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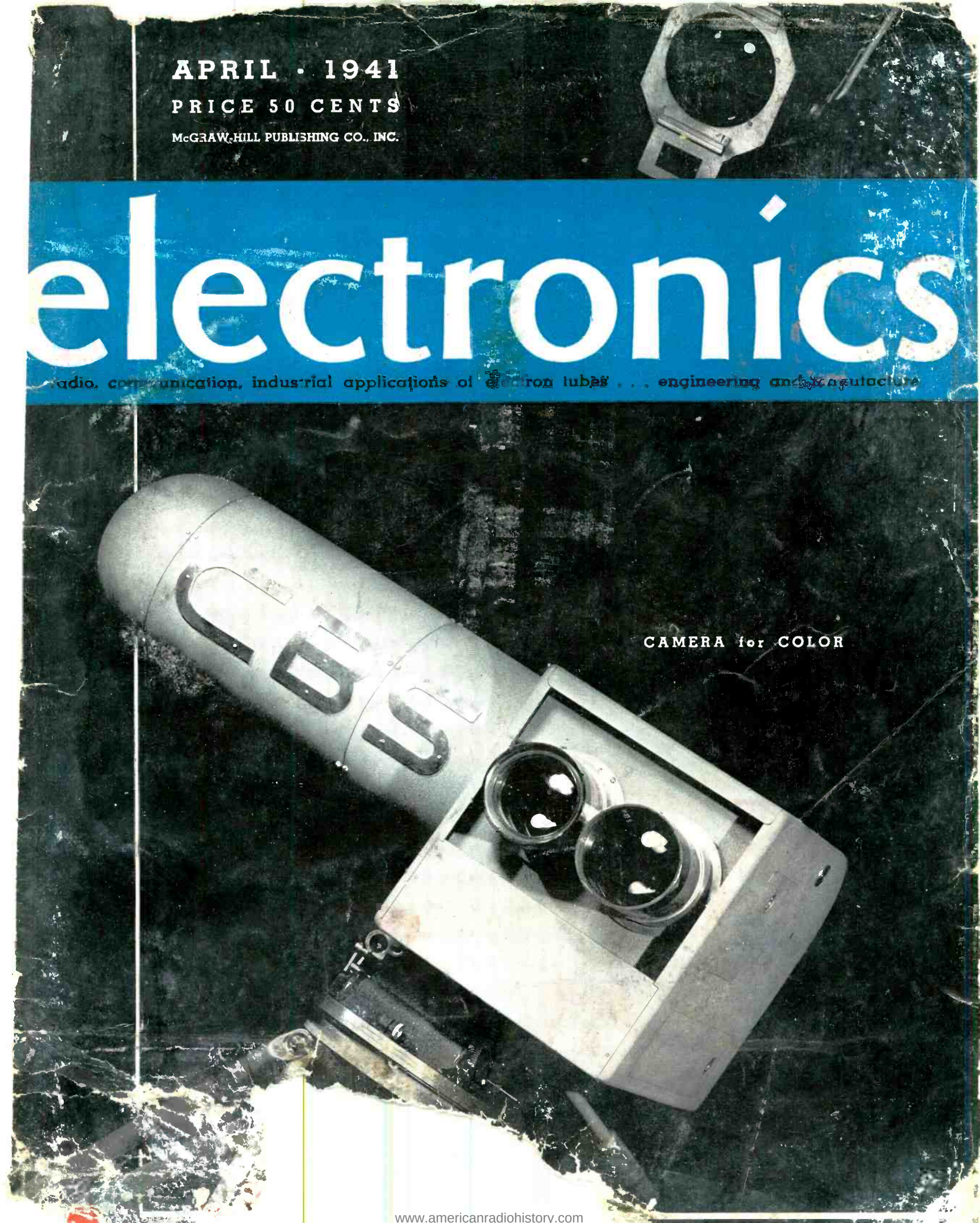


CAMERA for COLOR

"Immune to Heavy Overloads . . . Gratifying Performance . . . Easily Driven . . ."

Writes FRITZ BAUER
Chief Engineer, Radio Station KGBX

KGBX — FULL TIME 1230 KC — Owned and Operated by SPRINGFIELD BROADCASTING CO.

