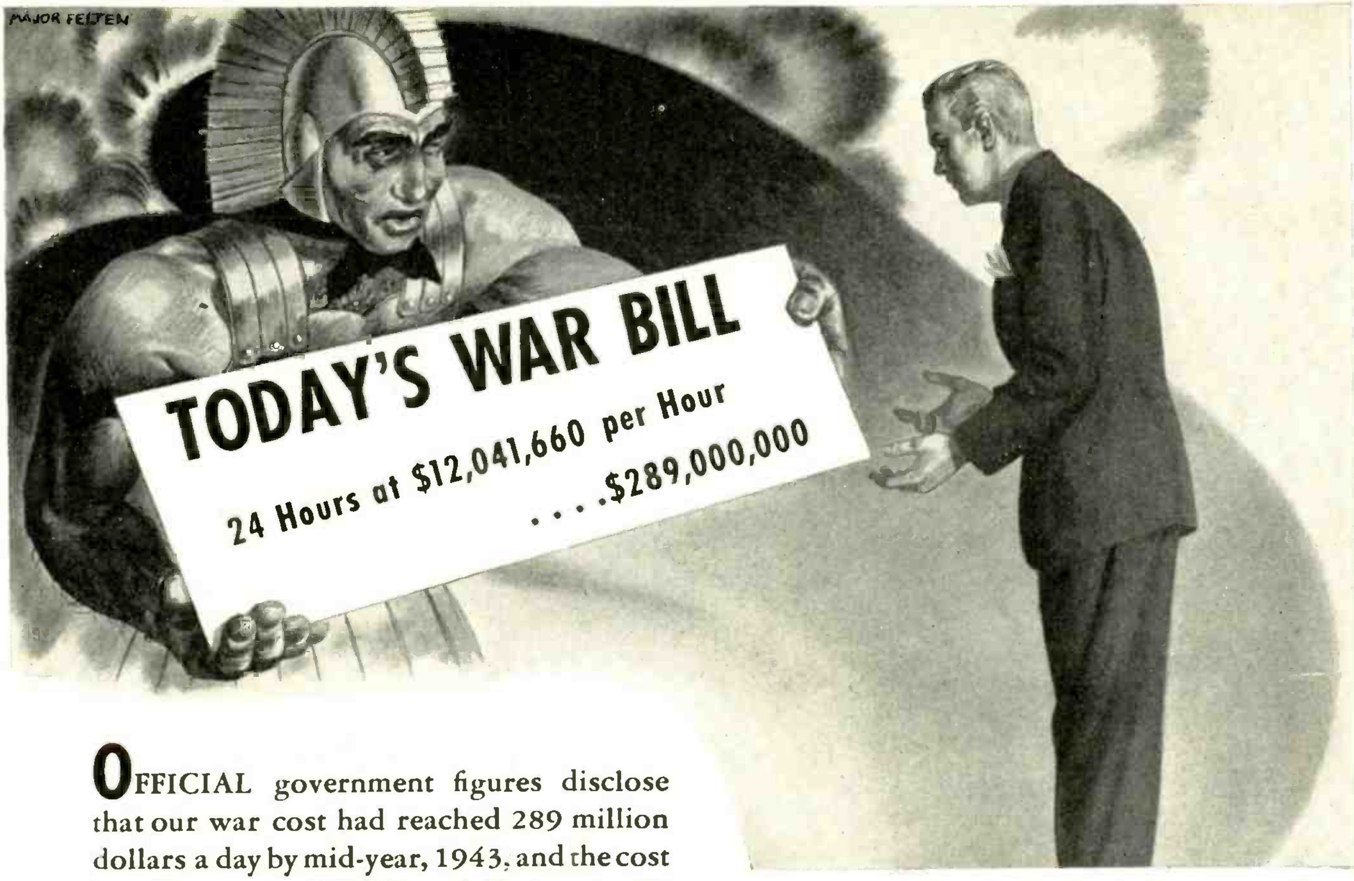

OFFICIAL government figures disclose that our war cost had reached 289 million dollars a day by mid-year, 1943, and the cost has been over 7 billion dollars a month ever since.

As manufacturers of communications and aircraft material on which human lives often depend, we know of one heartening reason for this tremendous cost: Uncle Sam will not compromise with quality at the expense of our fighting men. They are getting the finest, most dependable equipment any army ever had. And that saves lives.

Is it any wonder we are being asked to dig down and buy War Bonds until it hurts? And isn't it well worth it, knowing that our sacrifice is maintaining quality as well as quantity of weapons? Our people here at Connecticut Telephone and Electric Division think so . . . they are 100% pledged to regular payroll deductions for War Bonds, on an average of 15% of their incomes.

OUR CONTRIBUTION TO THE WAR EFFORT

GREAT AMERICAN INDUSTRIES INC.

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TELEPHONE & ELECTRIC DIVISION
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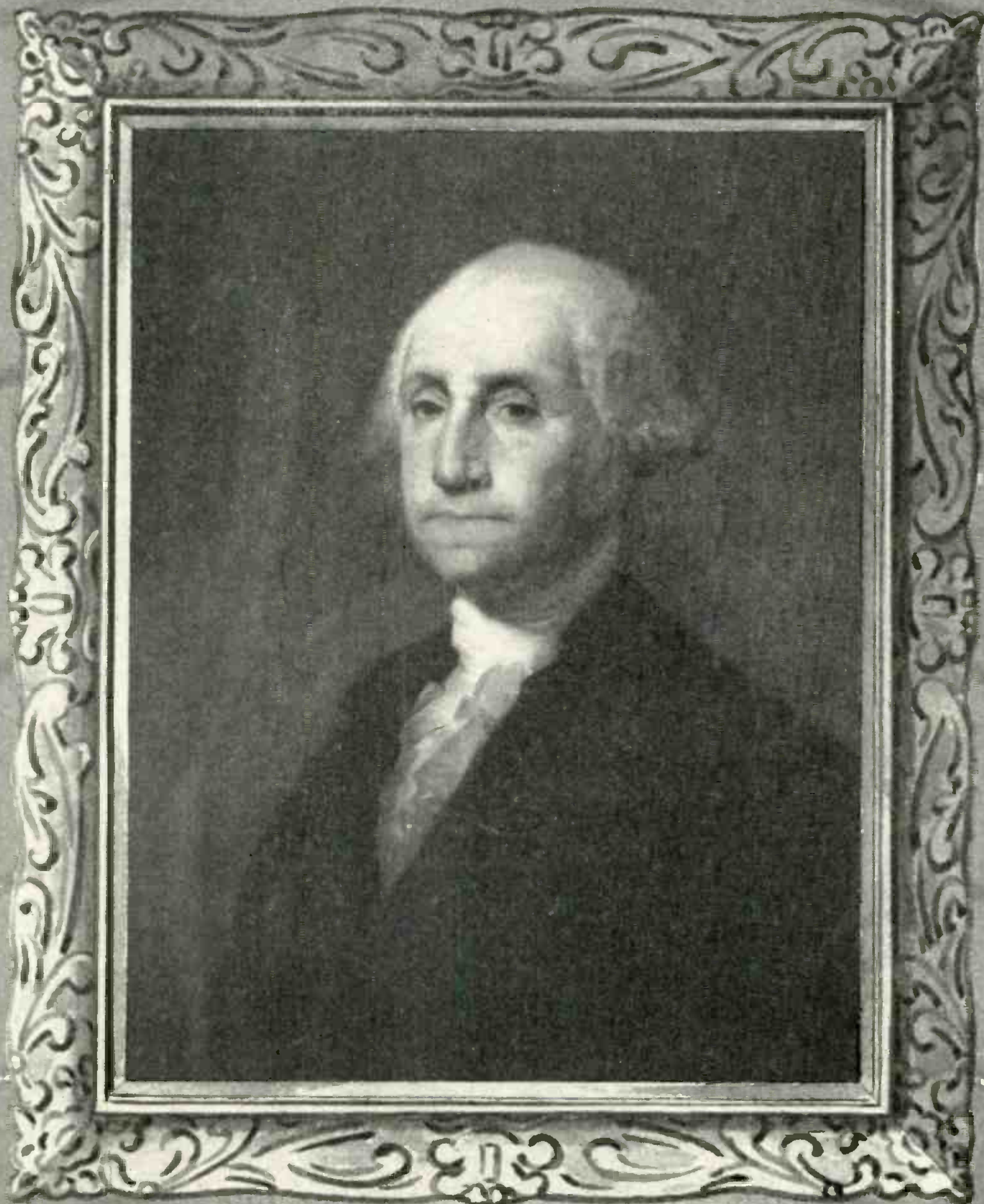
ARMY E NAVY

Engineering, Development,
Precision Electrical Manufacturing



A WIDE-RANGE LOGARITHMIC

D-C Amplifier

PAUL SELGIN
Polytechnic Institute of Brooklyn

Design Data Covering an Experimental D-C Amplifier, Suitable for Measurement Purposes, Which Has a Logarithmic Response Characteristic

★ It is often desirable to be able to read a wide range of d-c or a-c voltages or currents, without having to switch to an appropriate scale. This article describes a type of d-c amplifier, suitable for measurement purposes, which eliminates the need for range selection over a voltage ratio of 1000 to 1.

Ordinary meters do not function with greatest accuracy over a range much in excess of 10 db (or about 3 to 1); that is, if the full-scale reading is, say, 1 ampere, they will not indicate with utmost accuracy currents less than 0.3 ampere on the same scale. Meters with "square-law" scales are still poorer in this respect. Yet the audio current in a speaker, for instance, may vary in a ratio of 1000 to 1 during its normal operation or, in other words, the speaker may respond audibly, and without overload, to currents within a 60-db range, or more. The same is true of the ear with respect to sound pressures, or of an amplifier with respect to signal voltages. Thus these ranges are far beyond the practical limits of a single-range meter.

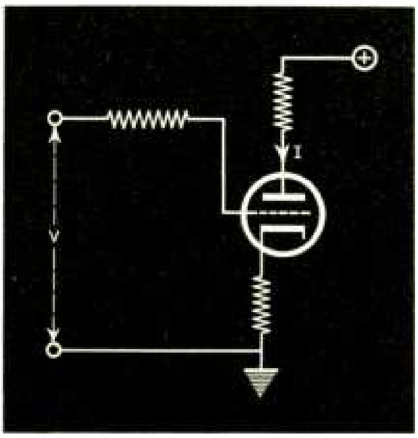


Fig. 1. Fundamental circuit of d-c amplifier stage

Range Selection

This shortcoming of meters is usually overcome by range selection. This is essentially a switching operation which reduces the sensitivity of the meter by steps; in this way the useful db range of the meter is multiplied by the number of steps (unless there is some overlapping, as is usually the case). The sensitivity of the meter is reduced by adding shunts or multipliers, or combinations thereof, depending on the type of meter.

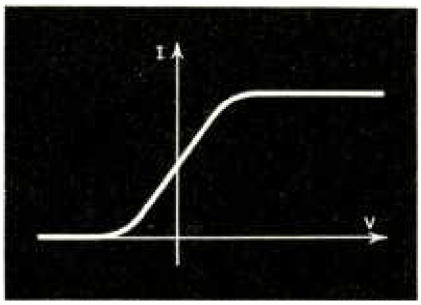


Fig. 2. Grid voltage-plate current characteristic

Range selection has the following disadvantages, which may be serious in some applications:

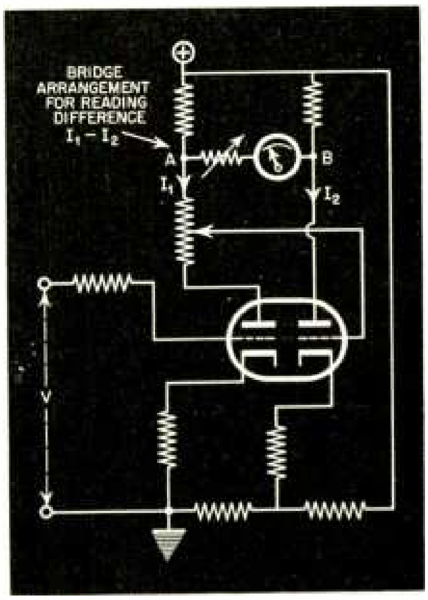


Fig. 3. A differential amplifier stage

1. It requires multiple switches which, sooner or later, cause trouble when subjected to constant use.
2. It changes the impedance of the meter circuit, with the result that, no matter how accurate the calibration, different readings are obtained on different scales. This is annoying even if the error involved is not important.
3. It exposes the meter to overload if the correct range is not selected.
4. It makes necessary a number of scales on the same dial or worse, it forces the operator to perform mental

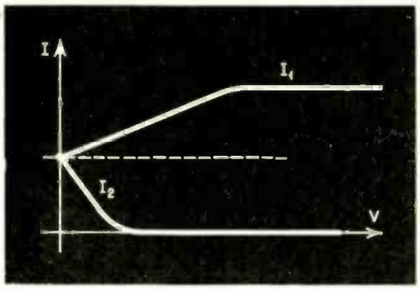


Fig. 4. Differential plate-current curves resulting from the circuit of Fig. 3

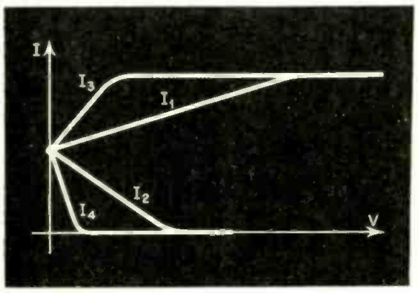
calculations which take his mind off more important matters.

5. It does not respond instantaneously, hence is useless when the readings are rapidly variable, and particularly for recording purposes.

The Logarithmic Scale

The disadvantages of range selection have led to considerable research in the hope of finding a suitable substitute. Evidently some device is needed which will automatically adjust the sensitivity of the meter according to the value of the voltage or current to be measured. An ideal device would perform this operation continuously, causing the sensitivity to be inversely proportional to the input current or voltage value. Mathematically, if D is the scale reading (number of divisions, assuming a uniform scale) and I is the input, the sensitivity is

$$S = \frac{dD}{dI}$$



We have to express S as a derivative because D and I do not vary proportionally, just as the velocity is expressed as a derivative when time and distance covered are not proportional. Now if S is to be inversely proportional to I, we have

$$SI = I\frac{dD}{dI} = K$$

where K is a constant. We have written the differential equation

$$dD = K\frac{dI}{I}$$

which can be integrated by inspection, giving

$$D = K \log I + K^1$$

K^1 is the reading for zero input. Making this coincide with the zero of the scale, letting D_f stand for the full scale

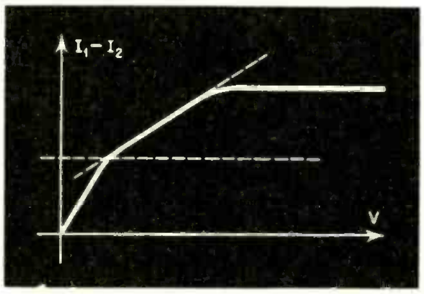


Fig. 5. The differential current plotted against a linear scale

reading (total number of scale divisions) and I_f for the full scale input, the above becomes:

$$\frac{D}{D_f} = \frac{\log I}{\log I_f}$$

It appears that this ideal meter would have a *logarithmic scale,* similar in every way to a slide-rule scale. On this scale, db readings would be uniformly spaced. It is a matter of common knowledge that the percent error in reading a logarithmic scale is constant, whereas on a linear scale it is higher near the low end.

Several logarithmic scale meters have been made: some of them have been extremely successful; however, the more successful ones minimize, but do not exclude the need for range selection; a very popular model has a 10 to 1 range, which may be extended by range selection.

Design Difficulties

The difficulty has been two-fold: First, attempts to obtain a response which is *exactly* logarithmic over a wide range (over some 30 db) have failed. Secondly, it has been considered undesirable to "crowd" more than 40 db into a meter scale. The second difficulty makes it imperative occasionally to resort to range selection for this reason, approximately logarithmic

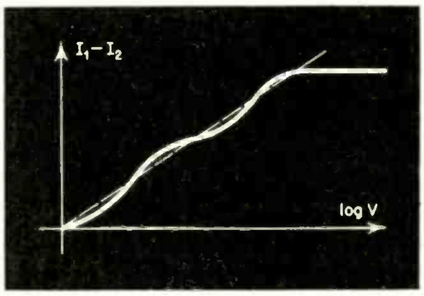
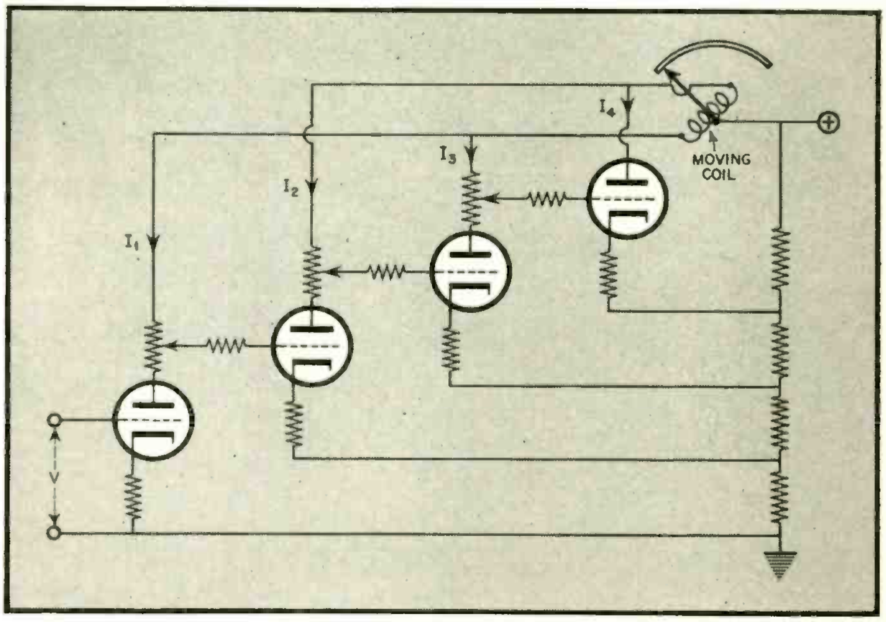


Fig. 6. Resulting differential current curve when plotted against a logarithmic scale

response will not do, because two separate scales would have to be provided. There have been other difficulties, of course, chiefly because experimenters (including the writer, in an early attempt) tried to obtain the desired feature by amplifying the a-c input to be measured through a special type of "variable gain" a-c amplifier. This is indeed a difficult assignment, because the amplifier gain, although variable

Fig. 7. In (A), below, a multi-stage version of Fig. 3 is shown. The current curves are plotted in (B), at left



with the input amplitude, must be constant with frequency.

Design Requirements

In the opinion of the writer, a very satisfactory all-purpose measuring instrument may be obtained by combining the following:

1. A rectifier of the "probe" type, designed for operation up to several hundred megacycles and converting the a-c voltage to be measured (whether a.f., r.f. or u.h.f.) into a d-c voltage *in the probe rectifier,* the lead from the probe to the meter carrying d-c only. This is a common feature of many vacuum tube voltmeters.
2. A "wide-range" d-c amplifier. The gain of such an amplifier varies in the number of steps, so that the output is *approximately* proportional to the log of the input. How such a unit may be designed will be shown presently.
3. A rugged d-c meter with a scale 6 inches long, or preferably longer, or a recording instrument. Meters wound on a differential principle would seem to be particularly suitable, although the writer has not been able to obtain one for experimental purposes.

A type of "wide-range" amplifier, which has been found satisfactory, will now be described. Other equivalent or better types might undoubtedly be, or perhaps already have been developed. While this instrument has not been used with the recommended probe for a-c measurements, it is adapted to this use, though the calibration will be different from that required when d-c voltages are being checked.