OPTIONAL RED OR BLUE NETWORK OF THE NATIONAL BROADCASTING COMPANY

SPRINGFIELD, MISSOURI

December 18, 1940

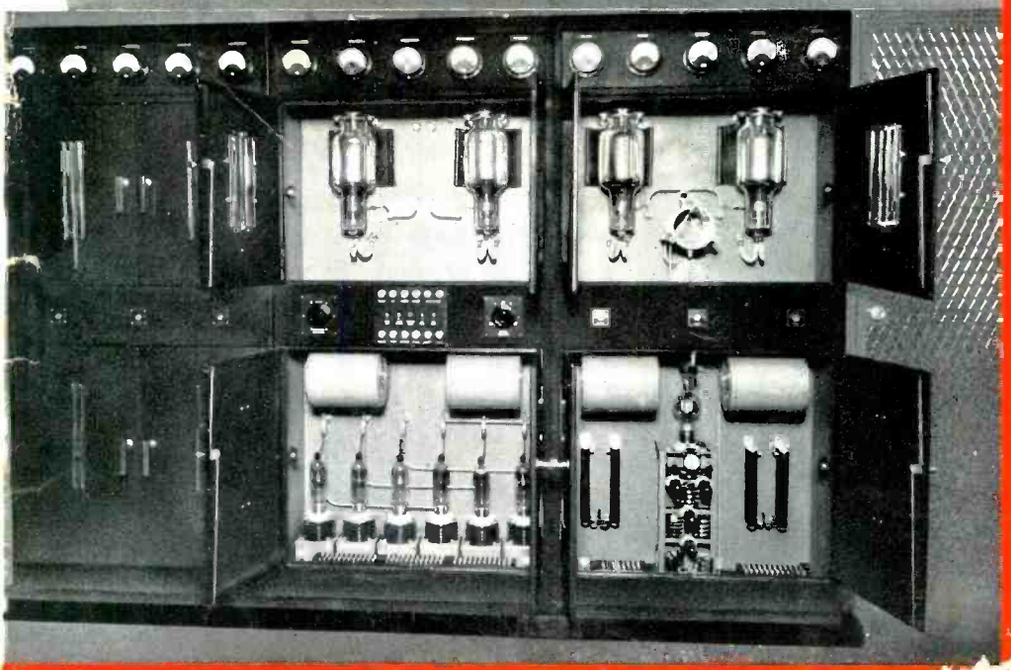
Amperex Electronic Products, Inc.,
79 Washington Street,
Brooklyn, New York.

Gentlemen:

Enclosed you will find the photographs of our new 5 Kilowatt Transmitter which you requested recently. The transmitter is now undergoing tests while we adjust the phasing equipment for our night time directional. **The performance of your HF-3000's as final Class "C" R.F. amplifiers and ZB-3200's as high level modulators, is especially gratifying. The ease with which they can be driven to full output, the extreme simplification of cooling arrangements, the relative immunity to heavy overloads, and the moderate plate voltages required together with the inherent stability of the high level modulated Class "C" system results in a combination that is not easily surpassed for reliable broadcast service.**

The entire 5 Kilowatt transmitter (excepting only the high voltage plate transformers and the modulator transformer and reactor) is built into the 2 righthand cabinets. The third cabinet contains the distribution and phasing networks for the directional array.

Yours very truly,
RADIO STATION KGBX
Fritz Bauer
Chief Engineer



AMPEREX

HF-3000 – ZB-3200

$300

AMPEREX ELECTRO

79 WASHINGTON STREET

INC.

BROOKLYN, N.Y.

A McGRAW-HILL PUBLICATION

electronics

CONTENTS—APRIL, 1941

DEPARTMENTS

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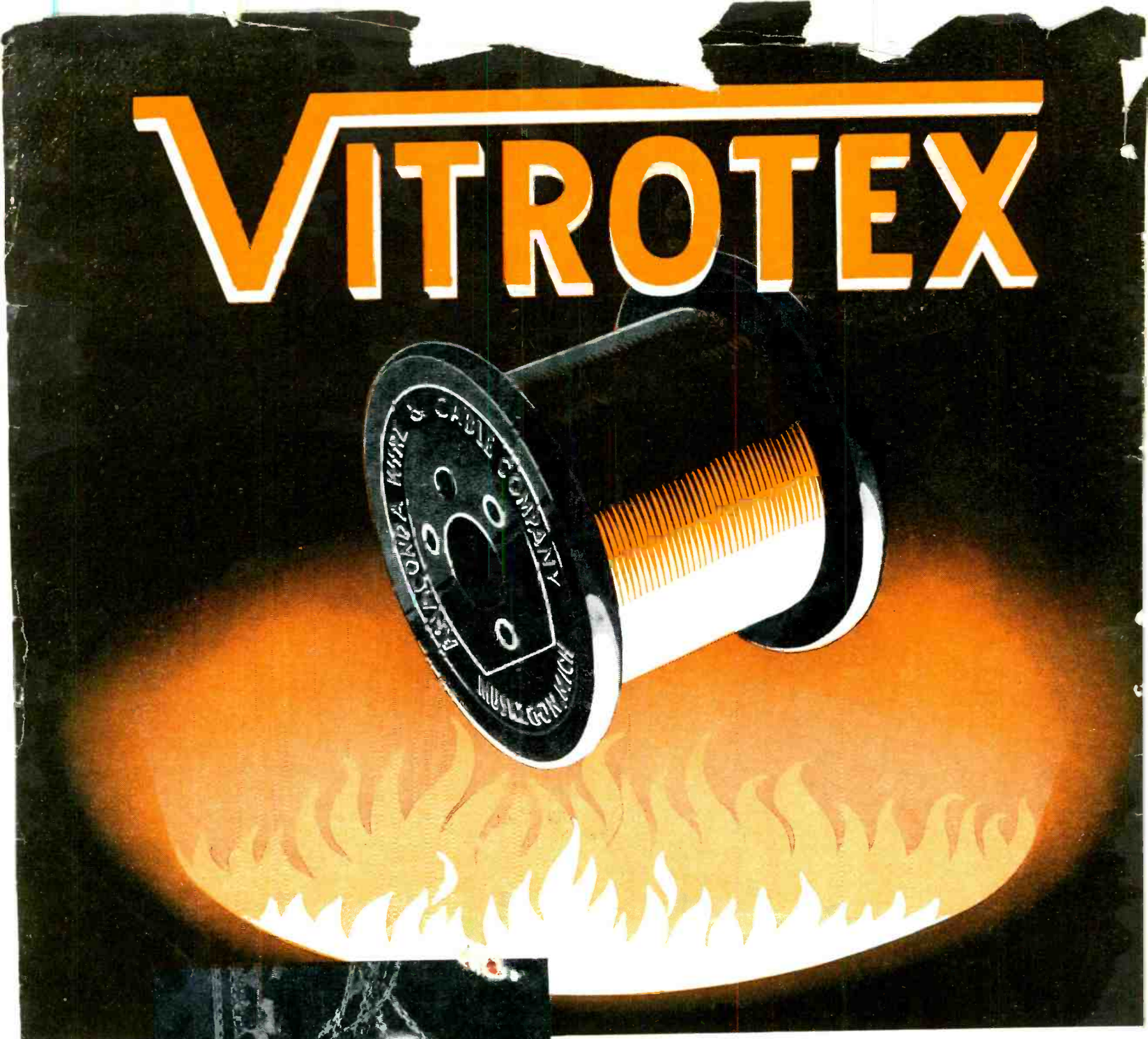
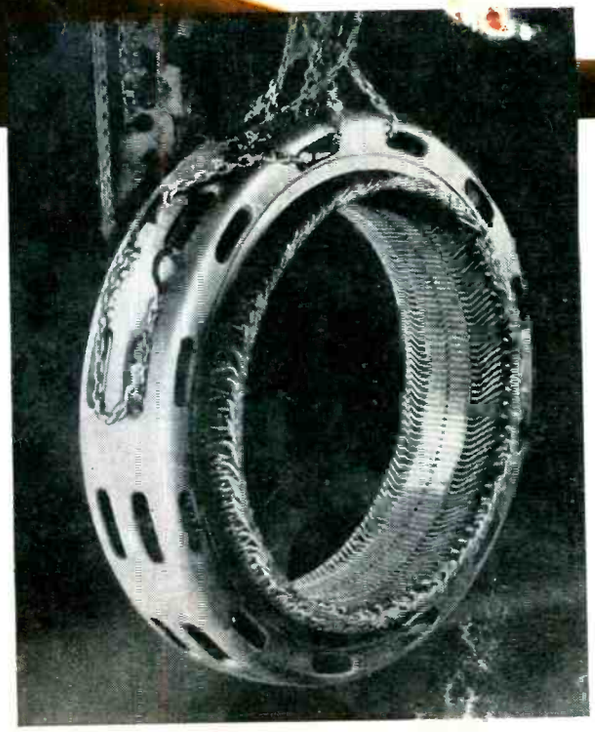
VITROTEX