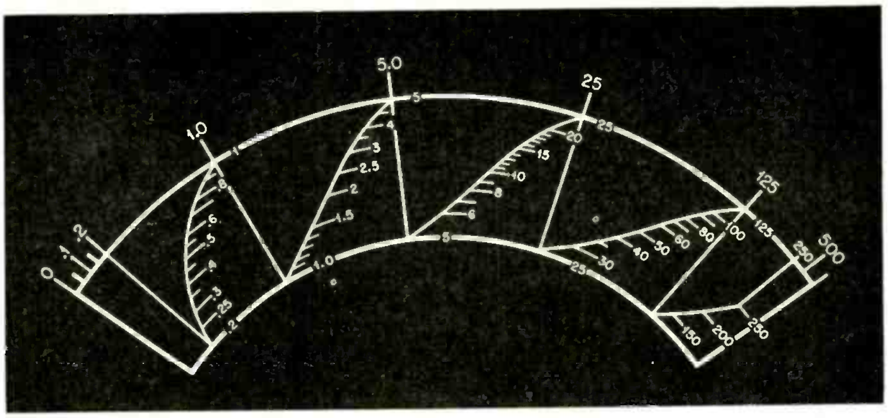


Fig. 10. The meter scale for the experimental d-c amplifier

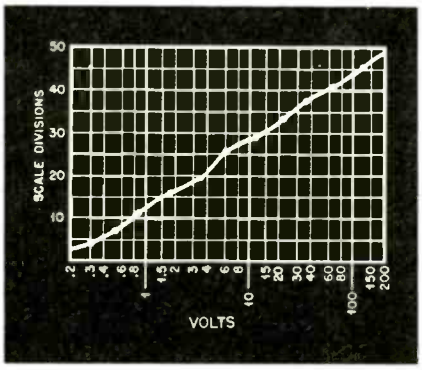


Fig. 9. Deflection vs. input voltage curve for the circuit of Fig. 8

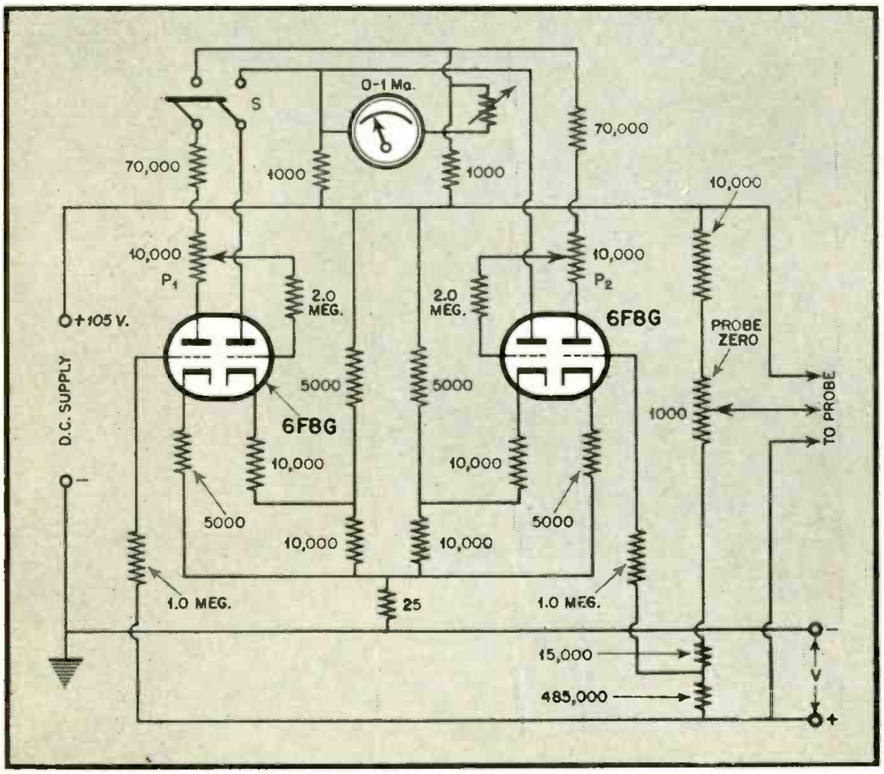


Fig. 8. Complete circuit of experimental d-c amplifier

The principle of the suggested wide-band d-c amplifier will be made clear by the circuit of *Fig. 1* and the diagram *(Fig. 2).*

The circuit includes a triode (type 6F8-G has been found satisfactory for the purpose) with plate load and cathode bias resistors. Also, the grid voltage is received through a series resistor of 1 meg. or higher.

Suppose the applied voltage varies between a *large negative* and a *large positive* value. At first, no plate current will flow; when the grid bias equals cut-off current will start to flow, and from that point on an increase of plate current will follow each increase of grid voltage until the grid becomes positive with respect to the cathode. At this point grid current will begin to flow, and this will promptly nullify any further increase of the applied voltage because of the large drop in the grid leak. Hence the overall plate current-applied voltage characteristic will be roughly that of *Fig. 2.* We may assume the rising part of this characteristic to be straight, although this is not exactly true.

In principle, the key to the problem is found in the shape of this characteristic. We have a stage which responds *only over a range* of the input. By placing many such stages in parallel, letting each receive a suitable fraction of the input (1/10, 1/100, etc.) and surmounting a number of difficulties the problem could be solved. However, a much more elegant solution results if we resort to the *differential stage* of *Fig. 3.*

The Differential Unit

Fig. 3 represents two stages like that of *Fig. 1,* coupled in cascade.

The tap on the plate resistor of stage *1* (this resistor is, in practice, a wire-wound potentiometer) can be adjusted until the currents at points *A* and *B* are equal when the applied voltage is zero. The difference between the two currents may be read by the bridge ar-

[*Continued on page 52*]

HERMETIC SEALING OF

Capacitors and Transformers

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Methods of Designing Satisfactory Hermetic Seals For Use Under Rigorous Climatic Conditions

★ The advent of war has brought about a great change in the construction of both capacitor and transformer casings. The primary cause for this change is the fact that the Armed Forces find themselves in all parts of the world. Their radio and electronic equipment must maintain satisfactory operation in a wide range of temperatures and unusual climatic conditions. It is not at all uncommon for a given type of equipment to be found on shipboard, in desert country, in subtropical regions, or in the arctic.

Unless special care is exercised in the design of capacitors and transformers the life of these components is short when subjected to the ravages of temperature and humidity. When salt spray is present, as encountered in marine installations, the deterioration is even greater and more rapid. In subtropical regions where high temperature as well as high humidity prevail, fungus growths add to the possibility of failure.

Why Failures Occur

Failure of these components frequently comes, first, from a breakdown of the insulating material between the leads or terminals of windings, or of the electrodes of the capacitor, or between the leads and the case (normally at ground potential). The case and insulating materials have different rates of expansion with temperature; the insulating material may be hygroscopic. These two conditions are sufficient to permit inclusion of humidity and/or salt-laden air into the interior of the device as "breathing" takes place with variation of temperature. Paper and cardboard containers offer no resistance to the destructive attack of the elements, and metal housings of conventional commercial design practice filled with potting compound do not offer sufficient protection.

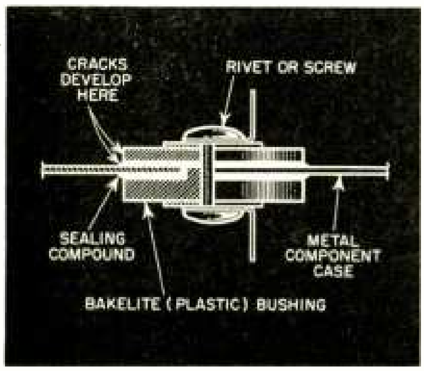

Fig. 1. Close fitting plastic assembly

Partial duplication of the actual climatic conditions to which these devices are subjected is possible in test chambers especially equipped to provide various combinations of temperature and relative humidity. This could prove to be a time-consuming procedure; hence, to accelerate the investigation of components proposed for marine service a standard test procedure has been evolved. This consists of a series of salt water immersion cycles.

A test transformer is immersed for 2 hours in a saturated solution of sodium chloride at 75° C; this is followed immediately by immersion for 2 hours in a similar solution at 0° C; after this the specimen is washed thoroughly, dried, and is operated at rated load for 2 hours. This cycle is carried out five times, after which the leakage resistance between windings or from windings to the case shall not be less than 75 megohms.

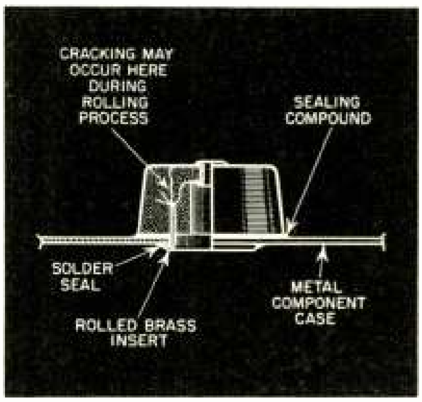

Fig. 2. Plastic bushing with insert

In the case of capacitors, five immersion cycles are employed consisting of 2 hours at 75° C, and 2 hours at 0° C; following this the capacitor is immersed in a saturated sodium-chloride solution at room temperature for 24 hours. After having been washed thoroughly and dried, the leakage resistance between terminals shall be greater than 600 megohm-microfarads, but need not exceed 2000 megohms.

These routines may appear unduly severe, but one can feel certain that any component packaged so that it will meet these requirements will have

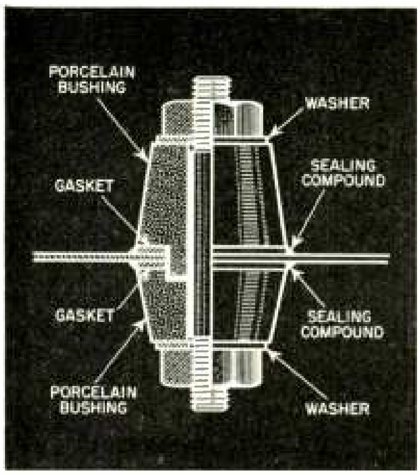

Fig. 3. Porcelain bushing with gaskets and sealing compound

more than a fair chance of rendering satisfactory service in actual use.

Precautions in Sealing

The direct solution to this problem is to seal hermetically the transformer or capacitor into a metal container. This solution is a satisfactory one except for the difficulty of creating an effective seal for the insulating bushings necessary for bringing out the terminal leads from the enclosed component. The metal housing is of drawn or welded sheet metal construction. Care must be taken to have all seams in the metal thoroughly filled with solder. All mounting studs must be mechanically secure, and must be sealed with solder. In no case should the solder be relied upon for mechanical strength; it is to be used as a sealing agent. Either the metal housing must be capable of resisting corrosion or it must be protected by an electrolytically deposited coating of any one of the corrosion-resisting metals. Cadmium-plated steel is frequently used, for it meets the requirements of withstanding 200 hours of salt spray without corrosion.

Creation of a tight seal at the point where a terminal lead is to be brought out is a much more difficult task. Several attacks have been made in this direction.

Close fitting bakelite bushings (*Fig. 1*) have been riveted or held together tightly with nuts and screws. Before assembly all joining faces were coated with a resinous sealing compound. Excess resin was removed and the whole assembly allowed to cure, either by natural "drying" or by heating. Accelerated life tests on this type of bushing disclosed a tendency of the bakelite to delaminate or to pull away from the sealing compound. In either case small cracks develop which permit entry of moisture. These small cracks would provide excellent places for fungus growths to start if the equipment is used in tropical regions. The growths expand and in time form a shunt path from one terminal to the next or to the case.

Molded plastic bushings with brass mounting inserts (*Fig. 2*) have been tried with partial success. Such bushings when mounted have the brass insert rolled over onto the metal housing and a solder seal is made at that point. Failure of this arrangement occurs most frequently when the brass insert is loosened in the plastic as a result of the rolling or riveting operation.

Successful Seals

Bushings of glazed ceramic, porcelain, and glass (*Fig. 3*) have been used in conjunction with sealing compounds and gaskets of various materials. Gaskets are used to fill up the major irregularities on the mounting surfaces of the bushings as well as to provide some resilience in the assembly when the screw stud is tightened. Here again sealing compounds are used on the interfaces of the mounting to complete the seal. By careful design of the various parts of the assembly, by proper choice of gasket material and sealing agent, and by care in execution of the assembly good seals can be achieved. To date this has been the most successful means of making a moisture-proof terminal.

While the porcelain (glass or ceramic) bushing together with gaskets and sealing compound has been successful, it leaves something to be desired in compactness, simplicity, and certainty of assembly. The ideal arrangement would be an insulating material which could be attached to a metal by soldering. A recent development of the glass industry is a bushing which appears to conform to these requirements. It consists of a thick-walled, heat-resistant glass tubing with bands of metal fused into the glass itself. The metallized surface is tinned to prevent corrosion and to aid in soldering (*Fig. 4*).

Metallized Glass Bushings

This type of bushing is easy to install for terminal studs and mounting rings may be attached by ordinary soldering techniques (both by iron and by gas flame). By the elimination of gaskets and sealing compound the uncertainties of these processes are obviated. It is claimed to have good mechanical strength, as well as high resistance to thermal shock and pressure variation.

This construction has been applied in the past to large porcelain high-voltage insulators and has proved very satisfactory. If the fusion of the metal is well done, this would seem to be the most satisfactory hermetic seal terminal yet devised. With it mounted on the solder sealed metal housing, true sealing against moisture penetration can be realized. A further advantage lies in the fact that no porous organic materials are used in the construction so that there is an absence of material from which fungus growths might find nourishment. This development holds much promise; a complete statement of its merit can be made only after it has been in use long enough to observe its performance.

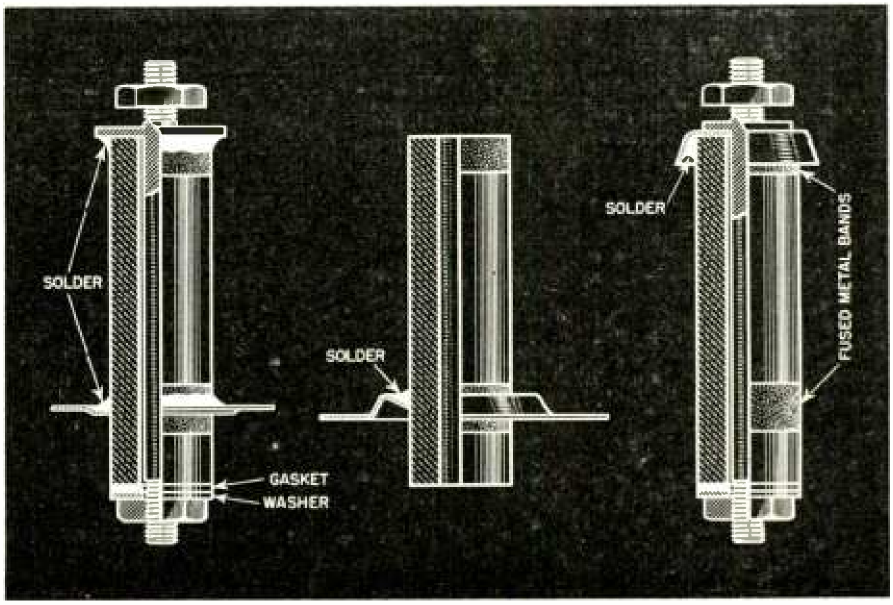

Fig. 4. Glass tubing bushings with fused metal bands

Slide Rule Short Cuts

JOHN M. BORST

Methods of Speedily Solving Many Equations Encountered in Radio and Electronic Design

★ Radio calculations can readily be performed on standard slide rules. While the slide rule is in common use among engineers and technicians, few take full advantage of all the facilities it provides. Especially the possibilities presented by the folded and inverted scales appear to be neglected. This article is a brief review of the properties and use of these scales with examples taken from the radio field.

Definition of Terms

In order to make this article useful to beginners who might otherwise not be able to follow it, it shall be necessary to define some very elementary terms. It is hoped that others will bear with us. The slide rule consists of a fixed part, called the *stock,* which bears graduated scales, and a sliding part, the *slide,* also provided with graduated scales. Over this runs a piece of translucent material with a hairline, the *indicator,* which serves to facilitate the reading of the scales.

The scales on both the slide and the stock consist of one or more cycles of a logarithmic scale beginning at 1 and ending at 1. These ends of the scale where the division 1 is located are called the *index.* Most scales have a left-hand and right-hand index. Some have an index in the center only.

The different scales on the slide rule carry identifying letters, such as *A*, *B*, *C*, etc., and these letters are the same on all slide rules; that is, the same letter always refers to the same kind of scale regardless of the type or make of the rule.

On some slide rules, the stock carries scales on one side only, while on others, the *duplex rules,* both the stock and the slide carry scales on both sides. On these rules the indicator carries a reference hairline on both sides of the rule and these two hairlines are so adjusted that when one is placed over an index of the stock on one side of the scale, the other hairline will cover the same index on the back side of the rule. Thus the two sides of the slide rule are really one and readings from one side can be referred to the other side.

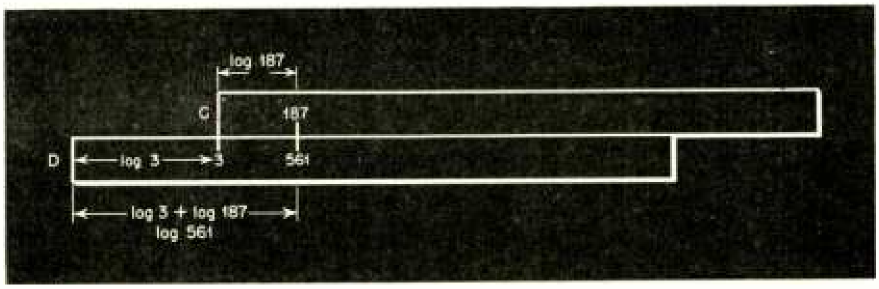

Fig. 1. Solving a simple example of Ohm's law

According to the complexity of the rule, it bears different names, such as the Mannheim slide rule, the polyphase, the polyphase duplex, log-log duplex, log-log vector, etc. We shall consider here all of the scales on these rules, starting with the simplest ones, so that an owner of a Mannheim slide rule can understand the beginning.

Directions for the use of a slide rule soon become a system of abbreviated sentences, technical jargon such as: To 2 on *D* set 3 on *C*, opposite 6 on *C*, read 4 on *D*. *Translation*: Set the hairline of your indicator to the division marked 2 on scale *D*. Move the slide so that the division marked 3 on scale *C* also comes exactly under the hairline of the indicator. Then move the indicator to the division 6 on scale *C* and read the answer on scale *D*. In this case it will be in line with the division marked 4. We have here performed the operation

$$\frac{2}{3} \times 6 = 4$$

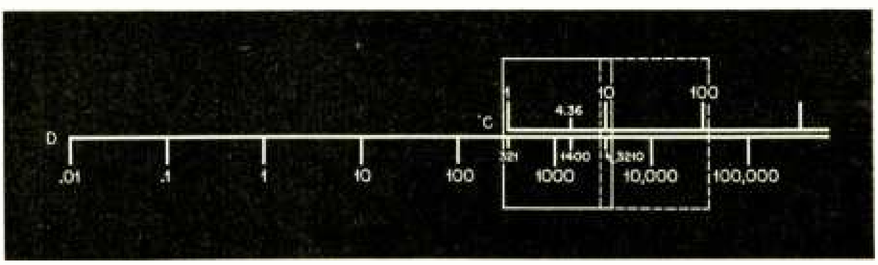

Fig. 2. How to keep the result "on scale". See text.

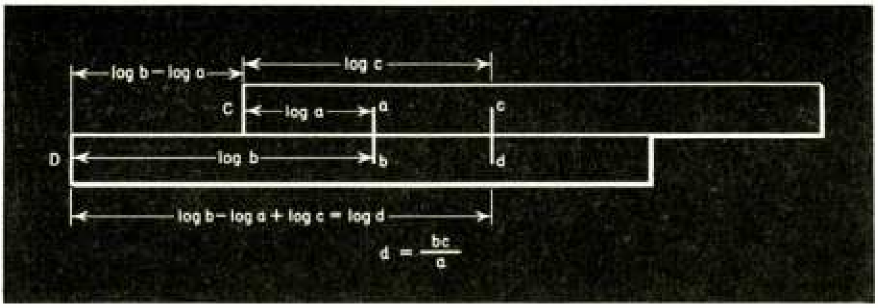

Fig. 3. Combining multiplication and division in a single setting

Use of "C" and "D" Scales

Simple multiplication of two factors, or ordinary division, is done by means of the *C* and *D* scales. Let us take a simple example of Ohm's law:

$$E = I R$$

To solve this equation one can use the following procedure: *Opposite I on scale D, set the index of scale C. Opposite R on C, read E on D.*

For example: Let the current in a circuit be .3 ampere and the resistance 187 ohms. To find the voltage drop across this resistance, set the left index of scale *C* opposite 3 on *D* (*Fig. 1*). Opposite 187 on *C*, read 561 on *D*. The decimal point is placed by inspection: obviously, the answer is 56.1 volts. Note in the illustration that the distances on the scales are proportional to the logarithms of the numbers marked on it and that we have added these logarithms in order to perform a multiplication.

When the result falls "off the scale," set the *right-hand* index of *C* to the value of *I* on *D* and proceed as before. Why this may be done is best illustrated by referring to *Fig. 2*. Scale *D* is shown here infinitely long; the slide rule represents any one section of this scale—any section or cycle desired by simply imagining the decimal point changed. Now let it be required to multiply 321 by 4.36. Setting the left index of *C* to 321 on *D*, the scale *D* now represents the section from 100 to 1000 on an infinitely long logarithmic scale. Similarly, the scale *C* represents the section from 1 to 10 on an infinitely long *C* scale. Placing them in the proper position with respect to each other, as in *Fig. 2*, the point 4.36 on the *C* scale will fall beyond the 100-1000 section of the *D* scale. Instead, it falls within the next, the 1000-10,000 section. We can now imagine the scale *D* of the slide rule to become this next section and to represent 1000-10,000. It is then necessary to place the *C* scale in the same relation to the *D* scale as it is in *Fig. 2*. This is done by setting the other index of *C*, the right-hand index, to the division 3210 on the *D* scale. Then it is possible to find our answer on *D* opposite 4.36 on *C*; the answer is 1400; (exact answer is 1399.56). Note that this procedure causes the decimal point to be moved one place to the right.

In the case of division, the same procedure is followed backwards. Opposite the dividend on *D*, set the divisor on *C*. Opposite either index on *C*, find the quotient on *D*. *Example*: What is the resistance of a circuit when a potential difference of 45 volts produces a current of .15 amp.? Set 15 on scale *C* to 45 on scale *D*. Opposite the left index of *C*, find 3 on *D*. The answer is 300 ohms.

Rules for Decimal Point

The fact that one does not find the decimal point is a difficulty at times. One way to simplify the problem is to write it in the following form

$$321 \times 4.36 = 3 \times 4.36 \times 10^2 = 14 \times 10^2 = 1400$$

Since we have seen that when the right index of the scale *C* has to be used in multiplication, the decimal point moves one more point to the right, this system shows the placing of the decimal point automatically.

In the case of division the same rules can be followed; here the decimal point moves one extra space to the left if the right index of *C* has to be used.

$$\frac{42}{1050} = \frac{4.2 \times 10^1}{1.05 \times 10^3} = 4 \times 10^{-2} = .04 \quad \text{(left index)}$$

$$\frac{42}{6000} = \frac{4.2 \times 10^1}{6 \times 10^3} = .7 \times 10^{-2} = .007 \quad \text{(right index)}$$

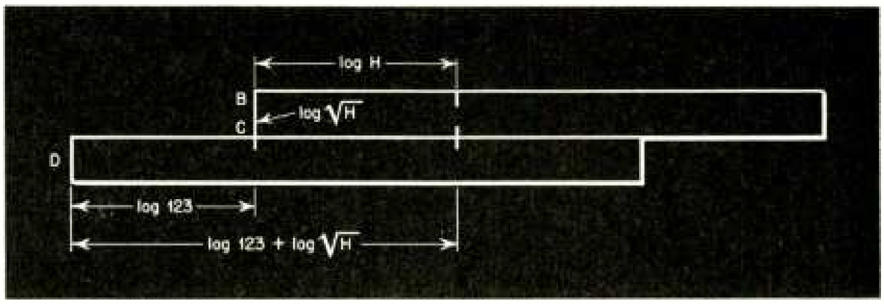

Fig. 4. Solving a common UHF transmission problem. See text.