Generator Capacity Upped 20% by VITROTEX

This generator armature sold to the City of Three Rivers, Michigan, by the L. R. Klose Company of Kalamazoo, was originally designed to operate at 75 Kw., 2,300 volts. *BUT*, since the machine was rewound with Vitrotex insulated magnet wire, it has been generating 90 Kw!...thanks to the thermal conductivity of this improved flexible fibre glass insulation.

Anaconda's improved Fibre Glass Insulation for Magnet Wire

This new inorganic textile insulation manufactured from alkali-free glass is composed of soft flexible fibres approximating steel in tensile strength. No other textile *is contained in Vitrotex!*

For many years it has been acknowledged that the ideal electrical insulation is glass. And now, after a period of long and exhausting research, its practical application has become possible . . . with the development of Anaconda's Vitrotex.

Important Characteristics

The dielectric strength of Vitrotex, its heat resistance and heat conductivity, its power factor, insulation resistance and space factors meet and in most cases exceed the values determined for every other comparable type of insulation including asbestos.

For Example . . .

When compared with asbestos, Vitrotex magnet wire has marked advantages in space factor. Single Vitrotex magnet wire has approximately the same space factor as double silk-covered magnet wire of equal gauge!

Handling Methods; Availability

Vitrotex magnet wire is smooth and uniform in diameter and can be handled in the same manner as silk-covered wire. No special precautions in winding are necessary—except the usual care should be exercised to avoid nicks and cuts in the insulation.

Vitrotex insulation may be applied to all standard forms of magnet wire: bare wire, enameled wire, lead wire and coils. More specific information will be sent you upon application . . . free, of course.

It is fireproof; withstands high temperatures

Has high dielectric strength and insulation resistance

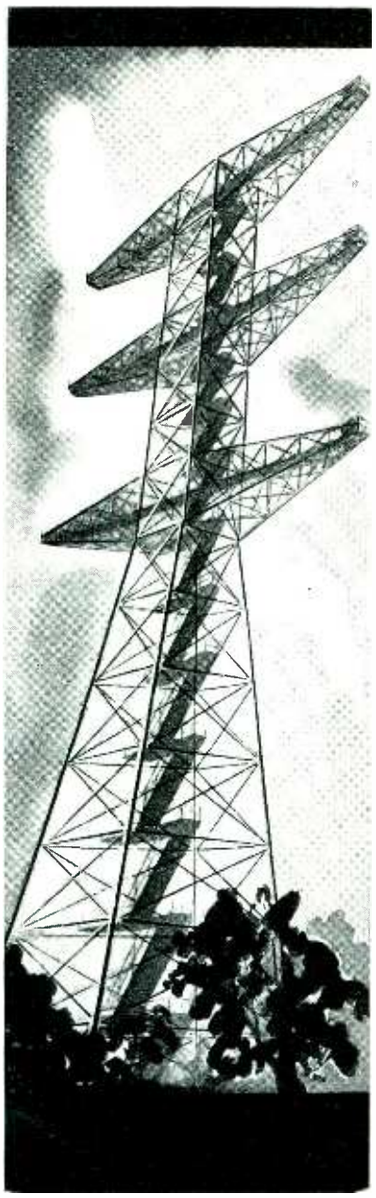
Is non-hygroscopic; unaffected by moisture

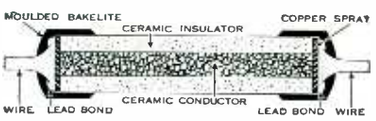
Possesses high resistance to acids, oils, and corrosive vapors

USE MODERN IMPROVED **Anaconda Wire & Cable**

ANACONDA WIRE & CABLE COMPANY, General Offices: 25 Broadway, New York City; Chicago Office: 20 North Wacker Drive

Subsidiary of Anaconda Copper Mining Company. Sales Offices in Principal Cities





Baptized in fire at 2500 degrees . . . hard as stone . . . impervious to moisture and temperature changes . . . center ceramic core and ceramic jacket fired together to form a single shockproof unit. Pure copper applied by Schoop metal spray process forms intimate end contact to conducting area.