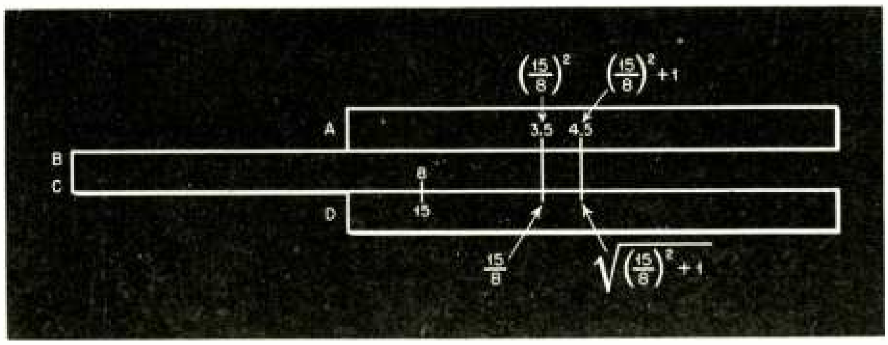

Fig. 5. A short-cut in calculating impedance. See text.

Two Simultaneous Operations

It is possible to do one multiplication operation and one of division at the same setting of the slide using nothing but the *C* and *D* scales. Such a problem may come up when solving for the unknown arm of a bridge network:

$$\frac{a}{b} = \frac{c}{d} \text{ or } d = \frac{bc}{a}$$

In this case the division is done first: Opposite *b* on *D*, set *a* on *C*; opposite *c* on *C*, find *d* on *D*. This is illustrated in *Fig. 3*.

It should also be clear that this can be done when one considers that when beginning a multiplication one sets an index of *C* to a factor on *D*. When finishing with a division, one ends up with this same situation, that is, an index of

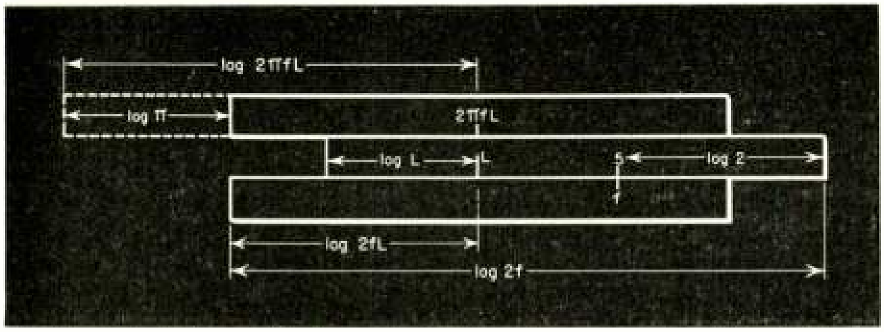

Fig. 6. Showing the use of folded scales. See text.

C is opposite the result on D and the slide is already in the correct position for multiplication of the result with any other factor.

This solution of proportions is very useful for conversion of units. To convert inches to centimeters or vice versa, set 254 on C to the index of D. Opposite inches on D, find centimeters on C, pointing off two places.

To convert statute miles to nautical miles or vice versa, set 5280 on C to 6080 on D; opposite nautical miles on D find statute miles on C.

Use of A and B Scales

The A and B scales carry two logarithmic cycles within the length of the slide rule and they are so positioned that any division on A is the square of any division on D directly below it, and the same applies to B and C.

To square a number, set the indicator to that number on D and read answer on A. To find the square root of a number, set the indicator to that number on A and find the square root on D. Here it is necessary to use the proper section of A, otherwise an incorrect answer will be obtained. The first half of the scale A can represent 1-10 and the second half 10-100. For numbers between 100-1000 the first section must be used again, and so on.

Employing the A and B scales to perform a multiplication together with extracting a square root is exemplified in the equation

$$D = 1.23\ \sqrt{H}$$

which gives the distance D in miles to the horizon for an observer H feet above the ground—an important equation for uhf transmission.

Question: How far away is the horizon for a man on top of a 1000 foot tower? Set index of C to 123 on D; opposite H on B find distance on D. In this case H is 1000 and we must use the 1 in the center of the scale. The answer is 38.9 miles. This is illustrated in *Fig. 4*.

The A and B scales are useful to find the power in equations such as

$$P = I^2R \qquad P = \frac{E^2}{R}$$

To R on D set index of C, opposite R on B find P on A. To E on D set R on B, opposite index of B find P on A.

Finding Z when R and X are given has always been a tedious job.

$$Z = \sqrt{R^2 + X^2}$$

This equation could be solved by finding the squares, adding them by longhand and then finding the square root, but it can be done more easily. The equation should be re-written:

$$Z = R\sqrt{1+(X/R)^2} \qquad Z = X\sqrt{(R/X)^2+1}$$

It will be easiest to choose that form of the equation which makes the fraction greater than unity.

Example: What is the impedance of a circuit when the resistance is 8 ohms and the reactance 15 ohms? Re-write the equation:

$$Z = 8\ \sqrt{1+(15/8)^2}$$

Referring to *Fig. 5*, to 15 on D set 8 on C. At index of C read 3.5 on A. Mentally add 1 and set index to this amount on A. Opposite 8 on C, find Z on D; the answer is 17 ohms.

In this connection it is well to remember that if either of the two quantities R and X is more than 10 times the other, the value of Z equals the larger one to within ½ per cent.

Another way of solving this particular problem is given later under "trigonometric scales."

Folded Scales, "CF" and "DF"

The two scales CF and DF are displaced with respect to the C and D scale by the amount of π; by this means one may multiply or divide by π without additional movements of the slide. For instance, to find the reactance of an inductor

$$X = 2\,\pi fL$$

set the index of C to $2f$ on D; opposite L on C, find X on DF. Or, to f on D, set 5 on C; opposite L on C, find X on DF. The why and wherefore is pictured in *Fig. 6*.

Conversely, any point on scale D is $1/\pi$ of the point on DF directly above it. To find the reactance of a capacitor, consider that the indicator set on 1 on DF shows $1/\pi$ on D and, when it is set at .5 on DF, shows $1/2\pi$ on D (this is .159). To find the reactance one has to divide successively by C and by f. This work can be shortened by using the inverted scales, discussed later.

Another benefit of the folded scales is that it eliminates the "off the scale" problem and obviates the necessity of drawing the slide more than half way out of the stock.

To multiply 3 by 4. Set 1 on CF to 3 on D. Opposite 4 on CF, read 12 on D. Had this been done in the ordinary

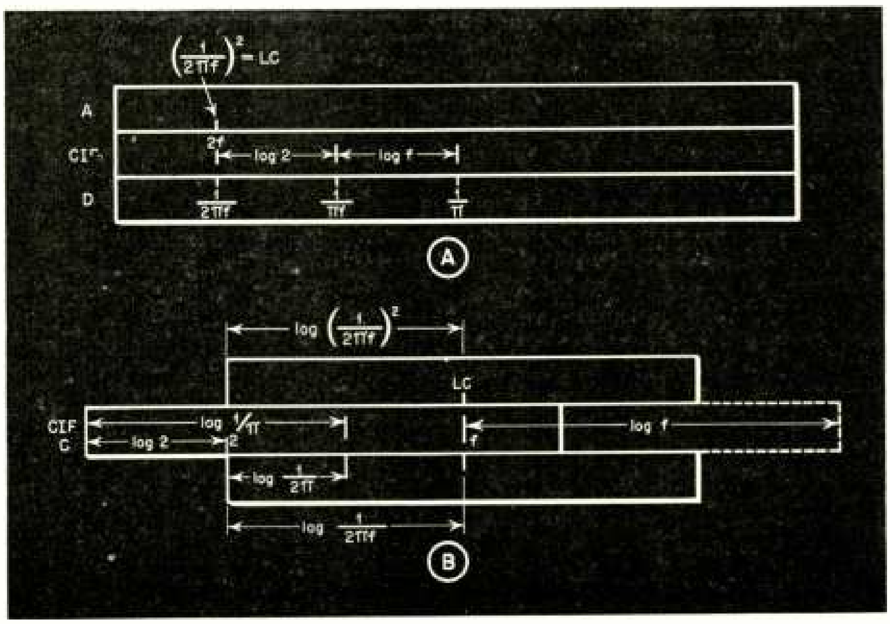

Fig. 7. In (A) and (B) alternative methods of finding LC products are shown

way, the answer would be off the scale and another move of the slide would be needed.

Let it be required to multiply 92 by 105. It would normally necessitate drawing the slide almost all the way out of the stock, if the *C* and *D* scales were used. However, set 1 on *CF* to 92 on *DF*; opposite 105 on *CF* find 966 on *DF*. The answer is 9660.

Inverted Scales, CI and CIF

The addition of the inverted scales makes it possible to multiply three factors with one setting of the slide (four factors if one of them is π), besides their use for inversion. Now there are two ways to multiply or to divide.

Heretofore, in order to multiply we have set the index of *C* to one factor on *D*. By means of the inverted scale we can set the second factor on *CI* to the first factor on *D* and read the answer at the index of *CI* on *D*. *Example*: To multiply 25 by 35, set 35 on *CI* to 25 on *D*; opposite the index of *CI* find the answer, 875, on *D*. If this product has to be multiplied again by a third factor, 2.3 for example, the index of *C* would have to be set to 875 on *D*; but it is there already. Therefore, by setting the indicator to 2.3 on *C*, read the answer, 2050, on *D*. If instead, the third factor should be a divisor, as in:

$$\frac{25 \times 35}{2.3} = \frac{875}{2.3} = 380$$

the indicator should be set to 2.3 on *CI* and the answer read on *D*. This last

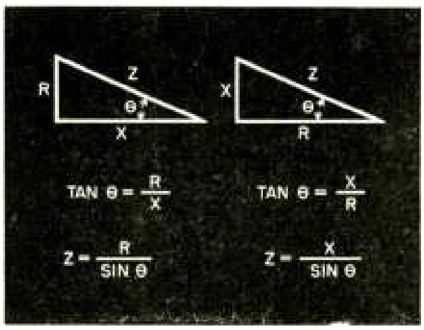

Fig. 8. Equivalent trigonometric formulas for impedance components

operation might be called a second form of division. In other words, to divide when using the *CI* scale, set the index of *CI* to the dividend on *D*. Opposite the divisor on *CI*, find the quotient on D.

Note that for this type of division the setting of the slide is the same regardless of the value of the divisor. Therefore, if one has to divide one fixed number by many different divisors, all divisions can be performed with but one setting of the slide. A typical application of this is to find the frequency when the wavelength is given, or vice versa. Set 3 on *CI* to the index of *D*; opposite *f* on *CI* read wavelength on *D*, or vice versa.

It is more convenient to use the *CIF* scale for this purpose. To 3 on *D* set 1 on *CIF*, opposite *f* on *CIF* find wavelength on *D*.

To find the wavelength in *inches*, set 254 on *C* to 3 on *D*; opposite megacycles on *CI*, find inches on *D*.

Solving Reactance Equations

By the use of the folded and inverted scales one can find the reactance in one setting. To find inductive reactance, set *f* on *CI* to *L* on *D*, opposite 2 on *C* find *X* on *DF*. *Example*: What is the reactance of a 2-henry coil at 60 cycles? Set 2 on *CI* to 6 on *D*; opposite 2 on *C*, find 756 ohms on *DF*.

To find the reactance of a capacitor: To 5 on *DF*, set *f* on *C*; opposite the value of capacitance on *CI* find *X* on *D*. *Example*: What is the reactance of an 8μf capacitor at 120 cycles? Opposite 5 on *DF* set 120 on *C*; opposite 8 on *CI*, find 166 ohms reactance on *D*.

If, in the above example, the frequency were 60 cycles, the answer would again be off the scale. This can be remedied by using the folded scales *CF* and *CIF* instead of the *C* and *CI* scales. So, to find the reactance of an 8μf capacitor at 60 cycles, set 60 on *CF* to 5 on *DF*; opposite 8 on *CIF*, find 322 ohms on *D*.

To find the *LC* product for any frequency, set 2 on *C* to the left index of *D*; opposite *f* on *CIF* read *LC* product on *A*. Or, line up indices of slide in stock at both ends, the slide being entirely within the rule. Mentally multiply *f* by 2, opposite 2*f* on *CIF* find *LC* product on *A*. The explanation of this can best be derived from *Figs. 7(A) and 7(B)*. As an example, let it be required to find the *LC* product to tune to 45 mc. Set 2 on *C* to left index of *D*; opposite 45 on *CIF*, find 125 on *A*. The answer is 12.5 in micromicrofarads and microhenries.

If the individual values of *L* and *C* are wanted one might divide, using the *A* and *B* scales, but it is more convenient to employ the *CI* and *D* scales, so that all the combinations of *L* and *C* which will tune to the required frequency can be had at once. To do this one must perform the previous operation twice. With both indices lined up, set indicator to 2*f* on *CIF*, move index of slide to indicator (use the right or left index, whichever is nearest to the indicator). Then set the indicator again to 2*f* on *CIF*; read *LC* on *D*. Set 1 on *CI* (or *CIF*) to indicator, whichever is more convenient, and read corresponding values of *L* and *C* on *D* and *CI* (or *CIF*).

The L Scale

A linear scale, the *L* scale, is most useful for solving problems involving decibels. The linear scale, if it is on the stock, shows the common logarithm of values on the *D* scale. On some rules it is on the slide and is then referred to the *C* scale.

Opposite power gain on *D*, find decibel gain on *L*. When the gain is between 1 and 10, the decibel scale runs

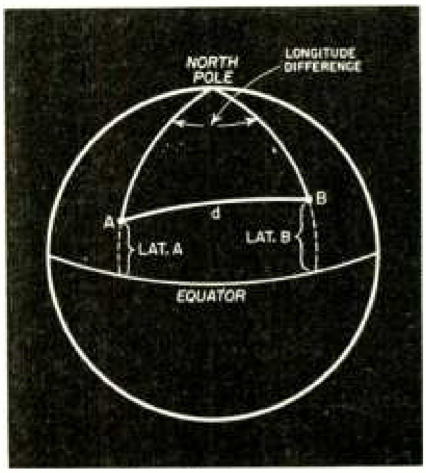

Fig. 9. Finding great circle distances. See text.

from 1 to 10. If the gain is between 10 and 100, the decibel scale runs from 10 to 20, etc.

Opposite power loss on *CI* (*C* and *D* in alignment), find db loss on *L* scale. Or, rather, when the gain is less than unity, use the *CI* scale. When the gain is between .1 and 1, the decibel scale runs from 0 to —10. When the power gain is between .01 and .1, the decibel scale runs from —10 to —20.

Use of Log-log Scales

Since the log-log scales enable one to find the logarithm of any number to any base, they are well suited to problems with decibels. When the left index of *C* is set to 10 on *LL3*, the power gain in decibels is found on the *C* scale opposite the power ratio on the *LL3* scale. The *C* scale here runs from 10 up. If the right index of the *C* scale were set to 10 on *LL3*, it would run from 10 down.

The conversion of voltage or current ratios to decibels is done by setting 2 on *C* to 10 on *LL3*.

With the slide entirely inside the stock, both indices aligned, the gain in nepers is found on *C* opposite the voltage or current ratio on *LL3*.

To convert nepers to decibels or vice versa, set 2 on *C* to 10 on *LL3*, opposite nepers on *D*, find decibels on *C*. If the neper scale runs from 1 to 10, the decibel scale runs from 10 to 100.

[*Continued on page 42*]

USING DETERMINANTS TO SOLVE

Kirchhoff's Equations

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How Determinants Can Save Time in Solving Problems Involving Simultaneous Equations

★ The subject of determinants, like so many other fields in mathematics, may easily be applied to practical problems with little or no knowledge of the principles involved. To a practicing engineer mathematics is just a working tool; but even the most practical minded one will admit that some understanding of his tools is essential for economical and intelligent handling.

These considerations have led the author to the task of including some of the theory of determinants, before their practical value is shown.

There is no shorter way of solving Kirchhoff's or any other simultaneous equations than by means of determinants and so this paper should prove of interest to all those engaged in the study of complex networks.

INTRODUCTION TO DETERMINANTS

Assume any hypothetical arrangement of impedances, such that the resulting simultaneous equations set up by means of Kirchhoff's rules are of some such form as

(1) $$Z^1_1 I_1 + Z^1_2 I_2 = E^1$$

(1a) $$Z^2_1 I_1 + Z^2_2 I_2 = E^2$$

where the Z^i_j and the E^i are known constants. The problem is to solve for the I_j—and that is not an impossible task provided the number of equations, i, equals the number of unknowns, j.

Multiplying (1) by Z^2_2 and (1a) by Z^1_2 and subtracting, we get a solution for I_1. By an analogous procedure we may solve for I_2, obtaining for the two unknowns.

(2) $$I_1 = (E^1Z^2_2 - E^2Z^1_2) \div (Z^1_1Z^2_2 - Z^1_2Z^2_1)$$

(2a) $$I_2 = (E^2Z^1_1 - E^1Z^2_1) \div (Z^1_1Z^2_2 - Z^1_2Z^2_1)$$

Substitution of I_1 and I_2 from (2) and (2a) into (1) or (1a) will show that the solutions given are correct.

Since (2) and (2a) contain only general numbers, they may be considered as a general formula for solving any equation in two unknowns. These formulas may be remembered more readily and the whole process may be generalized for any number of unknowns by introducing a new symbol called a *determinant,* namely

$$\Delta = \begin{vmatrix} Z^1_1 & Z^1_2 \\ Z^2_1 & Z^2_2 \end{vmatrix}$$

This symbol is just another form of $(Z^1_1Z^2_2 - Z^1_2Z^2_1)$ from (2) or (2a). Thus, by definition, we have

(3) $$\Delta = \begin{vmatrix} Z^1_1 & Z^1_2 \\ Z^2_1 & Z^2_2 \end{vmatrix} = (Z^1_1Z^2_2 - Z^1_2Z^2_1)$$

Since the left side of (3) is a square array formed by two rows and two columns, it is called a determinant of the second order. The individual numbers,

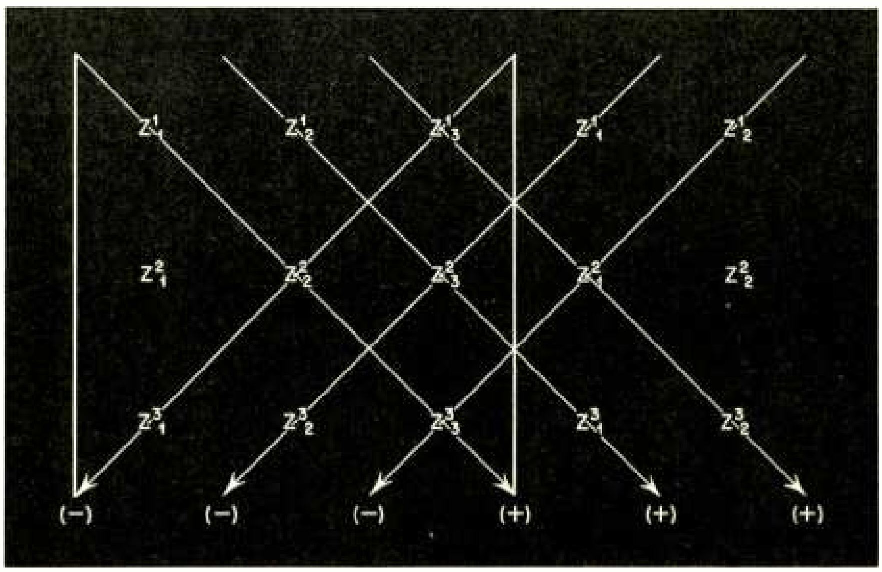

Fig. 1. A simple mechanical method of solving third-order determinants. See text.

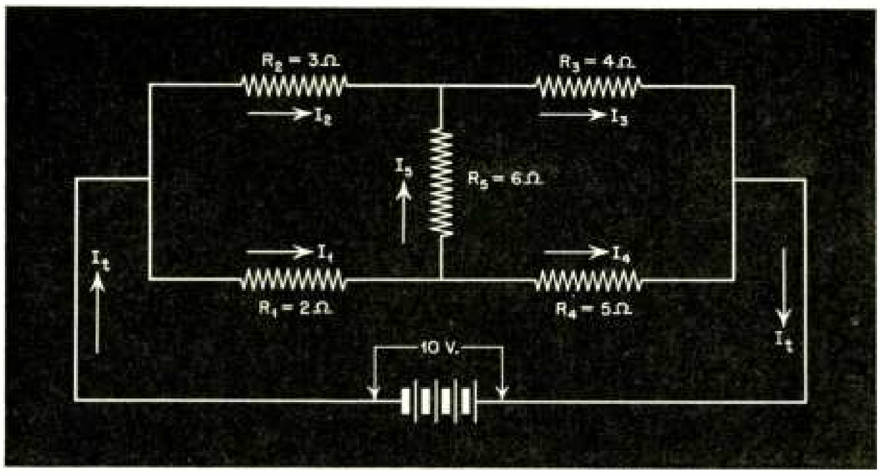

Fig. 2. Typical circuit of a resistance network

i.e. $Z^1{}_1$, $Z^1{}_2$, $Z^2{}_1$, $Z^2{}_2$, are called the *elements* of the determinant. The right side of (3) is called the *expansion* of the determinant. The numbers $Z^1{}_1$ and $Z^2{}_2$ form the *principal diagonal* and $Z^1{}_2$ and $Z^2{}_1$ form the *secondary diagonal*. Thus the product of the principal diagonal minus the product of the secondary diagonal gives an expansion of a second-order determinant.