Half watt size illustrated above (cross section view) is completely insulated.

for FM

specify Centralab

AXIAL LEAD RESISTORS

THE FM and other ultra-high frequency bands demand ultra-precision parts not affected by the vagaries typical of these fickle frequencies.

Because CENTRALAB FIXED RESISTORS maintain constant characteristics under ALL sorts of unusual operating conditions they are ideally suited for FM and other high-frequency circuits. Just as millions of CENTRALAB FIXED RESISTORS are performing perfectly in standard circuits . . . they also find a ready place in FM, Television and kindred applications. And so we suggest . . . for every use . . . specify CENTRALAB.

Send for detailed engineering bulletin

Centralab

Division of Globe-Union Inc.

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PHOENIX DEFIES MOISTURE GHOSTS . . .

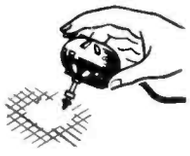
Your hands are never dry. Perspiration stains ordinary tracing cloth, producing opaque spots, or "ghosts," that show on blueprints. Water splashes make even more disagreeable stains.

PHOENIX *Tracing Cloth withstands actual immersion in water for more than 10 minutes at a time without ill effects!* Perspiration will not stain it!

PHOENIX LESSENS SMUDGE GHOSTS . . .

The improved surface of PHOENIX Tracing Cloth permits you to use harder pencils (5H and 6H) and to get sharper lines with less tendency to smudge.

Result: cleaner tracings and blueprints!



PHOENIX REDUCES ERASURE GHOSTS . . .

Ordinary tracing cloths become scarred when erased. Erased spots produce ghosts on the blueprints.

PHOENIX has a durable drawing surface that reduces working scars to a minimum.

THIS NEW TRACING CLOTH *IS* GHOST-PROOF!

Here is a new kind of tracing cloth that won't show perspiration stains or water marks—*that holds pencil smudges and erasure scars at a minimum.* Now you can have clear tracings, in pencil or ink, free from these untidy "ghosts" that reproduce on blueprints!

For PHOENIX is ghost-proofed by a remarkable new process that defies moisture, and gives you an unusually durable working surface. You can use harder pencils with this improved cloth and get sharper lines with less tendency to smudge. Even 6H pencil lines show clearly, and reproduce sharply! Erasing does not mar the drawing surface; erased areas take pencil smoothly—and ink without feathering. The new white color and increased transparency provide excellent drawing contrast and produce strong blueprints.

Try PHOENIX for yourself on your own drawing board. See your K&E dealer or write for a generous working sample and an illustrated brochure.