Using the determinant notation, the dividends of (2) and (2a) give respectively,

$$E^1Z^2{}_2 - E^2Z^1{}_2 = \begin{vmatrix} E^1 & Z^1{}_2 \\ E^2 & Z^2{}_2 \end{vmatrix}$$

and $$E^2Z^1{}_1 - E^1Z^2{}_1 = \begin{vmatrix} Z^1{}_1 & E^1 \\ Z^2{}_1 & E^2 \end{vmatrix}$$

We may now write the complete solution of the linear equations (1) and (1a) as follows

$$(4) \qquad I_1 = \frac{\begin{vmatrix} E^1 & Z^1{}_2 \\ E^2 & Z^2{}_2 \end{vmatrix}}{\begin{vmatrix} Z^1{}_1 & Z^1{}_2 \\ Z^2{}_1 & Z^2{}_2 \end{vmatrix}} = \frac{\Delta_1}{\Delta}$$

$$(4a) \qquad I_2 = \frac{\begin{vmatrix} Z^1{}_1 & E^1 \\ Z^2{}_1 & E^2 \end{vmatrix}}{\begin{vmatrix} Z^1{}_1 & Z^1{}_2 \\ Z^2{}_1 & Z^2{}_2 \end{vmatrix}} = \frac{\Delta_2}{\Delta}$$

It should be noticed in (4) and (4a) that the denominators are identical and that they represent the square array of coefficients of I_1 and I_2 from (1) and (1a). Furthermore, it should be observed that the numerator of I_1 is obtained from the common denominator by substituting the coefficients of I_1 (i.e., the first column) with the corresponding constants from the other side of the equation, namely E^1 for $Z^1{}_1$ and E^2 for $Z^2{}_1$. Solution for I_2 is obtained by an analogous procedure, except that this time the second or the I_2 column is substituted by the E^i.

A determinant of the third order, which would be obtained from an equation with three unknowns, is obtained from the second-order determinant by the addition of the third row and the third column, thus

$$(5) \quad \Delta = \begin{vmatrix} Z^1{}_1 & Z^1{}_2 & Z^1{}_3 \\ Z^2{}_1 & Z^2{}_2 & Z^2{}_3 \\ Z^3{}_1 & Z^3{}_2 & Z^3{}_3 \end{vmatrix} \begin{matrix} = Z^1{}_1Z^2{}_2Z^3{}_3 - Z^1{}_1Z^2{}_3Z^3{}_2 \\ + Z^1{}_2Z^2{}_3Z^3{}_1 - Z^1{}_2Z^2{}_1Z^3{}_3 \\ + Z^1{}_3Z^2{}_1Z^3{}_2 - Z^1{}_3Z^2{}_2Z^3{}_1 \end{matrix}$$

The left side of (5) is the expanded form, which may be obtained by several methods discussed in a later section.

We saw the determinants of the second and third order; finally we are introducing the most general determinant, namely that of the *n*th order.

$$(6) \quad \Delta = \begin{vmatrix} Z^1{}_1 & Z^1{}_2 & Z^1{}_3 \ldots\ldots & Z^1{}_n \\ Z^2{}_1 & Z^2{}_2 & Z^2{}_3 \ldots\ldots & Z^2{}_n \\ \ldots\ldots & \ldots\ldots & \ldots\ldots & \ldots \\ \ldots\ldots & \ldots\ldots & \ldots\ldots & \ldots \\ Z^n{}_1 & Z^n{}_2 & Z^n{}_3 \ldots\ldots & Z^n{}_n \end{vmatrix}$$

Here again, as before, the superscripts denote the rows and subscripts the corresponding columns. This determinant consists of ($n \cdot n$) terms and its expanded form has $n!$ terms.

EXPANSION OF DETERMINANTS

Looking at the right side of (5) it is obvious that this expression cannot be obtained by the simple rule which we applied to second-order determinants. Since, for the purposes of actual numerical calculation it is necessary to have the expanded form, several methods of obtaining it are discussed here.

I. Expansion by Inversions or Permutations

Careful scrutiny of the right side of (5) reveals that the superscripts in each of the 3! or six terms remain in their natural order, i.e., 123. On the other hand, the subscripts had undergone a series of inversions or permutations. When the inversion is even the term is positive and when it is odd the term is negative. A permutation is *even* or *odd* depending on whether the number of interchanges necessary to bring an inversion back to its original form is even or odd.

In (5) the positive inversions are 123, 231, and 312. The negative inversions are 132, 213 and 321. To convert, say, 231 to 123 it is necessary to interchange, first, 3 and 1 and then 2 and 1. Since there are two interchanges, 231 is an even permutation and so on.

We mentioned before that a determinant of *n*th order has $n!$ terms in its expanded form. This is self-evident now since there are $n!$ permutations of the first n numbers (subscripts).

II. Expansion by Minors (Laplace)

The minor of any element $Z^i{}_j$ in any determinant of the *n*th order is defined as that determinant (of order $n - 1$) resulting from suppressing the *i*th row and the *j*th column. Thus, for example, in (5) the minor of $Z^2{}_2$ is

$$\begin{vmatrix} Z^1{}_1 & Z^1{}_3 \\ Z^3{}_1 & Z^3{}_3 \end{vmatrix}$$

It may be shown that any determinant of any order may be expressed as the sum of products formed by multiplying the elements of any row or any column by their respective minors. Moreover, each product is assigned the plus or minus sign depending on whether, in the element $Z^i{}_j$, the sum of i and j is even or odd. Thus (5) may be written as follows

$$(5a) \quad +Z^1{}_1\begin{vmatrix} Z^2{}_2 & Z^2{}_3 \\ Z^3{}_2 & Z^3{}_3 \end{vmatrix} - Z^1{}_2\begin{vmatrix} Z^2{}_1 & Z^2{}_3 \\ Z^3{}_1 & Z^3{}_3 \end{vmatrix} + Z^1{}_3\begin{vmatrix} Z^2{}_1 & Z^2{}_2 \\ Z^3{}_1 & Z^3{}_2 \end{vmatrix}$$

$$(5b) \quad -Z^1{}_2\begin{vmatrix} Z^2{}_1 & Z^2{}_3 \\ Z^3{}_1 & Z^3{}_3 \end{vmatrix} + Z^2{}_2\begin{vmatrix} Z^1{}_1 & Z^1{}_3 \\ Z^3{}_1 & Z^3{}_3 \end{vmatrix} - Z^3{}_2\begin{vmatrix} Z^1{}_1 & Z^1{}_3 \\ Z^2{}_1 & Z^2{}_3 \end{vmatrix}$$

After the second-order determinants in (5a) and (5b) are evaluated we find that (5), (5a) and (5b) give the same result. We gave only two examples, but a third-order determinant may be expanded by minors in $2n$ different ways (2x3 ways in this case), each of which will give the same result.

For determinants of higher orders the same method is applied—but several times in succession. With each application of this rule the order of determinants is reduced by one—and so this process is continued till there are no more determinants.

III. Mechanical expansion

The very simple device shown in this section applies only to third-order determinants and will not work on any other determinants.

(a) Copy the first two columns immediately to the right of the original determinant.

(b) The product of the elements in the diagonals parallel to the principal are given the positive sign and the products of elements in the diagonals parallel to the secondary are given a negative sign. The algebraic sum of these six products is the desired polynomial.

This may be illustrated with equation (5), using the form shown in *Fig. 1*. The arrows indicate what products are to be formed; the proper signs are shown below each arrow; the mechanical details are left to the reader.

THE EPSILON SYSTEM

In discussing some of the practical and important properties of determinants—in the next section—we save much space by using a shorter notation for determinants, which will be explained presently: it is the epsilon system.

In its main features the ϵ—system provides a set of symbols for the numbers 0, —1 and +1. The symbols

$$\epsilon^{\alpha\beta\gamma----\nu} \quad \text{OR} \quad \epsilon_{\alpha\beta\gamma----\nu}$$

are defined as follows: the value is 1 if $\alpha\beta\gamma\ldots\ldots\nu$ is an even or no permutation of $123\ldots.n$; it is —1 if the permutation is odd; and it is zero if any two of the indices repeat, i.e., if it is no special arrangement of $123\ldots.n$. The last statement shows that the epsilon system is skew symmetric in each pair of its indices.

With this notation in mind, determinants assume the following form

$$\text{2nd order } \Delta = \sum_{\alpha,\beta} \epsilon^{\alpha\beta} Z^1_\alpha Z^2_\beta$$

$$\text{3rd order } \Delta = \sum_{\alpha,\beta,\gamma} \epsilon^{\alpha\beta\gamma} Z^1_\alpha Z^2_\beta Z^3_\gamma$$

$$\text{4th order } \Delta = \sum_{\alpha,\beta,\gamma,\delta} \epsilon^{\alpha\beta\gamma\delta} Z^1_\alpha Z^2_\beta Z^3_\gamma Z^4_\delta$$

It is convenient to omit the summation sign and we can do so provided it is agreed that summation is indicated for all repeated indices. This is known as the *summation convention*. With its aid we can write the third-order determinant, for example, as follows:

$$\Delta = \epsilon^{\alpha\beta\gamma} Z^1_\alpha Z^2_\beta Z^3_\gamma$$

Since in (7) α, β and γ are repeated, summation is indicated over all of the n permissible values—in this case n = 3. Expanding (7), and remembering that the epsilons are skew symmetric, we obtain

$$\epsilon^{\alpha\beta\gamma} Z^1_\alpha Z^2_\beta Z^3_\gamma = \epsilon^{123} Z^1_1 Z^2_2 Z^3_3 + \epsilon^{132} Z^1_1 Z^2_3 Z^3_2 + \epsilon^{231} Z^1_2 Z^2_3 Z^3_1 + \epsilon^{213} Z^1_2 Z^2_1 Z^3_3 + \epsilon^{312} Z^1_3 Z^2_1 Z^3_2 + \epsilon^{321} Z^1_3 Z^2_2 Z^3_1$$

This expression reduces to (5) since

$$\epsilon^{123} = \epsilon^{231} = \epsilon^{312} = 1 \quad \text{and} \quad \epsilon^{132} = \epsilon^{213} = \epsilon^{321} = -1$$

Arrangements such as $\epsilon^{112} = \epsilon^{122} = 0$ etc., were omitted for obvious reasons.

PROPERTIES OF DETERMINANTS

(1) *The expansion of a determinant of order n yields n! terms.* This was shown in the section on expansion by permutations.

(2) *Each product of the expanded form has as a product one, and only one, element from each row and each column.*

(3) *Corresponding rows and columns of a determinant may be interchanged without altering the value of the determinant.* This follows from property (2) and the fact that the elements obey the commutative law of multiplication. Same law restated in terms of permutations would permit the application of inversions to either the subscripts or the superscripts. In symbolic form

$$\epsilon^{\alpha\beta\gamma} Z^1_\alpha Z^2_\beta Z^3_\gamma = \epsilon_{\alpha\beta\gamma} Z^\alpha_1 Z^\beta_2 Z^\gamma_3$$

(4) *Interchanging two rows or two columns and multiplying the determinant by —1 leaves it unchanged.* Interchanging, say, two columns, is equivalent to permuting the subscripts in the epsilon system. Interchanging any two columns in a third-order determinant may be done in three ways: interchanging α and β, α and γ, or β and γ (only in the subscripts of the Z's). But all of these are odd inversions and hence the new determinant will be of the same value but of opposite sign. For example, interchanging the 1st and 3rd columns gives

$$\epsilon^{\alpha\beta\gamma} Z^1_\beta Z^2_\alpha Z^3_\gamma$$

(5) *Multiplying every element in a certain row or column by the same quantity and the determinant by that quantity's reciprocal leaves the determinant unchanged.* This is obvious from the commutative law of multiplication

$$\Delta = \frac{1}{\lambda} \epsilon^{\alpha\beta\gamma} Z^1_\alpha (\lambda Z^2_\beta) Z^3_\gamma$$

where λ is any non-zero constant.

(6) *If any two rows or two columns are identical the value of the determinant is zero;* for if we interchange the two identical rows or columns the value of such a determinant will remain unchanged, or by property (4) $\Delta = -\Delta$ and hence $\Delta = 0$. The same could be inferred from our epsilon notation, for two of the indices would be identical and by definitions from previous section that is the condition for zero value.

(7) *Replacing every element in a fixed row (or column) by the sum of itself and a fixed multiple of the element on a different fixed row (or column) and the same column (or row) leaves the determinant unchanged.* This can be shown as follows: Let

$$L^2_\beta = m Z^3_\gamma$$

where m is any non-zero constant, then we have

$$\begin{aligned} &\epsilon^{\alpha\beta\gamma} Z^1_\alpha (Z^2_\beta + L^2_\beta) Z^3_\gamma \\ &= \epsilon^{\alpha\beta\gamma} Z^1_\alpha Z^2_\beta Z^3_\gamma + \epsilon^{\alpha\beta\gamma} Z^1_\alpha L^2_\beta Z^3_\gamma \\ &= \epsilon^{\alpha\beta\gamma} Z^1_\alpha Z^2_\beta Z^3_\gamma + m\, \epsilon^{\alpha\gamma\gamma} Z^1_\alpha Z^3_\gamma Z^3_\gamma \\ &= \epsilon^{\alpha\beta\gamma} Z^1_\alpha Z^2_\beta Z^3_\gamma \end{aligned}$$

(8) *If each element of a certain row or column is zero, the determinant is zero.* This property follows directly from property (2).

CRAMER'S RULE

As will be seen presently, Cramer's rule is very important and useful since it enables us to set up the solutions for the different unknowns directly from the simultaneous equations.

Let it be required to solve for I_1, I_2 and I_3 in the following Kirchhoff relationships

$$(8) \quad \begin{cases} Z^1_1 I_1 + Z^1_2 I_2 + Z^1_3 I_3 = E^1 \\ Z^2_1 I_1 + Z^2_2 I_2 + Z^2_3 I_3 = E^2 \\ Z^3_1 I_1 + Z^3_2 I_2 + Z^3_3 I_3 = E^3 \end{cases}$$

Step I: Set up the common denominator in a determinant form. This denominator is essentially a square array of the coefficients of the unknowns, thus

$$(9) \quad \Delta = \begin{vmatrix} Z^1_1 & Z^1_2 & Z^1_3 \\ Z^2_1 & Z^2_2 & Z^2_3 \\ Z^3_1 & Z^3_2 & Z^3_3 \end{vmatrix}$$

Step II: In solving for a certain unknown, say I_2, replace all the coefficients of I_2 in Δ by the corresponding constants from the other side of the equation and divide that new determinant by Δ. Thus

$$(10) \quad I_1 = \begin{vmatrix} E^1 & Z^1_2 & Z^1_3 \\ E^2 & Z^2_2 & Z^2_3 \\ E^3 & Z^3_2 & Z^3_3 \end{vmatrix} \div \Delta$$

$$(11) \quad I_2 = \begin{vmatrix} Z^1_1 & E^1 & Z^1_3 \\ Z^2_1 & E^2 & Z^2_3 \\ Z^3_1 & E^3 & Z^3_3 \end{vmatrix} \div \Delta$$

$$(12) \quad I_3 = \begin{vmatrix} Z^1_1 & Z^1_2 & E^1 \\ Z^2_1 & Z^2_2 & E^2 \\ Z^3_1 & Z^3_2 & E^3 \end{vmatrix} \div \Delta$$

[*Continued on page 54*]

RADIO DESIGN WORKSHEET

NO. 21—INDUCTANCE MEASURING BRIDGE; POLYPHASE COMMUNICATION CIRCUITS

INDUCTANCE-MEASURING BRIDGE

Probably the most common form of Wheatstone bridge circuit for the measurement of inductance is one in which self-inductance is balanced directly against a self-inductance in the adjacent conjugate arm. A somewhat less common bridge circuit also widely used for inductance measurement is that shown in *Fig. 1*. *Fig. 2* shows an obviously equivalent network.

When the bridge is balanced we have:

$$R_1(1/R'_2+j\omega C) = \frac{R_x+j\omega L_x}{R'_3}$$

Also:

$$R_1/R'_2 = R_x/R'_3$$
$$R_1R'_3 = L_x/C$$

Whence:

$$R_x = R_1R'_3/R'_2$$

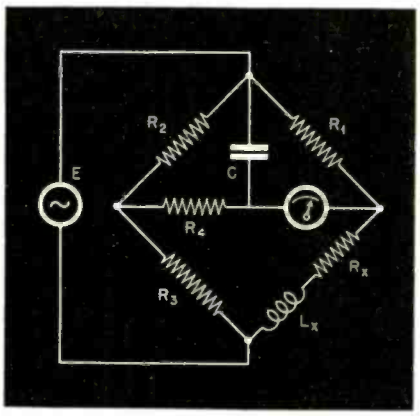

Fig. 1. Bridge for inductance measurement

and:

$$L_x = R_1R'_3C$$

$$R'_3 = R_2+R_4+\frac{R_2R_4}{R_3} = \frac{R_2R_3+R_4R_3+R_2R_4}{R_3}$$

$$R'_2 = R_4+R_3+\frac{R_4R_3}{R_2} = \frac{R_2R_4+R_2R_3+R_4R_3}{R_2}$$

from which we have:

$$R_x = R_1\frac{R'_3}{R'_2} = R_1\frac{R_2}{R_3}$$

$$L_x = R_1C\left(R_4+R_3+\frac{R_4R_3}{R_2}\right) = R_1C[R_4(1+R_3/R_2)+R_3]$$

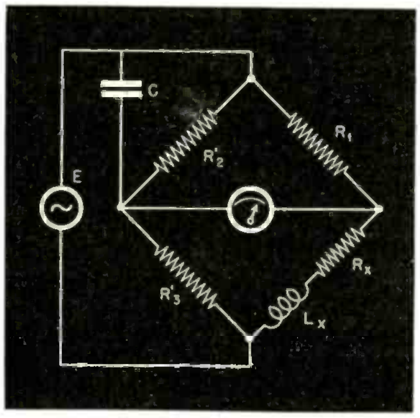

Fig. 2. A bridge circuit equivalent to Fig. 1

This balance is obviously independent of frequency. Capacitance C may be fixed and the bridge balanced by varying R_1 and R_4, or if R_1 is fixed by varying C and R_4.

POLYPHASE COMMUNICATION CIRCUITS

Some few years ago there was considerable mention in the technical press of polyphase broadcasting, in which modulation was accomplished by variation of the phase of one component of a polyphase wave. One advantage of this system was higher efficiency. Still earlier, considerable development of polyphase communication circuits took place for wired radio, to be distributed over three-phase power lines. There seems little doubt that, had the distribution of wired radio over power lines come into general commercial use, polyphase circuits would have found wide use for this purpose. One of the important criteria would again have been higher efficiency of distribution. It seems probable in the post-war era we shall hear even more of polyphase communication circuits. Hence it seems worthwhile to explore some of the possibilities in this field.

If a voltage $e = E \sin \omega t$ is impressed across an impedance consisting of a pure resistance and a pure capacitance in series, as in *Fig. 3*, the voltage across each separate section will differ in phase. If $R = 1/\omega C$ the two voltages will be equal.

If two quadrature voltages are impressed on a Scott transformer, three voltages differing in phase by $2\pi/3$ radians will result. The transforma-

[*Continued on page 32*]

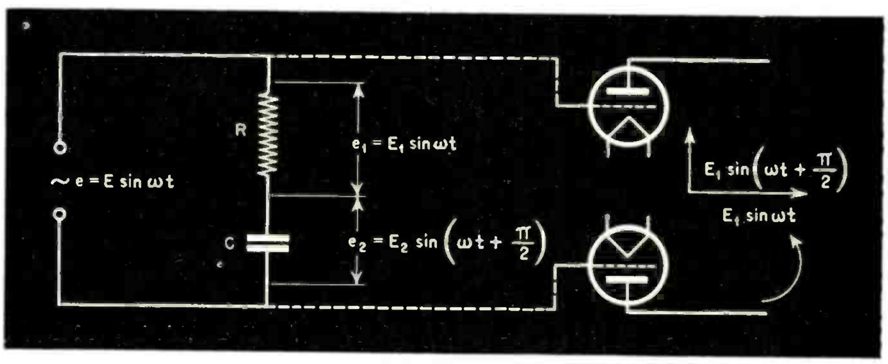

Fig. 3. The voltages across each section of the above network differ in phase as shown

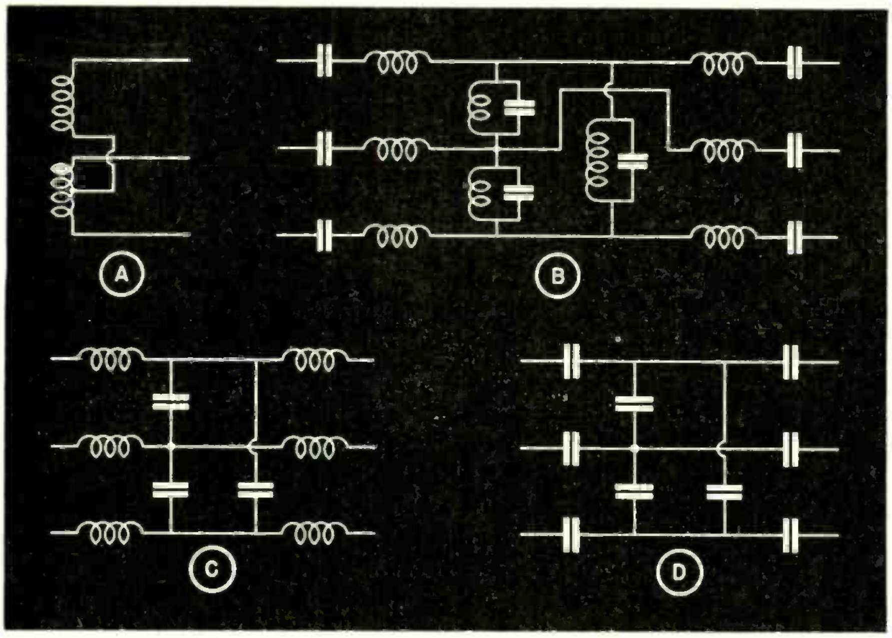

Fig. 5. The filter circuits, B, C, and D, may be used with the three-phase output circuit shown in A

tion ratios (if the quadrature voltages are equal in magnitude) of a and b in *Fig. 4* should be in the ratio $1 : \sqrt{3}/2$ respectively.