K&E

Phoenix

TRADE MARK

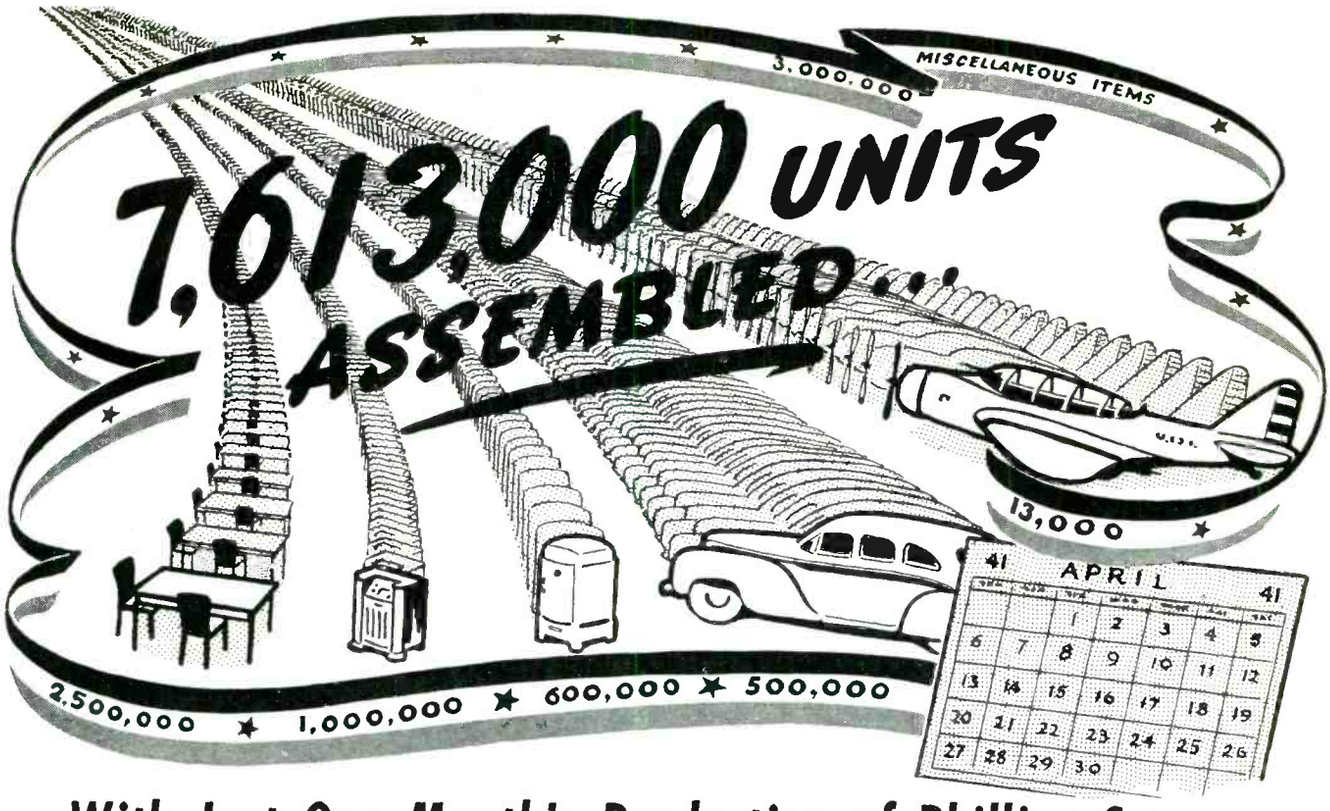
TRACING CLOTH

EST. 1867

KEUFFEL & ESSER CO.

NEW YORK · HOBOKEN, N. J.

CHICAGO · ST. LOUIS · SAN FRANCISCO · LOS ANGELES · DETROIT · MONTREAL



With Just One Month's Production of Phillips Screws

18 Phillips Screw Manufacturers can absorb tremendous defense orders — and still deliver to the rest of Industry.

Regardless of the business you're in... if you want Phillips Recessed Head Screws, you can get them.

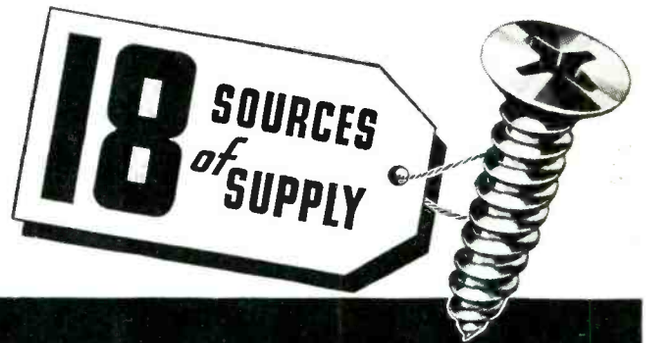
Even though the defense industries have *multiplied* their orders . . . plenty of production capacity remains for filling non-military needs.

Long ago, Phillips Screw manufacturers foresaw the needs of war-time industries... and prepared for the demand. Today, 18 companies are equipped to produce millions of Phillips Screws a day to rigid aircraft specifications *without retarding the normal flow* of screws for peacetime purposes.

To give you an idea — in a *single month,* Phillips Screw Manufacturers can produce sufficient screws to assemble 500,000 cars, trucks, busses . . . 600,000 refrigerators... 1,000,000 radios... 2,500,000 tables and chairs . . . 3,000,000 miscellaneous items . . . *on top of* 13,000 airplanes!

Present production of Phillips drivers and bits is keeping pace, and can be easily expanded.

If you want to save time or cut assembly costs by employing the *one truly efficient screw* . . . place your order with one of the firms listed below.



PHILLIPS RECESSED HEAD SCREWS...