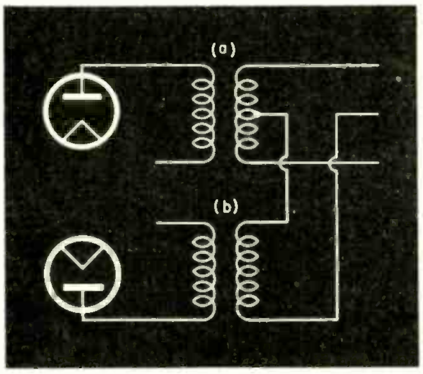

Fig. 4. A Scott transformer circuit

These three-phase voltages may be impressed on a three-phase band-pass filter (or other type of properly proportioned three-phase filter), as shown in *Fig. 5,* to feed a three-phase distribution system, which might be a wire line or an antenna system. It will be observed that the circuits so far shown are balanced or symmetrical.

Fig. 6 indicates a push-pull three-phase amplifier and a two-phase amplifier with a Scott-connected output circuit.

Fig. 7 illustrates by vector representation some of the foregoing circuit arrangements. Particular attention is directed to those diagrams showing a Scott connection for converting a two-phase quadrature system of voltage to a three-phase system with voltages of equal magnitude but having a phase difference of $2\pi/3$ radians. Obviously the Scott connection is a special case of a more general arrangement.

In a future data sheet, it will be shown that any two voltages having a phase difference other than 0 or π may be converted to a three-phase system of voltages of equal magnitude and phase differences of $2\pi/3$ by proper transformer ratios and proper choice of the tap on one secondary.

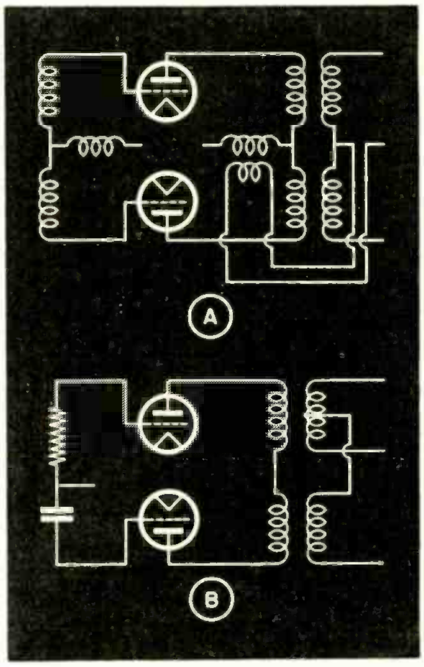

Fig. 6. In A, a push-pull three-phase amplifier, and in B, a two-phase amplifier, with Scott-connected output circuits.

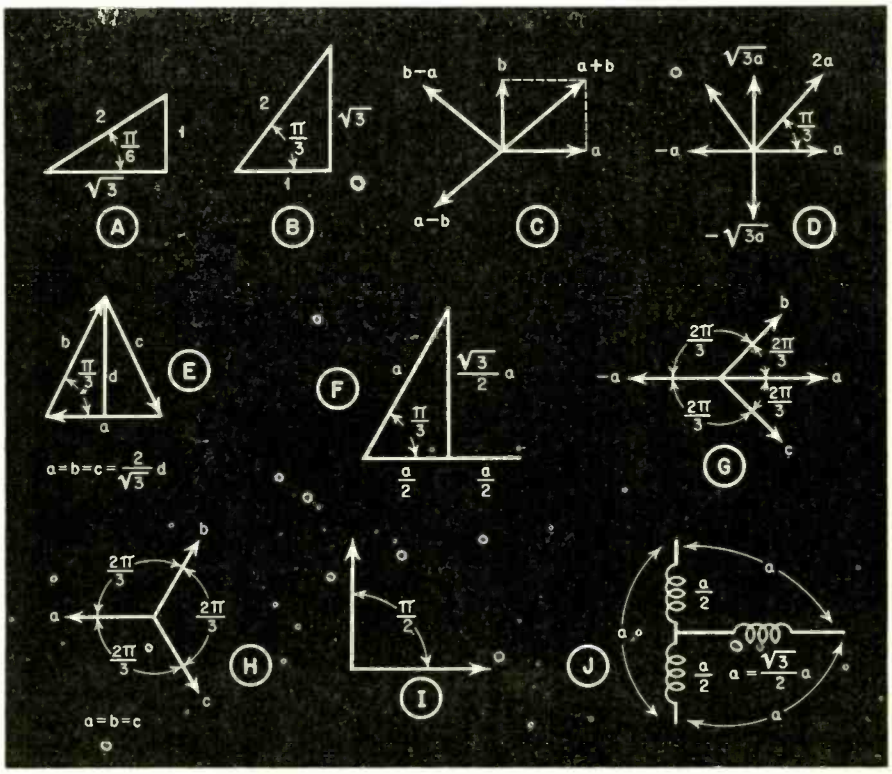

Fig. 7. Vector diagrams of circuits described in the text. Scott connections are shown in E and H; phase quadrature in I

Class C Amplifiers

CORTLANDT VAN RENSSELAER

The Principles of Class C Operation and their Application to the Design of Practical Amplifiers of this Type

PART 2

Amplifier Design

★ The problem will now be considered of designing an amplifier, assuming a reasonable value of d.c. supply voltage This value is generally given for each tube by the manufacturer. To clarify the procedure, the portion of *Fig. 6* including the constant current curves is shown in *Fig. 7*.

The factors available for governing operation are (1) angle of plate current flow, θ_p, (2) crest space current, I_m, (3) maximum positive grid voltage, *Emax*, and minimum plate voltage, *Emin*.

The factor of greatest importance to the operation of the amplifier is the period of time during which the plate current flows, θ_p. Angles of flow of less than 90 electrical degrees result in a high conversion efficiency but reduce the amplifier output below the optimum value. A large amount of grid driving power is also required for short pulses. Larger angles of flow, between 90 and 180 electrical degrees, cause the amplifier to operate at a lower efficiency, but to deliver a reasonable power output with normal driving power. Experience has shown that for a compromise between high efficiency and low output, the range between 120 and 150 electrical degrees is best for general operation.

The angle of plate current flow is governed by the position of the quiescent point, which in turn is determined by the grid bias. The bias required to produce a given angle of flow may be determined from the formula,

$$\text{Grid bias} = E_c = \frac{E_b}{\mu} + \left(Emax + \frac{Emin}{\mu}\right)\left(\frac{\cos\frac{\theta_p}{2}}{1 - \cos\frac{\theta_p}{2}}\right)$$

where μ is the amplification factor of the tube.

This formula is obtained from considering the voltage and current relations in the circuit at the instant plate current stops flowing. The derivation is given in reference 7 of the bibliography.

Where optimum operation is not of great importance, it is generally permissible to select a bias of from two to three times cutoff. Cutoff bias for given supply voltages is indicated on the constant current curves.

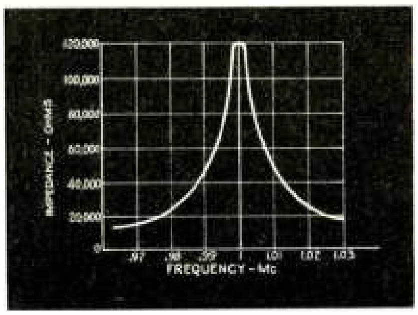

Fig. 3. Impedance of a parallel resonant circuit as a function of frequency

Peak Space Current

The maximum allowable peak space current is governed by the emission capabilities of the cathode. This value is generally supplied by the manufacturer. Where information is not available, a value may be obtained by multiplying the sum of the maximum permissible d.c. plate and grid currents, as specified by the manufacturer, by four. This constant is arrived at by determining the relation which exists between the peak and average values of the plate and grid current pulses. Further information is contained in reference 10 of the bibliography.

The peak space current is obtained at the instant during the cycle when the potential of the grid is at its maximum value, *Emax*, and the potential of the plate is at its minimum value, *Emin*. The values of *Emax* and *Emin* therefore determine the peak space current of the tube. The ratio between *Emax* and *Emin* must be carefully observed. The grid voltage must never be allowed to become more positive than the plate voltage, for under this condition the grid would actually draw power from the plate, with resulting damage to the tube. In order to realize the full power capabilities of the tube, the plate voltage must be allowed to approach the cathode potential but the grid must also be driven to an appreciable positive potential to obtain good efficiency. Therefore a ratio *Emax/Emin* of nearly unity it desirable. A value of 0.8 is generally acceptable for tubes operating at plate voltages of less than one or two thousand volts. Where larger voltages are used, this ratio is usually made smaller as a further protection to the tube.

A line may now be drawn on the constant current curves representing the locus of points at which the plate and grid voltages are equal to the ratio *Emax/Emin*. This line is labeled *O-C* in *Fig. 7*. The point on this line is then found at which the sum of the grid and plate currents, as indicated by the current curves, is equal to the peak space current desired.

The load line may now be plotted on the constant-current diagram. The upper extremity, labeled *A* in *Fig. 7*, will be located at the point where the peak space current is drawn. The central, or quiescent point, *B*, will be located at the intersection of the plate-supply voltage and the grid bias on the constant-current diagram. Only this

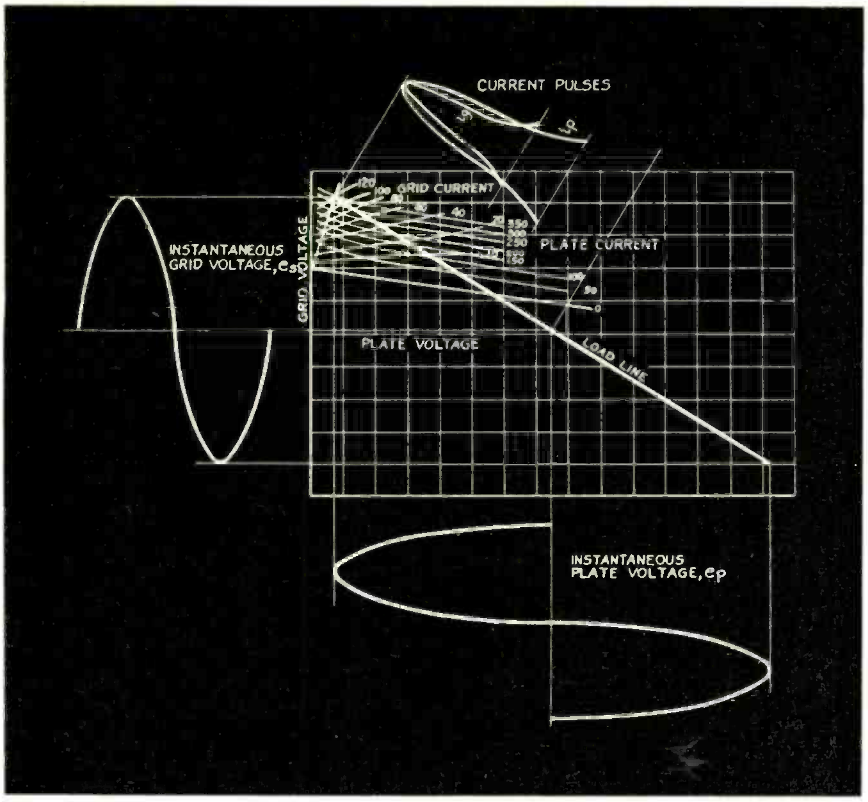

Fig. 6. Voltage and current relations on constant-current curves for a transmitting triode

half of the load line need be considered since no current will be drawn by the plate during the other portion of the cycle.

Pulse Shapes

The manner in which the tube potentials vary over the cycle has been shown. The next step is to determine the shape of the pulses from the load line. These may be plotted on a time scale by joining points of instantaneous current obtained by projecting equal intervals of the driving voltage cycle to the load line. It is necessary to plot only half of each pulse since both sides are symmetrical. Because the driving voltage increases sinusoidally rather than linearily, it is necessary that the load line be divided sinusoidally. This may be done by measuring the half-length of the load line with a metric or decimal rule and proportioning the intervals according to sine functions from 0 to 90 degrees. Generally, 10-degree intervals yield good results. This procedure is illustrated by the projections of driving voltage to the load line in *Fig. 6.* The divisions are shown on a larger scale in *Fig. 7,* and the half-pulses which result are plotted in *Fig. 8.*

The d.c. plate and grid currents are determined by averaging the areas of the pulses over a complete 360-degree cycle. If they have been drawn on cross-section paper this may be accomplished by adding up the squares under the half-pulse, multiplying by two, to include the entire pulse, and dividing by the number of squares which would be included in 360 degrees on the time axis.

The power output is determined by multiplying equal intervals of instantaneous plate current by corresponding intervals of instantaneous sinusoidal plate voltage over a cycle and dividing by the number of intervals in a complete cycle. The power delivered will, of course, be zero during the time that no plate current flows. The same time scale intervals as were used in plotting the pulses may be employed in this case. The number of intervals taken, or the number of times that the instantaneous voltages and currents are multiplied together, determines the accuracy of the result.

The power required by the grid circuit is determined in the same manner. Values of instantaneous sinusoidal grid driving voltage and instantaneous grid current are used.

Tank Circuit

The operation of the Class C amplifier is largely affected by the design of the tank circuit. The tank circuit must offer a fairly high impedance to the resonant frequency, but at the same time, must offer a very low impedance to harmonic frequencies which would otherwise be present in the amplifier output. The character of the resonant impedance curve of the tank circuit, shown in *Fig. 3,* is defined by the ratio of inductive reactance to resistance, $2\pi fL/R$, which is designated by the letter Q. The Q of the tank circuit will in general be very high while no power is being drawn from the amplifier, but as load is applied, the Q will decrease to a fairly low effective value due to an apparent change in the resistance of the circuit. The effective Q obtained when full power is being taken from the amplifier is the operating Q.

A high operating Q will offer almost complete freedom from harmonic output, but will result in an appreciable fraction of the available power output

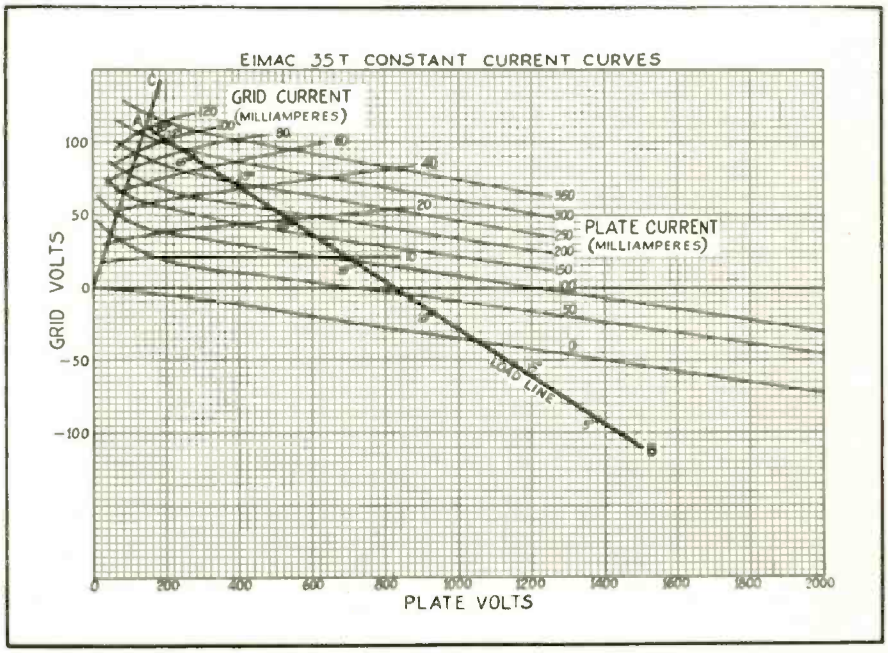

Fig. 7. Constant-current curves of Eimac 35T.

being expended in the tank circuit. A low Q reduces the amount of power which must be stored in the circuit during the cycle and consequently makes possible the use of smaller inductances and capacities, but introduces harmonic energy into the output. An operating Q of between 8 and 12 is generally used in power amplifiers. Q's of lower than 8 are occasionally used in large low-frequency apparatus,

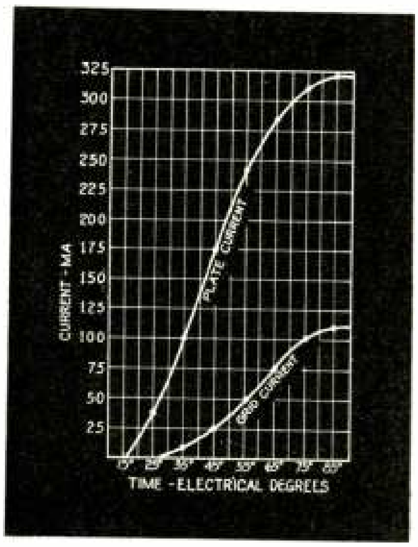

Fig. 8. Plate and grid current half-pulses

particularly in modulated amplifiers. Values greater than 12 are sometimes used where a very high rejection of harmonic energy is required.

The efficiency of the tank circuit, i.e., the ratio of the amount of power delivered to the tank circuit to the amount of power delivered to the load, is given by the formula:

$$\text{Efficiency} = \frac{Q' - Q}{Q'} \, 100\%$$

in which Q' is the effective Q when no power is being taken from the circuit. In the general case, Q' will be at least several hundred and the tank circuit efficiency will be about 95%. This loss of power through the tank circuit must obviously be considered in the design of the amplifier.

For optimum operation the impedance offered to the plate of the amplifier tube must be such that a maximum transfer of power will occur. The magnitude of this load impedance is given by the relation

$$\text{Load impedance} = Z_1 = \frac{(E_b - Emin)^2}{2P_o} \text{ ohms}$$

in which P_o is the power output. This formula is derived from the ratio of the resonant frequency voltage to the resonant frequency current which appear in the tank circuit.

The inductance required to produce this load impedance for a given value of Q is

$$\text{Inductance} = L = \frac{Z_1}{2\pi f Q} \text{ henrys}$$

in which Q is the operating Q.

The capacity to resonate this circuit to the frequency of operation is

$$\text{Capacity} = C = \frac{1}{4\pi^2 f^2 L} \text{ farads}$$

where L is in henrys.

Design Example

To illustrate more clearly the general procedure outlined for design of a Class C amplifier, an example of such a design for a 35T tube is presented below.

The given factors in the design are:

Supply voltage, $E_b = 1500$ volts
Ratio $Emax/Emin = 0.8$
Peak space current, $I_m = 450$ ma.
Plate current pulse interval, $\theta_p = 140°$
μ for 35T $= 30$
Operating tank circuit $Q = 12$
Frequency of operation $= 2$ mc.

Procedure

1) A line representing the locus of points at which $Emax/Emin = 0.8$, OC, is drawn on the constant-current curves.

2) The point, A, on the line OC is determined at which $I_p + I_g = I_m = 450$ ma. At point A, $Emax = 110$ volts and $Emin = 140$ volts.

3) For $\theta_p = 140°$, the grid bias is,

$$E_c = \frac{E_b}{\mu} + \left(Emax + \frac{Emin}{\mu}\right) \left(\frac{\cos\frac{\theta_p}{2}}{1 - \cos\frac{\theta_p}{2}}\right)$$

$$E_c = \frac{1500}{30} + \left(110 + \frac{140}{30}\right) \left(\frac{\cos 70°}{1 - \cos 70°}\right)$$

$$E_c = -110 \text{ volts}$$

This value corresponds to a bias of approximately two times cutoff.

4) The load line, AB, is drawn on the constant-current curves. The lower extremity, B, is the intersection of E_c and E_b. *Fig. 7* illustrates this procedure for the 35T.

5) The load line is divided into intervals corresponding to sinusoidal functions from 0 to 90 degrees. The plate and grid currents and voltages at each interval are tabulated. The currents are determined directly from the intersection of the load line with the constant current curves. The plate voltage is equal to the supply voltage less the voltage at the point on the load line, and the grid voltage is equal to the sum of the bias voltage and the voltage at the point on the load line.

6) Plate and grid current half pulses are plotted from tabulated values in *Fig. 8*. The areas under these curves are determined by counting squares, and the average or d.c. values of the currents are computed by multiplying this area by two to include the entire pulse, and dividing by the time scale length included in 360 degrees.

$$\text{D.c. plate current} = \frac{\text{area} \times 2}{36} = \frac{1462 \times 2}{36} = 81 \text{ ma.}$$

$$\text{D.c. grid current} = \frac{350 \times 2}{36} = 19.5 \text{ ma.}$$

7) The power output and driving power are determined by totaling the powers obtained at each of the intervals of step 5, and averaging the result. $I_p \times E_p$ and $I_g \times E_g$ are tabulated. The sums are multiplied by two to include the entire pulse, and divided

[*Continued on page 58*]

INTERVAL (Deg.)	I_p (Amps)	I_g (Amps)	E_p (Volts)	E_g (Volts)	$I_p \times E_p$ (Watts)	$I_g \times E_g$ (Watts)
5	–	–	–	–	–	–
15	–	–	–	–	–	–
25	.035	–	570	–	17	–
35	.100	.008	780	123	78	1.0
45	.175	.020	960	151	168	3.0
55	.245	.045	1110	176	272	7.9
65	.285	.075	1240	196	354	14.7
75	.310	.102	1310	208	406	21.2
85	.320	.119	1350	214	432	25.4
				TOTAL	1727	73.2

Tabulated data for design of 35T amplifier

THEORY AND APPLICATION OF

Nomographs

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Project Engineer, Templeton Radio Company

PART 3

How to Determine Nomograph Scale Factors to Fit Any Size Sheet

★ The theory of the nomograph was considered in the last article,[1] with the exception of the scale factor. Scale factors make nomographs "fit on the sheet."

As an illustration of a scale factor, let us construct a two-scale nomograph for frequency vs. wavelength, or

$$f\lambda = c$$

where f = frequency in megacycles
λ = wavelength in meters
c = light velocity or 300,000,000 m/s

[1] Theory and Application of Nomographs —RADIO, Dec., 1943.

If we choose a scale 10 inches long, and wish to include λ from 1 to 200 meters, we may determine the necessary scale factor by equating

200/10 = 20 meters per inch
or, 1 meter = 1/20 inch

Therefore we shall mark 200 on the nomograph at the top end (*Fig. 8*), and mark 180 meters 1 inch from the top, etc., with as many subdivisions as appears desirable for ease of reading. 1/20 is the scale factor in this case, and we may write

$$N = \lambda/20$$

where N is the number of inches corresponding to a given wavelength from the start of the scale.

The frequency scale is conveniently graduated from substitution of given values in the original formula.

It is seen therefore that an equation in two variables requires one scale for each variable, and these two scales may be adjoining. However, adjoining scales are not possible for equations in three variables.

By utilizing the derivation developed in the second part of this series of articles, the reader may show that an equation in three variables:

$$\alpha(U) + \beta(V) + \gamma(W) = 0$$

has a corresponding working determinant:

$$\begin{vmatrix} -S_1 & S'_1\,\alpha(U) & 1 \\ 0 & \dfrac{S'_1 S'_3}{S'_1 + S'_3}\,\beta(V) & 1 \\ S_3 & S'_3\,\gamma(W) & 1 \end{vmatrix} = 0$$

where S_1, S_3, and S'_1 and S'_3 are scale factors having the mutual relation:

$$S_1 S'_3 = S_3 S'_1$$

A general consideration of the working determinant tells a great deal about the nomograph before actual calculations are made; the scale factors are constants, and therefore the scale of U is parallel to the scale of V and to the left by an interval equal to S_1; likewise the scale of W is parallel to the scale of V and to the right by an interval equal to S_3. Therefore as soon as we choose the first two scale factors to "fit the sheet" left and right, we may draw the scale lines of the nomograph paral-

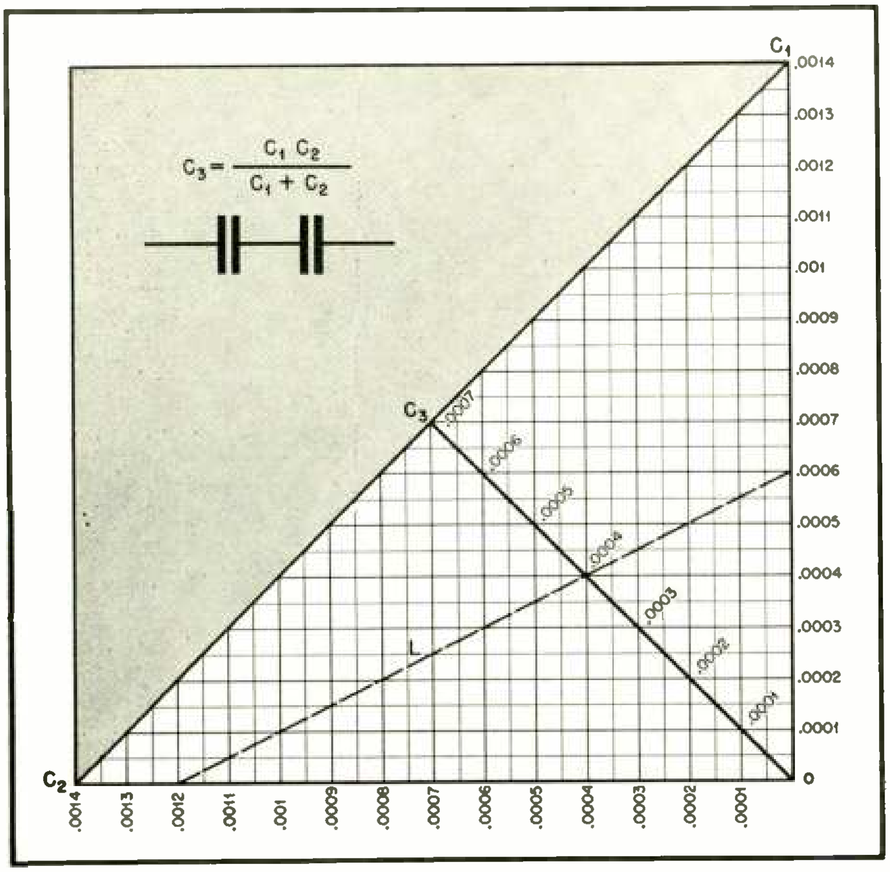

Fig. 10. Nomograph for two capacitors in series. The point of intersection of the straight line L on C_3 is the resulting capacity

lel to one another. In general, unless special considerations govern, we should choose S_1 approximately equal to S_3.

Scale factors S'_1 and S'_3 may then be conveniently determined, remembering that $S'_1 S'_3$ must be equal to $S_3 S'_1$ or otherwise the nomograph "won't work."

Nomograph of Capacitor Energy

As an illustration of this equation, let us construct the nomograph for the energy present in a capacitor at any given voltage

$$W = CE^2/2$$

where W is the stored energy in watt-seconds or joules;
C is the capacity in farads;
E is the potential difference in volts.

The equation may be brought into the form just discussed by writing

$$2W = E^2C$$

and then taking logs:

$$\log 2 + \log W = \log E + \log C$$

or:

$$2 \log E + \log C - \log W - \log 2 = 0$$

or:

$$2 \log E + \log C - \log W - 0.30103 = 0$$

This is now equivalent to our basic equation except that the constant 0.30103 is present. Such a constant may be grouped with any variable we choose, and the working determinant then formed. We may group the constant with W, and by the method previously discussed proceed to set up the working determinant:

$$\begin{vmatrix} -S_1 & 2S'_1 \log E & 1 \\ 0 & \frac{S'_1 S'_3}{S'_1 + S'_3} (\log W + .30103) & 1 \\ S_3 & S'_3 \log C & 1 \end{vmatrix} = 0$$

We must choose certain limits for the variables, so:

E varies from 1 to 1000 volts
C varies from .001 to 10 μfd.

We must choose a size for the nomograph, say, 7 x 10 inches.

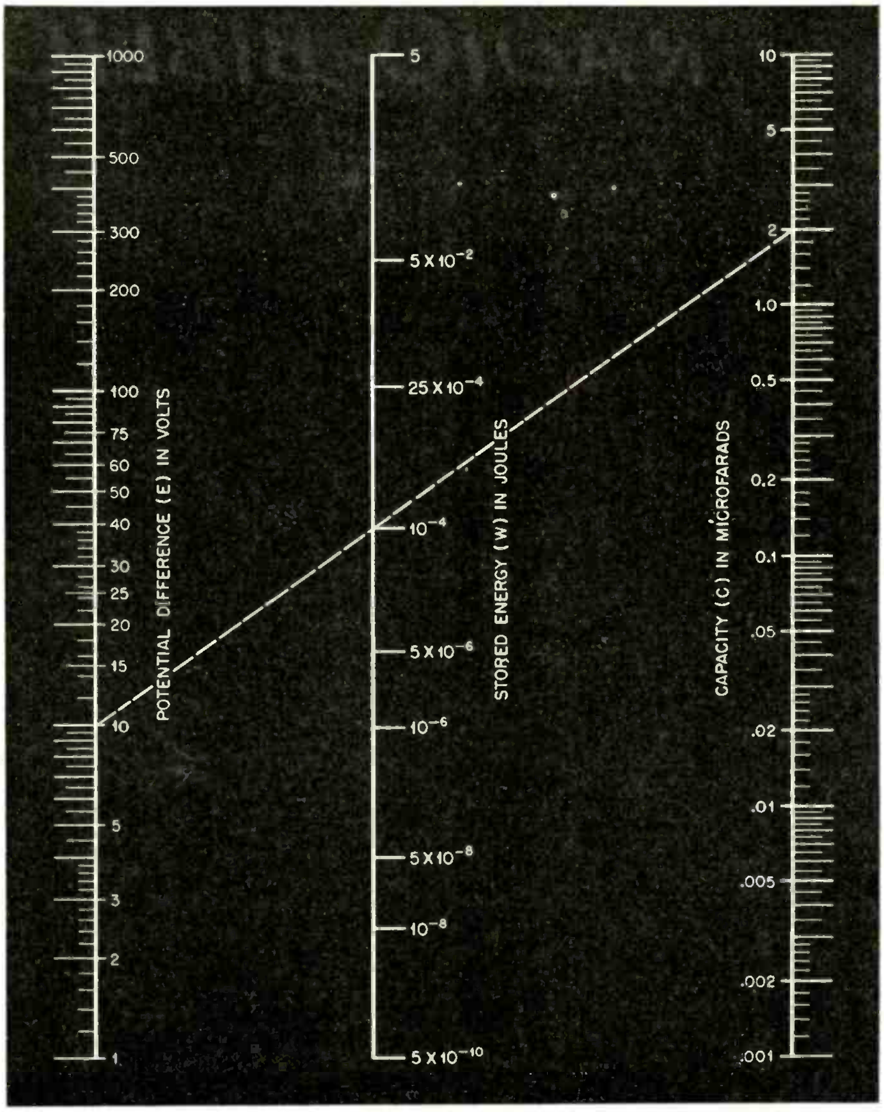

Fig. 9. Nomograph showing energy stored in a capacitor at any given voltage

Then calculating the scale factors,

$$10'' = 2S'_1 (\log 1000 - \log 1)$$

or,

$$S'_1 = 5/3$$

and,

$$10'' = S'_3 (\log 10^{-5} - \log 10^{-9})$$

or,

$$S'_3 = 5/2$$

Likewise

$$S_1 + S_3 = 7'' \text{ and } S_1 S'_3 = S_3 S'_1$$

whence,

$$S_1 = 14/5 \text{ and } S_3 = 21/5$$

Fig. 9 illustrates how these values determine the position of the scales upon the sheet, as well as the scale graduations which are derived from substitution of various values of E, W and C in the working determinant:

$$\begin{vmatrix} -\frac{14}{5} & \frac{10}{3} \log E & 1 \\ 0 & 1 \log W + .30103 & 1 \\ \frac{21}{5} & \frac{5}{2} \log C & 1 \end{vmatrix} = 0$$

[*Continued on page 62*]

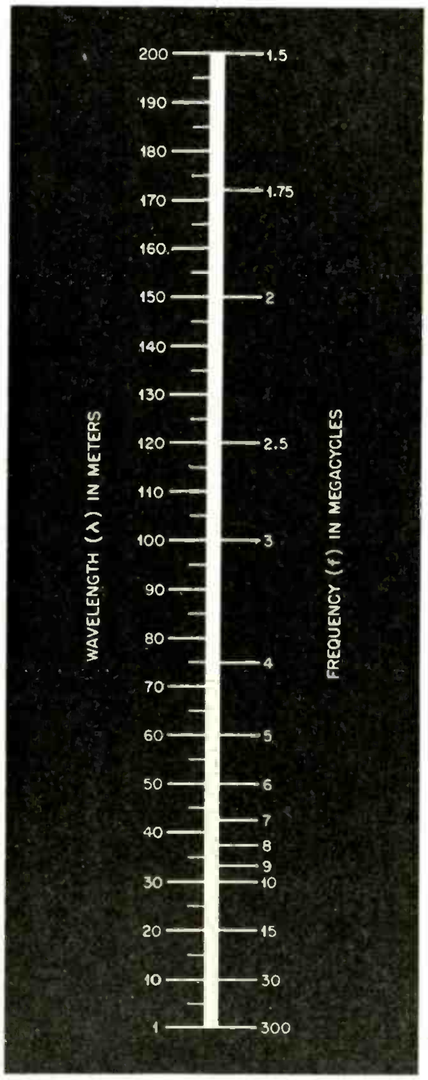

Fig. 8. Wavelength-Frequency Nomograph

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Using Slide Rule

[*Continued from page 27*]

Wire Gauges

Since the diameter of wires and their cross-section runs in a geometric progression for consecutive gauge numbers, the log-log scales will serve to find these values.

To find diameter in mils, set 2 on *C* to 10 on *LL3.* Calling the gauge number *N*, opposite (50-*N*) on *C*, find diameter on *LL3*.

To find cross-sectional area in circular mils, set 1 on *C* to 10 on *LL3*, opposite (50-*N*) on *C* find cross-sectional area on *LL3*.

Impedance of Coaxial Lines

The relation between *Z* and the two diameters is

$$Z = 138 \log_{10} \frac{D}{d}$$

where *D* and *d* are the diameters of the outer and inner conductors, respectively.

Find the ratio *D/d* from the *C* and *D* scales, set 138 on *C* to 10 on *LL3*. Opposite *D/d* on *LL* scale, find *Z* on *C* scale.

Use of Trigonometric Scales

The arrangement of the trigonometric scales differs very markedly on the various types of rules. Therefore, some operations which can easily be performed on some rules are well-nigh impossible on others. The applications shown here can be done with a polyphase duplex or a log-log duplex. The log-log vector slide rule offers the greatest convenience as far as triogonometric scales are concerned.

On most rules the sine scale at the back is referred to the *A* and *B* scales while the tangent scale is referred to the *C* and *D* scales. This has to be remembered when multiplying a sine or a tangent by any factor. It is even more of a headache when multiplying one trigonometric function with another one, as in the solution of spherical triangles.

Finding Z from R and X

The impedance can be found from *R* and *X* by trigonometric formulas as shown in *Fig. 8*. For the sake of convenience it is desirable to avoid tangents of angles over 45 degrees and therefore, the angle opposite the shortest side should be found.

Applying this to our previous problem: To find *Z* when *R* is 8 ohms and *X* is 15 ohms. To 15 on *DF* set 8 on *C*; opposite index of *DF* read $\theta = 28°$. Set 28° on sine scale opposite 8 on *A*; opposite index of sine scale, read 17 on *A*. It may be convenient to use the *D* and the *C* scales instead of *DF* and *C*, depending on the values involved.

Finding Great Circle Distances

If only the great circle distance is needed, and not the bearing, the law of cosines for spherical triangles can be used. (*Fig. 9*).

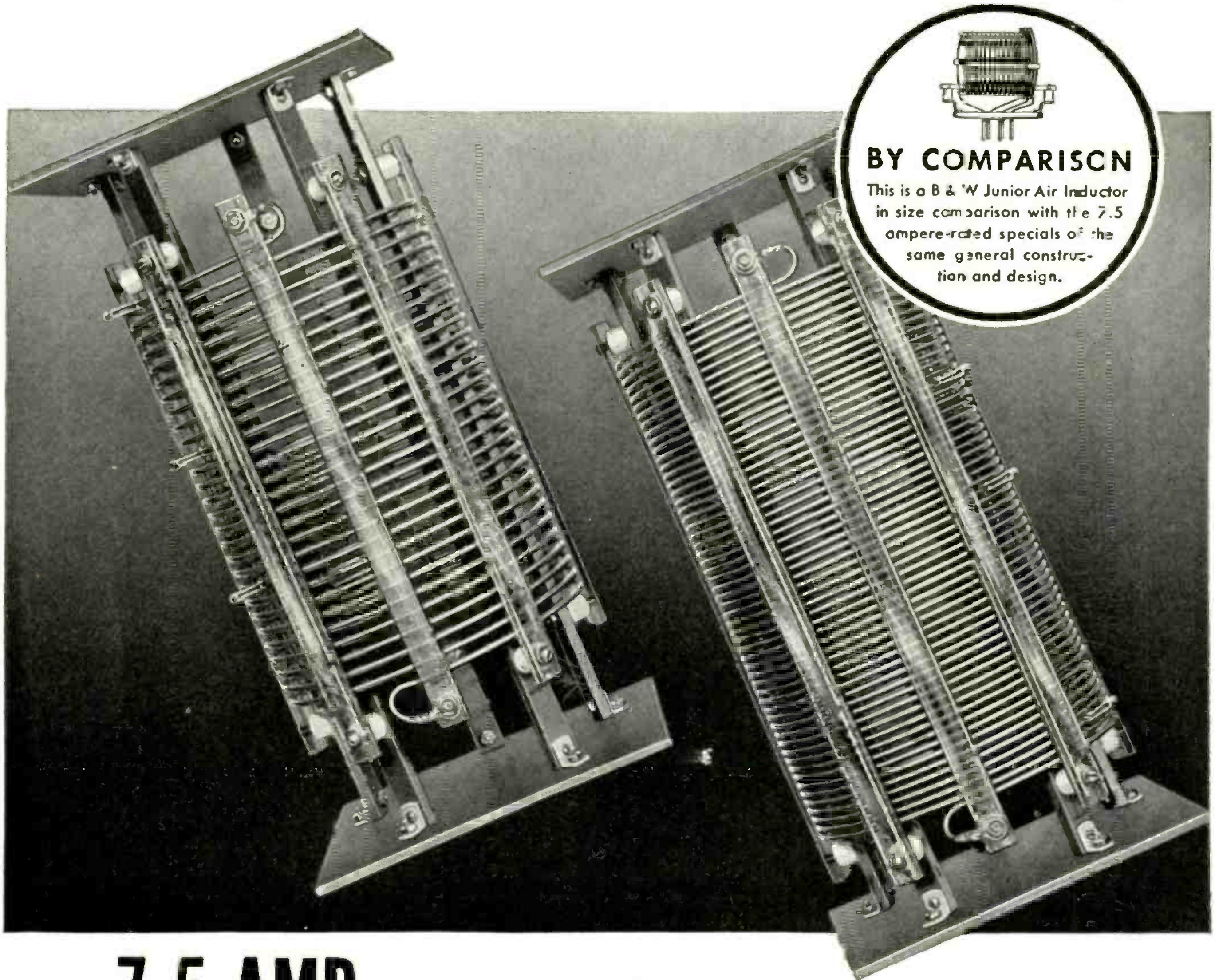
This equation is directly adapted for use with latitudes

$$\cos d = \sin \text{Lat. } A \sin \text{Lat. } B + \cos \text{Lat. } A \cos \text{Lat. } B \cos \text{Long. diff.}$$

Where *d* is the great circle distance in degrees. If one considers the latitude positive when it is North and negative when it is South, this one equation will do for all cases.

It will then be necessary to adjust the equation in each case so that all the

[*Continued on page 61*]

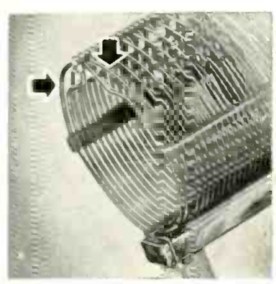


7.5 AMP. CONTINUOUS RATING

But the only thing "Special" is the size

Actually, these 20" giant B & W Air Inductors, wound with #8 solid wire, are simply grown-up war versions of the famous B & W Junior "Air Wound" Coils of amateur radio fame. The only special feature is the size plus, of course, the attendant bracing of triple x bakelite strips and plates for absolute mechanical rigidity. They're attractive in appearance, sturdy as you'd ever expect coils to be, and serve as interesting examples of B & W's unexcelled facilities for the production of special units—often with only a minimum of change from standard designs of unquestioned dependability.

Coils of this type are available through the entire broadcast frequency range. Adaptations are available for specific applications on any frequency. Other B & W coils in both "Air Wound" and form-construction types can be supplied for practically any inductance requirement. Details on any type, or quotations to your specifications, gladly sent.



HOW TO TAP SMALL COILS—EASILY

Ever try to tap a tiny coil where the turns were so close together you felt as though you were trying to fasten a rope to a middle tooth of a fine-tooth comb? Then you'll appreciate this special B & W small coil indent feature. The windings on either side of the turn you want to tap are indented out of the way, thus making tapping quick and easy, anywhere on the Inductor.

B&W

AIR INDUCTORS

BARKER & WILLIAMSON, 235 FAIRFIELD AVE., UPPER DARBY, PA.

THIS MONTH

RADIO EMPLOYMENT

Employment and compensation data for standard broadcast stations and networks during 1943 were released by the Federal Communications Commission.

Responses from 815 standard broadcast stations and 10 networks, covering the week of October 17, 1943, revealed that 24.515 persons were employed full-time and 4,862 part-time. Approximately 52 stations had not filed their returns at the date of this compilation.

The total weekly compensation paid to all full-time employees amounted to $1,-366,687 or an average of $55.75 per employee. This represents an increase of 6.6% over the October 1942 average of $52.32.

Average weekly compensation for full-time employees, excluding executives, was $49.50 or an increase of 7.3% over last year's average of $46.12.

The two releases containing these data show for each broadcast district and region, the number of employees and average compensation per employee in each of the various radio occupations. Data are shown separately for full- and part-time employees.

Prompt response on the part of the great majority of stations and networks has enabled the Commission to make this information available at a much earlier date this year.

Three war workers, each representing a different Asiatic race, proudly show how they co-operate in producing communications equipment for the Army Air Forces. Shown at a bench in the Jefferson-Travis Radio Manufacturing Corporation are (left to right) Capt. Alvin Grauer, U. S. Army; Moy Guay Chuck, a native of China; Col. Charles W. Kerwood, U. S. Army Air Forces; Toshio Niniomiya, American-born Japanese; Rama Chattopadhya, an American Hindu

HALLICRAFTERS AWARDS

1st Lt. *Robert Phillips*, Jr., of the Signal Corps, and T/Sgt. *Ervin A. Hurley*, with an Air Base Squadron, tied for first prize in the Hallicrafters Company cash prize contest for radio men in the service. Each of the soldiers received a check for $100. The prizes were awarded for letters telling of their personal experiences with Hallicrafters military and naval and communications equipment.

Lt. Robert Phillips, Jr., receiving the Hallicrafters' award from Kenneth McClelland, personnel director of the company

Lt. Phillips, who was invited to come to Chicago and attend Hallicrafters annual Christmas dance, was presented personally with his $100 check on that occasion. At the battle of Kasserine Pass, he was driving an SCR-299 mobile radio station when hit by dive bombers. He wears an empty sleeve as a result, also the Order of the Purple Heart. With his arm nearly blown off, he drove six wounded men to a first-aid station and sent back an ambulance for more. In his prize-winning letter he told how the Hallicrafters SCR-299 was used to establish communication between an African base and London, England—a distance of 2,300 miles.

T/Sgt. Ervin A. Hurley told in his letter how the SCR-299 overcomes severe radio disturbances caused by adverse weather conditions.

NEW CENTRALAB BULLETINS

To supplement bulletin No. 630 on Ceramic Capacitors, Centralab has released a new 4-page folder No. 721. It contains condensed information on special types of capacitors now in production.

Bulletin No. 720-A provides complete specifications and advantages of "Centradite," a new development in ceramic material, and Steatite.

Either or both bulletins may be obtained on request to Centralab, Division of Globe Union, Inc., 900 East Keefe Ave., Milwaukee, Wis.

CANNON WIRE DATA

Cannon Electric Development Company, 3209 Humboldt Street, Los Angeles 31, California, has just published a 24-page loose-leaf booklet on Signal System, Cable and Wire Data for engineers, estimators, wiremen and the electrical industry in general.

Among the data will be found the following: standard telephone cable color code, interphone telephone cable, switchboard telephone cable, wire types used in telephone and signal installations, resistance of copper wire, carrying capacities of wires, etc.

The pages 4 x 6⅛ are 3-hole punched to fit into standard data books. Copies will be sent free upon request.

ASA STANDARDS LIST

The American Standards Association announces the publication of its new list of standards. There are more than 600 standards listed, of which 64 have been approved or revised since the last price list was printed (April, 1943). The standards cover specifications for mate-

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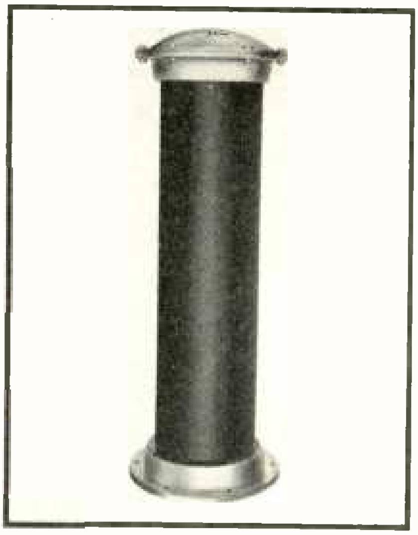
NEW PRODUCTS

NEW QUARTER MILLION VOLT CAPACITOR

The .02-mfd. 250,000-volt capacitor shown is the latest type Industrial Specialty unit. It consists of liquid impregnated capacitors housed in a wet process porcelain tube and filled with a liquid di-



electric. The end caps are the Westinghouse solder seal type which act both as a mounting arrangement and terminals.

This unit is built for total submersion for salt water and operation under the severest conditions. Voltage ratings range from 7500 volts to a quarter of a million volts in single units and can be connected in series for operation up to several million volts.

Manufactured by Industrial Specialty Company, 1725 West North Avenue, Chicago, 22, Illinois.

CML PRODUCTION PLUGS

Developed for use with the Rotobridge in testing electronic equipment, CML production plugs are now available generally for use by electrical manufacturers.

CML production plugs are 5 inches long and 1¼ inches in diameter, so that the handle will project above the average i-f transformer, condenser, making it readily

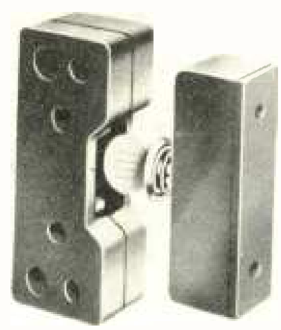
accessible. CML Production Plugs are made with a heavy steel barrel and are filled with a wooden handle to permit ready removal from socket. All pins are case hardened steel to assure long life, yet may be replaced when worn or broken. In both the octal and loktal plugs, center key extends through in form of a threaded rod to permit cable to be fastened firmly in position without strain on pin connections. A flat head machine screw serves same purpose in the other plugs.

In addition to the octal and loktal types, these plugs are available in 4, 5, 6 and 7 pin models, small and medium. Descriptive bulletin is available from Communication Measurements Laboratory, 116 Greenwich Street, New York.

G-E SAFETY DOOR INTERLOCK SWITCH

A new door interlock switch, designed as an emergency device to interrupt control circuits where access doors are opened when the power is on, has been announced by the Specialty Division of the General Electric Electronics Department at Schenectady, N. Y.

It has a carrying capacity of 10 amp., 110 or 220 volts a.c. or d.c., and an emergency opening capacity of a.c. 7½ amp., 110 or 220 volts; on d.c. low inductive cir-



cuits, 5 amp., 125 volts; 2½ amp., 250 volts.

Application covers a wide range where doors, windows or covers must be interlocked for the protection of the equipment and safety of the personnel. For example, doors on radio transmitters, x-ray and therapeutic machines, burglar alarms, and signal controls for fire doors.

SHEFFIELD PRECISIONAIRE

An instrument for checking the dimensional tolerances of quartz crystals without marring their surfaces has been developed by the Sheffield Corporation of Dayton, Ohio. This device, called the Precisionaire, is used for accurately gaging a part as to size, out-of-round, taper, and bell mouth at any section of its length or at any point on the diameter within its length. The principle of air flow, instead

of air pressure, permits relatively low pressures during the gaging operation.

Crystals to be checked are placed in a snap-type gaging fixture which has a column of air flowing against the top and bottom of the crystal from the gaging fingers. Interchangeable spacer blocks are inserted in the fixture to permit the checking of several basic sizes. Crystals of known sizes are used as masters to set the limits.

This device may be used for checking other items, such as delicate parts of glass or other materials which are fragile and easily marred. Parts having tolerances ranging from .0001 to .005 inch may be accurately checked.

SQUARE-WAVE GENERATOR

The newly organized Reiner Electronics Company of New York City announces a new low-priced Square-Wave Generator Model 530, designed for production testing. It is claimed to incorporate a feature not found in other square-wave generators, the facility of synchronization with any external frequency source.

Model 530 Square-Wave Generator has a hand-calibrated frequency scale reading from below 10 cycles to more than 100 kilocycles. The accuracy of the frequency

[*Continued on page 48*]

utah V-NEWS

RADIO INDUSTRY NOW PRODUCES FOR WAR—BUT PLANS FOR PEACE

UTAH EMPLOYEES BREAK PRODUCTION RECORDS FOR UNCLE SAM

FRED R. TUERK

Month by month, production records have been broken as Utah has gone "all out" for Uncle Sam, according to Fred R. Tuerk, President.

He points out that experience gained during the war period will be ably utilized in efficient peacetime production.

With emphasis on quality, the dependability of Utah parts, long a by-word in the radio and sound equipment industries, will be maintained.

YOU ARE PART OF UTAH'S POSTWAR PLANS

ODEN F. JESTER

"We're working for Victory and planning for peace now," stated Oden F. Jester, Vice-President in Charge of Sales of the Utah Radio Products Company, when queried recently on Utah's postwar plans. "Our experts are hard at work, developing plans for the future—plans that take utmost consideration of the needs of industrial concerns. Better products are on the way. In the Utah laboratory rapid strides have been made in adapting new electronic and radio developments for war uses—and making them available for the requirements of tomorrow."

CARTER DIVISION IN FULL SWING FOR WAR PRODUCTION—AND POSTWAR PLANNING

FRANK E. ELLITHORPE

Frank E. Ellithorpe, Sales Manager of the Carter Division of the Utah Radio Products Company, declared in a recent interview that Utah Jacks, Switches, Vitreous Enameled Resistors, Plugs, Wirewound Controls and other Utah-Carter parts are seeing service on wide fronts—in the air, on the sea and on the ground. They are playing an important part in adapting the new electronic and radio developments—in making them militarily and commercially usable.

Mr. Ellithorpe went on to state that Utah-Carter parts are proving that the engineering which created them and the manufacturing methods which are turning them out in ever-increasing quantities are worthy of the fighting men who depend on those parts. This same engineering staff and these same manufacturing facilities, Mr. Ellithorpe went on to say, will be converted to the development and production of the Utah products to meet the demands of industry for "tomorrow."

WAR DEVELOPMENTS AND THEIR PEACETIME MARKETS

The war has speeded discoveries and improvements in many fields, said W. A. Ellmore, Vice-President in Charge of Engineering of the Utah Radio Products Co. "Nowhere," he went on, "has this been more true than in the radio and communications fields. Today, electrical and electronic miracles are enlisted in the armed forces—but tomorrow they will be at the service of peacetime America." Mr. Ellmore further pointed out that because of the wartime research and improvements now going on at Utah, there will be greater enjoyment and convenience in the American home—greater efficiency in the American factory.

W. A. ELLMORE

UTAH RADIO PRODUCTS CO., 846 *Orleans St., Chicago, Ill.*

New Products

[*Continued from page 46*]

calibration is 5 percent over extended periods. In cases where great accuracy of frequency is desired, the instrument can be made to synchronize with any standard frequency generator, provided that a synchronizing voltage of at least 0.1 volt is available. The synchronization can also be made with any other external frequency source.

The output impedances available are 100-200-500-600-1,000-2,000 ohms. Output voltage may be varied either in fixed steps or may be continuously varied by means of the variable voltage potentiometer. When the latter is used, the output impedance is from 0-2,000 ohms. The maximum voltage output is approximately 200 volts.

The power supply of Reiner Electronics Model 530 Square Wave Generator is designed to operate on 110-120 volts, 60 cycles a.c. It is also available for other voltages or line frequency. The power consumption is 30 watts. Prompt delivery can be made on properly certified orders.

The Reiner Electronics Company, located at 152-6 West 25th Street, N. Y. C., will also manufacture oscilloscopes, signal generators, vacuum tube voltmeters and general electronic equipment. A new bulletin describing their products will soon be available from the manufacturer.

R-F LACQUER

A new and improved radio frequency lacquer with a remarkably low loss factor over a wide frequency range has recently been offered for various electronic applications by Communication Products Company, 744 Broad Street, Newark, N. J. In a 24-page booklet, now ready for distribution, the uses of Q-Max A-27 Radio Frequency Lacquer are illustrated and described. The electrical and physical properties of Q-Max, as determined by careful laboratory tests, are recorded in a series of useful graphs and charts. Illustrated graphically, for a wide frequency range, are the dielectric constant, power factor and loss factor while data are included for dielectric strength, density, drying time, adhesion and other characteristics.

GLASS VEE JEWELS

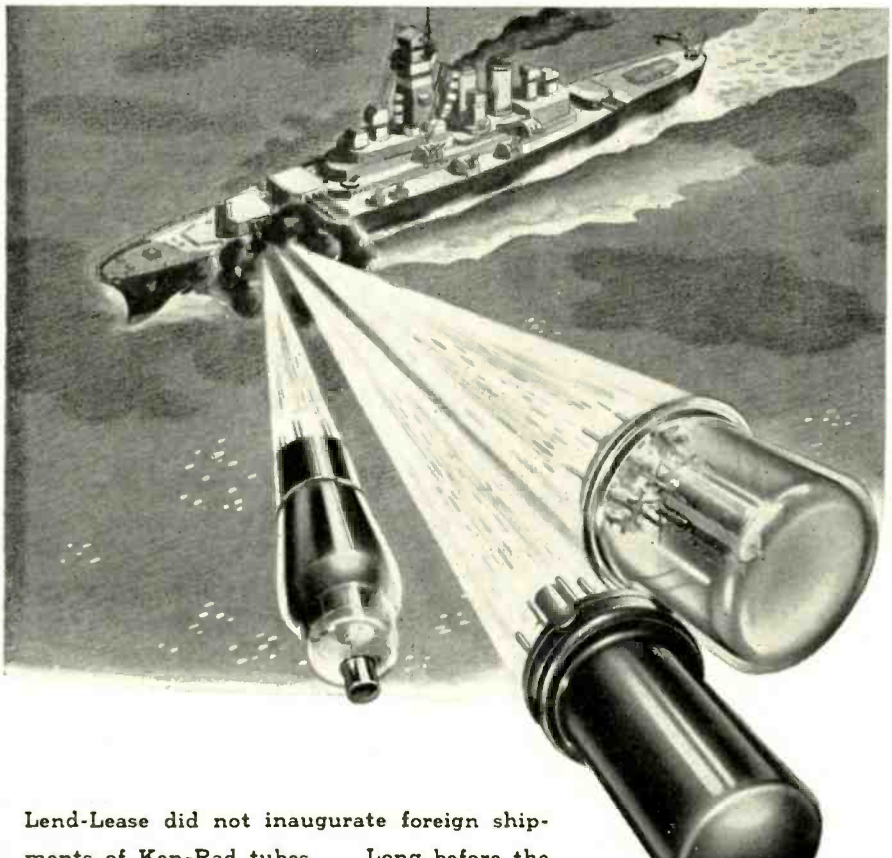
Previously offered as run-of-mill quality, General Electric glass vee jewels are now ready to set. Before jewels are shipped, they are examined under a binocular microscope, which has a magnification of 40 diameters, for incipient flaws in the glass, the depth of the vee and its concentricity. Simultaneously the bearing is explored for pits or roughness

with a fine steel needle. All jewels now furnished have passed this rigid inspection and are ready to be set in jewel screws. This inspection saves the purchaser inspection time.

Glass vee jewels have been manufactured in tremendous quantities since the beginning of the war to replace imported sapphire jewels which have become practically unobtainable. G.E. has supplied the majority of these jewels to the war effort. They are used in small panel instruments with a moving system which weighs one gram or less. The jewels have the same coefficient of friction as the sapphire and in combination with instrument steel pivots, under vibration, they often produce less friction increase than does the sapphire.

Vast improvement has been made in the glass as compared with that previously used. These jewels will resist shocks in

[*Continued on page 50*]



New Products

[*Continued from page 18*]

excess of those required to damage instrument steel pivots. This is because the glass jewels are specially designed for this application.

Following inspection and before shipment, all jewels are cleaned in three positions in a special watch-cleaning machine and spun dry for five minutes between each position.

Two sizes of glass vee jewels are now available; diameters of 0.051 and 0.076 inch. General Electric is an approved source of supply—Navy Department, Bureau of Aeronautics.

Publication GEA-4134, available from General Electric at Schenectady, gives specifications and ordering information together with suggestions for press setting the jewels.

G.E. "LECTROFILM"

Lectrofilm, a new synthetic dielectric material for capacitors, developed after several years of General Electric laboratory research, and made of materials available in the United States, has been announced by the Company.

Lectrofilm, the development of which was hastened by the growing shortage of high-grade mica, can be best applied to the manufacture of most radio-frequency, blocking and by-pass, fixed capacitors used in communications and other electronic equipment. The new product has a greater combination of desirable properties than was previously available in any one dielectric material. It is available in both rolls and sheets and can be used in present capacitor production lines with

very little change in equipment or method of manufacture.

In addition, lectrofilm's strength and flexibility make it well-suited to automatic methods of manufacture. The careful control used in its production, together with its chemical stability, assure uniform properties and freedom from defects. Furthermore, it requires little grading or sorting before being placed into a capacitor production line.

This Month

[*Continued from page 41*]

rials, methods of tests, dimensions, definitions of technical terms, procedures, etc.

One important phase of the work built up during the 25 years that the ASA has been in existence, is in the field of safety engineering. The new list includes 95 safety standards.

BOOK ON "SMALL RADIO"

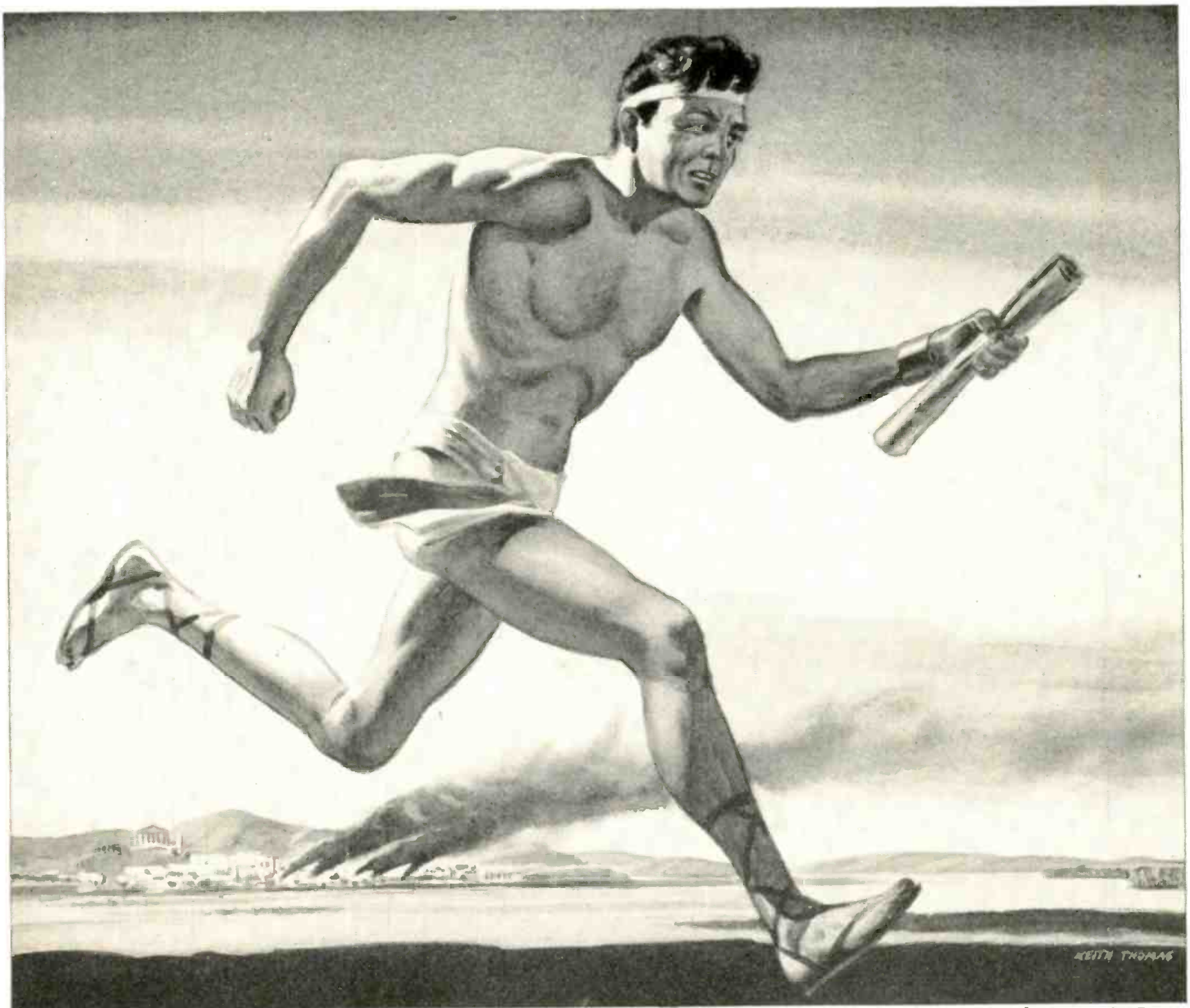
Small Radio, Yesterday and In The World of Tomorrow, titles an impressive book on that subject and on the vast strides of electronic development during the past two years which is now being issued by the Emerson Radio and Phonograph Corporation.

In the several chapters of the attractively bound volume, *Benjamin Abrams,* president of Emerson, traces the evolution of small radio from the early midget designs of 1928 up to the last compact models which were produced in 1941. He reviews not only the types and styles of receivers which captured public fancy during the thirteen-year stretch, his observations on merchandising and trade and consumer trends are perhaps even more interesting and constructive.

REPS MAKE PLANS

At the November meeting of the Mid-Lantic Chapter of "The Representatives"

[*Continued on page 63*]



History of Communications Number One of a Series

A FORERUNNER OF MODERN COMMUNICATIONS

One of the first known channels of message carrying was by runner, and annals of Grecian and Phoenician history describe the nimble lads who firmly grasped rolls of parchment and sped hither and yon. Clad in typical running gear of the period, they covered amazing distances with almost incredible speed. That was the forerunner of today's modern communications where scientific electronic devices are "getting the message through" on every war front. Universal Microphone Co. is proud of the part it plays in manufacturing microphones and voice communication components for all arms of the United States Armed Forces, and for the United Nations as well. Other drawings in the series will portray the development of communications down through civilization and the ages to the modern era of applied electronics.

< Model 1700-UB, illustrated at left, is but one of several military type microphones now available to priority users through local radio jobbers.

UNIVERSAL MICROPHONE CO., LTD.

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D-C Amplifier

[*Continued from page 21*]

rangement of *Fig. 2*, or, better still, by a differential ammeter as in *Fig. 7*.

Now imagine a voltage to be applied. The plate current of tube *1* will increase, that of tube *2* will decrease (see *Fig. 4*). Presently tube *2* will reach cut-off, while the current in tube *1* goes on increasing. Eventually, this will level off to a final value.

If the difference in currents is plotted, we have the curve of *Fig. 5*. If we draw this curve using a *logarithmic scale* for the volt scale, it may take the form of *Fig. 6*, provided the resistors have been correctly chosen. The plate resistor of tube *2* has been eliminated.

Fig. 7 (*A*) shows a multiple arrangement similar to *Fig. 3*, and (*B*) the current plots. The range of this multiple circuit is no wider than that of the circuit of *Fig. 3*, but the response approaches the logarithmic law more closely. In order to obtain a wide range, either arrangement must appear twice (or as many times as desired) in the complete circuit.

The Complete Amplifier

The complete circuit in the form used experimentally is shown in *Fig. 8*. It includes two "differential units" like that of *Fig. 3*, one of which receives the full applied voltage, while the other receives only 3% of it. The second unit has no appreciable effect on the reading until the applied voltage reaches sizeable values. The operation of the entire device may be summarized by stating that those tubes which contribute more to the overall gain (or have more stages following them) "drop out" first.

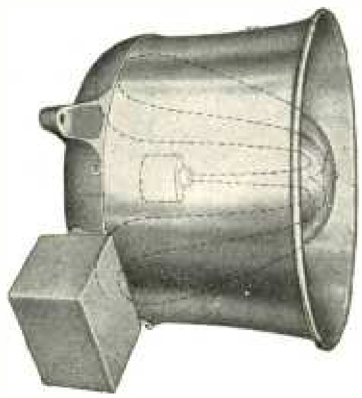
The switching arrangement *S* of *Fig. 8* is designed for calibration purposes. If it becomes necessary to change tubes, the switch *S* is opened and the input is short-circuited. Under these conditions the reading should be zero. If it is not, potentiometer P_2 is adjusted for zero reading. Then the switch *S* is closed; this may cause the meter to read a slight current. Potentiometer P_1 is now adjusted until the reading is again zero.

If the zero is adjusted in this way, the instrument is surprisingly unaffected by tube changes. No error in the calibration was detected even with very poor tubes. If the tubes are not changed no apparent "drift" occurs over long periods. So far as stability is concerned, the instrument is highly satisfactory.

The deflection vs. input-voltage curve of the amplifier, as shown in

[*Continued on page 54*]

Like RACONs—I'm Rugged and Efficient!



Here is the RACON MARINE HORN Speaker used on many bombers and navy vessels. Approved by the U. S. Coast Guard, formerly the Bur. of Marine inspection, Dept. of Commerce. Several sizes available, Stormproofed, of the reentrant type, suitable for indoor or outdoor use—may be used as both speaker and microphone.

RE-ENTRANT TRUMPET; available in 3½′, 4½′ and 6′ sizes. Compact. Delivers highly concentrated sound with great efficiency over long distances.

There are many types of dog—and loud speakers. There's as much difference between a champion and mongrel. RACONS and I, we're Champs! We're both outstanding, rugged, dependable, efficient—pure-bred from date of conception.

It's not the external appearance of a dog or loud speaker that counts. For example, several other makes of loud speaker outwardly look something like RACONS. But there the similarity ends because in engineering design, workmanship and use of quality materials, *RACONS are the "tops".*

Only RACON makes a complete line—a speaker for every conceivable sound distribution application. *Only* RACON Speakers can supply patented Stormproof, Weatherproof Acoustic Material which is impervious to any weather condition and prevents resonant effects. And RACONS deliver greater output per watt of energy input, assuring greatest efficiency and economy.

Army, Navy and other Military Services, also leading shipyards and war plants use many types of RACON Speakers and Driving Units. *Specify RACONS for your next sound installation.*

RACON ELECTRIC CO. 52 E. 19th St., N. Y.

RACON

D-C Amplifier

[*Continued from page 52*]

Fig. 8, is that of *Fig. 9*. The meter scale is reproduced in *Fig. 10*. The accuracy would be improved by the use of a longer scale. This presents no mechanical difficulty if a differential meter is employed in place of the bridge device of *Fig. 8*, as such a meter would be relatively insensitive (a large wall-type milliammeter would do).

Conclusion

A type of d-c amplifier, particularly suitable for measurement purposes, eliminating the need for "range selection" over a 1000-to-1 range, has been described. The amplifier includes two twin-triode tubes: which go "out of action" in a certain order, with the result that the overall gain is, approximately, in inverse ratio to the input voltage. This causes the output circuit meter deflection to be approximately proportional to the db level of the input voltage over a wide range.

The logarithmic law may be approached to any desired degree by using a greater number of tubes in each "unit" of the instrument. The number of "units" used is the factor influencing the "range" of the instrument.

The amplifier was found to have good stability. A simple "zero adjustment" operation resets the instrument whenever a tube is replaced.

Using Determinants

[*Continued from page 30*]

PRACTICAL EXAMPLE

Consider the hypothetical circuit shown in *Fig. 2*, and let it be required to find the values of the currents I_1, I_2, I_3, I_4, I_5 and I_t.

We may reduce the number of unknowns because of the following relationships, namely

$$I_2 = I_t - I_1$$
$$I_5 = I_1 - I_4$$
$$I_3 = I_t - I_4$$

Setting up the Kirchhoff equations in the usual manner, we obtain our simultaneous equations

$$(13)\quad \begin{aligned} 7I_t - 3I_1 - 4I_4 &= 10 \\ 0 + 2I_1 + 5I_4 &= 10 \\ 3I_t - 11I_1 + 6I_4 &= 0 \end{aligned}$$

To solve these equations not only systematically but also quickly, we use determinants—and in this case we follow Cramer's Rule. We set up our common denominator by simply copying all the coefficients from the left side of the equation exactly the way they appear. Notice that for ease in copying the coefficients we place a zero in the equations for all unknowns that do not appear, as shown in the second equation. We have thus

$$(14)\quad \Delta = \begin{vmatrix} 7 & -3 & -4 \\ 0 & 2 & 5 \\ 3 & -11 & 6 \end{vmatrix}$$

Next, in solving for I_t we replace the coefficients of I_t in (14) (i.e., the first column) by the corresponding constants from the other side of the equations, and divide the new determinant by (14). Thus,

$$(15)\quad I_t = \begin{vmatrix} 10 & -3 & -4 \\ 10 & 2 & 5 \\ 0 & -11 & 6 \end{vmatrix} \div \Delta$$

Similarly, we have for I_1 and I_4

$$(16)\quad I_1 = \begin{vmatrix} 7 & 10 & -4 \\ 0 & 10 & 5 \\ 3 & 0 & 6 \end{vmatrix} \div \Delta$$

$$(17)\quad I_4 = \begin{vmatrix} 7 & -3 & 10 \\ 0 & 2 & 10 \\ 3 & -11 & 0 \end{vmatrix} \div \Delta$$

In evaluating, we start from (14) since it appears in every subsequent equation. Two methods are applicable here: either expansion by minors or the mechanical expansion (discussed

[*Continued on page 58*]

Centradite

A new Centralab Ceramic Material

Centradite is particularly recommended for coil forms where thermal expansion must be low to prevent undue change in inductance. At 20-600°C thermal coefficient of expansion is 3.1×10^{-6} as compared to 8.3×10^{-6} at 20-800 °C for Steatite.

Centradite can be supplied in various shapes by extrusion or pressing.

Centradite due to its resistance to heat shock, lends itself to a new process of soldering metal to ceramic, whereby the ceramic surface is metallized to permit soldering.

We invite inquiries regarding the future uses which may fit your applications.

BODY NO. 400	DESCRIPTION OF MATERIAL
20-100 °C 1.9×10^{-6} 20-600 °C 3.1×10^{-6}	Thermal coefficient of expansion per degree Centigrade
13,000 lbs.	Modulus of rupture in lbs. per sq. in.
5.4	Dielectric constant
3.00 or less.	Dielectric loss factor
Class "L3" or better	Grade per American Stand. C 75.1-1943
Zero to .007 %	Porosity or moisture absorption
White	Color of material

★ LOW THERMAL EXPANSION

★ HIGH RESISTANCE TO HEAT SHOCK

★ LOW POROSITY

★ LOW LOSS FACTOR

Centralab

Division of GLOBE-UNION INC., Milwaukee

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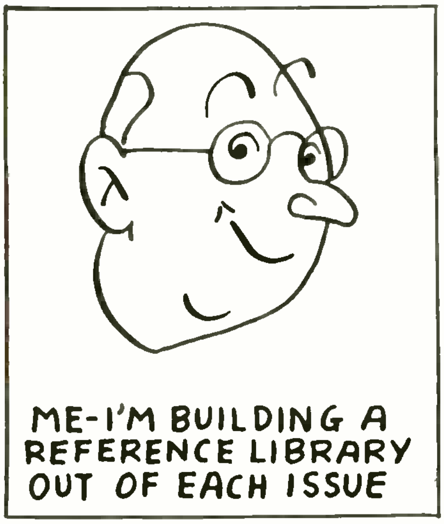

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RADIO MAGAZINES, INC.

342 MADISON AVENUE NEW YORK 17, N. Y.

Using Determinants

[*Continued from page 54*]

above). We shall use the former since it is a more general method and since the latter needs no illustration. Thus in expanding by minors we are to choose any column or any row and subsequently multiply each element of that choice by its minor. It is always best to choose that row or column, which has most zeros in it. Very often new zeros may be introduced by using property (7) but that is not the case here. A good choice here would be either the first column or the second row. Using the first column, we have

$$(14)\quad \Delta = \begin{vmatrix} 7 & -3 & -4 \\ 0 & 2 & 5 \\ 3 & -11 & 6 \end{vmatrix} = 7\begin{vmatrix} 2 & 5 \\ -11 & 6 \end{vmatrix} - 0 + 3\begin{vmatrix} -3 & -4 \\ 2 & 5 \end{vmatrix}$$

Now expanding the second-order determinants, we obtain

$$\Delta = 7[2\times 6 - (-11)\times 5] + 3[(-3)\times 5 - 2\times(-4)]$$
$$= 7\times 67 + 3\times(-7) = 469 - 21 = 448$$

Proceeding in exactly the same way but omitting the intermediate steps, we have for I_t, I_1 and I_4

by (15) $I_t = 1290 \div 448 = 2.88$ amp.
by (16) $I_1 = 690 \div 448 = 1.54$ amp.
by (17) $I_4 = 620 \div 448 = 1.38$ amp.

We obtain the values of the other currents from the relationships between them, as was shown before

$I_2 = I_t - I_1 = 2.88 - 1.54 = 1.34$ amp.
$I_5 = I_1 - I_4 = 1.54 - 1.38 = 0.16$ amp.
$I_3 = I_t - I_4 = 2.88 - 1.38 = 1.50$ amp.

With minimal practice many of these steps can be carried out mentally and so this process becomes really speedy. With many equations in only two unknowns it is possible to obtain the solution entirely mentally.

Class C Amplifiers

[*Continued from page 35*]

by the number of intervals in a complete cycle.

$$\text{Power output, } P_o = \frac{1727 \times 2}{36} = 96 \text{ watts}$$

$$\text{Driving power} = \frac{73.2 \times 2}{36} = 4.1 \text{ watts}$$

8) The impedance of the tank circuit is,

$$Z_1 = \frac{(E_b - E_{min})^2}{2P_o} = \frac{(1500 - 140)^2}{2 \times 96} = 9650 \text{ ohms}$$

The inductance and capacity re-

[*Continued on page 60*]

Technicana

[*Continued from page 14*]

ticians but startles laymen. It has to do with the formation of real images by large mirrors of short focal length. This is illustrated in *Fig. 4*. A lapel

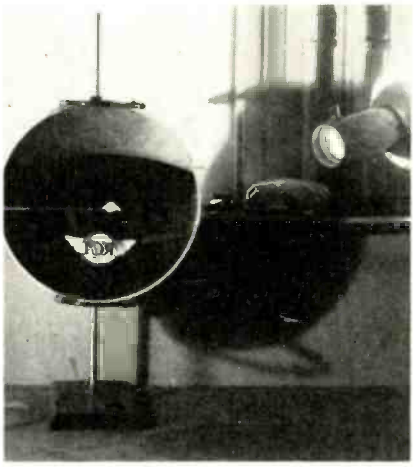

Fig. 4. Image formation

emblem suspended near the center of curvature of the mirror appears hanging in the air about two feet in front of the mirror and so real that one feels like touching it. One can put his finger through it and find nothing but thin air.

GERMAN TECHNICAL BOOKS

★ Many foreign technical books are now being published in this country under the auspices of the Alien Property Custodian.

Of particular interest to radio and electronic engineers are the works of Hollman and Groos on ultra-short waves, Strutt on vacuum tubes, Born on optics, and Vilbig on high-frequency technique.

These books, and others listed, are written in the original German. A complete list and prices may be obtained by writing the publishers, Edwards Brothers, Inc., Ann Arbor, Mich.

Production

[*Continued from page 16*]

move the plugs in a single operation became excessive, due to the multiplied jack-spring tension. By turning down the knob portion of the plug to a pin outline, this difficulty was overcome.

The result was highly successful, the test operation being handled with ease by a girl operator.

Class C Amplifiers

[*Continued from page 58*]

quired to obtain this impedance at the frequency of operation are,

$$L = \frac{Z_1}{2\pi f Q} = \frac{9650}{6.28 \times 2 \times 10^6 \times 12} = 64 \times 10^{-6} \text{ henrys} = 64 \text{ microhenrys}$$

$$C = \frac{1}{4\pi^2 f^2 L} = \frac{1}{39.5 \times 4 \times 10^{12} \times 64 \times 10^{-6}} = 99 \times 10^{-12} \text{ farads} = 99 \text{ micromicrofarads}$$

A number of other factors besides those determined here, such as neutralization, coupling systems, driving stages, etc., must be considered in the practical design of an amplifier. For discussions which take these into account, the reader is referred to the bibliography.

Conclusion

It should be pointed out that the method of analysis presented here is one of several which are available for design of Class C stages. This method has the worthwhile advantage that it is exact. Its accuracy is limited only by the degree to which the tube characteristics will follow the constant current graph, and by the μ of the tube used in the grid bias formula. The great disadvantage is that the required calculations are laborious. This is particularly true if the first calculation does not yield the desired results and a re-calculation is required with different parameters. Other available methods are generally simplified. Since these are sufficiently accurate for most practical purposes, and are, in general, less time consuming, the reader will probably wish to study them before attempting a design problem. References are included in the bibliography.

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Using Slide Rule

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factors become functions of angles in the first quadrant. This should not be hard for a man who knows his sine waves.

In the case of most slide rules, the equation will have to be expressed in sines only.

Example: To find the great circle distance from New York (41.5 *N* 74 *W*) to London (51.5 *N*. 00 *L*).

The equation becomes

$$\cos d = \sin 41.5° \sin 51.5° + \cos 41.5° \cos 51.5° \cos 74°$$

For purposes of the slide rule, the cosines have to be expressed into the sines of their complements

$$\cos d = \sin 41.5° \sin 51.5° + \sin 48.5° \sin 38.5° \sin 16°$$

Align the right and left indices of the slide with that of the stock, set indicator at 41.5° on the *S* scale, move right index to indicator. Set the indicator to 51.5° on *S* scale, read .519 on *A* scale.

Align the indices again, set indicator to 48.5° on the *S* scale, move index to indicator, set indicator to 38.5° on *S*, move index to indicator, set indicator to 16° on *S*, read .129 on *A* scale.

Adding: $.519 + .129 = .648 = \cos d$

Opposite .648 on *B* read 40.5 on *S* scale. Therefore, $d = 90° - 40.5° = 49.5°$. To find statute miles one multiplies this by 69.05; the result is 3420 miles, approximately.

In cases where the direction is desired as well, as in determining the orientation of directional antennae, it is necessary to make a complete solution of the spherical triangle. This is done by Napier's Analogies and Gauss's equations.

Nomographs

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Any line across the nomograph, such as L, then connects corresponding values of E, W and C. Since these are logarithmic scales, the graduation may be rapidly carried out by determination of a pair of values by calculation, then by striking in as many intermediate values as desired by means of projection from a standard log scale, as illustrated in the previous article.

Sum of the Reciprocals Equation

Another useful type of equation is of the form:

$$A = \frac{BC}{B+C}$$

which is recognized as the "sum of the "sum of the reciprocals" equation. The formula for the equivalent capacity C_3 of two capacitances C_1 and C_2 may be written:

$$1/C_3 = 1/C_1 + 1/C_2$$

or,

$$C_3 = \frac{C_1\ C_2}{C_1 + C_2}$$

and proper manipulation will yield the working determinant:

$$\begin{vmatrix} S_1B & 0 & 1 \\ S_1A & S'_3A & 1 \\ 0 & S'_3C & 1 \end{vmatrix} = 0$$

Consideration of this determinant indicates that the B and C scales must be at right angles, while the A scale is inclined to them at an angle determined by the magnitudes of the scale factors. Moreover, all terms become zero at the same time and so the scales must all pass through a point.

If we apply the determinant to the capacity formula mentioned above, letting

C_1 vary from 0 to .0014
C_2 vary from 0 to .0014,
and setting $S_1 = S'_3 = 5000$

we see that the C_3 scale is equidistant between the C_1 and C_2 scales, as illustrated in *Fig. 10*.

We now write the working determinant:

$$\begin{vmatrix} 5000\ C_1 & 0 & 1 \\ 5000\ C_3 & 5000\ C_3 & 1 \\ 0 & 5000\ C_2 & 1 \end{vmatrix} = 0$$

The nomograph is rapidly graduated for intermediate values since all three scales are linear. To use the nomograph, a straight line, such as L, is drawn intersecting the three scales, and the points of intersection determine values of capacity which satisfy the original equation.

Since two resistors in parallel may be calculated by the same form of equation, it is evident that the same general form of nomograph may be used to solve resistor circuits. Likewise, equations may be encountered which, although not of the specified form, may be reduced to this form by means of some expedient such as we observed earlier where logarithms served to reduce an equation to a specified form.

This Month

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held at the Engineer's Club, a Planning Committee under the chairmanship of *S. K. Macdonald* was formed. This committee working with the Chapter's president, *L. D. Lowery*, will consider not only "post-war" possibilities of the Mid-Lantic Chapter, but will make immediate recommendations regarding publicity for the local organization and a new buyer's guide which will be a revised edition of the "Classified Index" published last year.

A membership committee was appointed by *Norman M. Sewell*, Vice President, presiding in the absence of President, *L. D. "Doc" Lowery*, consisting of Chairman *Roy Benge, John McKinley*, and *Robert Williams*. The membership goal is set for 50 and new members are being added at each meeting. *Bob Williams* and *Don Gawthrop* were accepted as new members at this November meeting.

W.E. LEASES MORE SPACE

The Western Electric Company has leased 200,000 square feet of floor space in two industrial buildings in Lincoln, Nebraska, which will be devoted to war production.

The buildings leased are the Buick Service Plant at 245 Thirteenth Street and the Hardy Furniture Company building at 745 R. Street. The expansion of Western Electric Company's war production responsibilities has grown beyond present facilities, which include three main manufacturing plants at Chicago, Ill., Kearney, N. J., and Baltimore, Md., in addition to numerous distributing houses throughout the country.

BELMONT EXPANDS

Construction was started recently on an addition to the plant of the Belmont Radio Corporation, 5921 W. Dickens Avenue. The estimated cost is $70,000. The addition will provide space for the firm's augmented laboratory staff which is developing electronic devices for the armed forces.

The construction work will extend the

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This Month

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second-story portion of the plant and will give an additional floor area of 200 x 45 feet. The new facilities are expected to be ready for use by March 1.

CREATIVE OPENS N. Y. OFFICE

Creative Plastics Corp., 963 Kent Ave., Brooklyn, N. Y., manufacturers of insulating grommets and other fabricated plastic parts for industrial uses, has opened New York city sales and executive offices at 393 Seventh Ave.

These offices, established for the convenience of Creative's out of town customers, expediters and salesmen, both for now and postwar, will be open Mondays through Fridays.

BRYANT JOINS G. E.

J. W. Bryant, formerly with the radio division of the Missouri State Highway Patrol, has joined the General Electric Company's Electronics Department, and will be located at the company's Chicago office. He will assist users of emergency communication equipment in the selection and installation of equipment for their needs in the central region of the United States.

"UNIVERSAL" APPOINTMENTS

Jerry Kane, formerly in the research laboratories of The Turner Co., Cedar Rapids, Iowa, has joined the staff of the Universal Microphone Co., Inglewood, Cal., as electro-acoustics engineer. He will be assigned to design in current war microphone production, as well as the postwar planning division.

The announcement was made by *James L. Fouch,* president, who also announced that factory production would be upped in January, and by June, six new styles of microphones would be available.

Dean Cell, formerly with the Robert Hadley Co., Los Angeles transformer manufacturers as assistant engineer in charge of production testing and production methods, has joined the staff of the Universal as an assistant supervisor. He was recently awarded the B.S. degree in radio engineering by the Radio Institute of California, Los Angeles.

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For reliable aircraft operations, dependable radio communications are essential. Wilcox Aircraft Radio, Communication Receivers, Transmitting and Airline Radio Equipment have served the major commercial airlines for many years, and now are in use in military communications in all parts of the world.

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In this grim business of war, the men in uniform take the risks; they deserve the decorations.

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> **"Let me take a moment for special mention of the tube engineers. Too often they are not fully recognized. We see fine accomplishments in apparatus, but we fail to appreciate the important work that has been done behind the scenes by the tube engineer. Hats off to you—your accomplishment has been most extraordinary. But you, also, you cannot as yet rest upon your oars. The job is not finished, and new and additional accomplishments are required before we are finished with this war." ***

Hytron engineers realize fully that "the job is not finished", and they continue to strive for "new and additional accomplishments" needed to win the war. Their aim is to develop better tubes to make possible better fighting equiment—let the decorations fall where they may.

* Excerpt from address of Paul V. Galvin, president of the Radio Manufacturers Association at the Institute of Radio Engineers' Rochester Fall Meeting, November 9, 1943.

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