WOOD SCREWS • MACHINE SCREWS • SHEET METAL SCREWS • STOVE BOLTS
SPECIAL THREAD-CUTTING SCREWS • SCREWS WITH LOCK WASHERS

U. S. Patents on Product and Methods Nos. 2,046,343; 2,046,837; 2,046,839; 2,046,840; 2,082,085; 2,084,078; 2,084,079; 2,090,338. Other Domestic and Foreign Patents Allowed and Pending.

Speed Product Deliveries by Cutting Assembly Time

American Screw Co., Providence, R. I.
Central Screw Co., Chicago, Ill.
Chandler Products Corp., Cleveland, Ohio
Continental Screw Co., New Bedford, Mass.
The Corbin Screw Corp., New Britain, Conn.
International Screw Co., Detroit, Mich.
The Lamson & Sessions Co., Cleveland, Ohio
The National Screw & Mfg. Co., Cleveland, Ohio
New England Screw Co., Keene, N. H.
The Charles Parker Co., Meriden, Conn.
Parker-Kalon Corp., New York, N. Y.
Pawtucket Screw Co., Pawtucket, R. I.
Pheoll Manufacturing Co., Chicago, Ill.
Russell, Burdsall & Ward Bolt & Nut Co., Port Chester, N. Y.
Scovill Manufacturing Co., Waterbury, Conn.
Shakeproof Lock Washer Co., Chicago, Ill.
The Southington Hardware Mfg. Co., Southington, Conn.
Whitney Screw Corp., Nashua, N. H.

60 MILLION WATTS must be right!

"How To Plan an FM STATION"
by W. R. David
. . . is a valuable aid to any FM-minded organization. Ask the G-E representative who serves you for a free copy, or write direct to General Electric, Radio and Television Department, Schenectady, N. Y.

60 MILLION WATTS—that's the production record *in 862's alone* since our engineers developed the tube years ago. It's undeniable evidence of sound design, thorough engineering. And today GL-862's are setting enviable performance records wherever they are used. Be sure *your* next 862's are GL-862's.

WHATEVER YOUR TUBE-NEEDS
whether you operate at 50 watts or 50 thousand, tube-up next time with General Electric. Five warehouses with carefully regulated stocks speed up deliveries. A nation-wide sales organization saves you time and money.

AND HISTORY REPEATS ITSELF
for today G.E. is a leader in the field with high-power tubes for FM and television. Just another way that G-E research and foresight speed the progress of your industry.

NEED TUBES TODAY?
Call the nearby G-E office for quick service. And be sure you have your copy of our new transmitting-tube bulletin GEA-3315B. General Electric, Schenectady, N. Y.

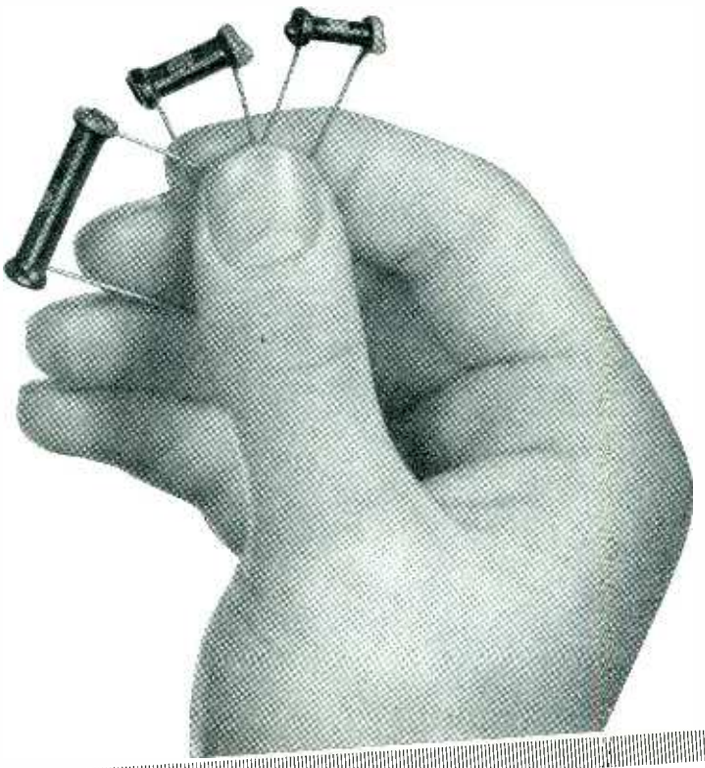
GENERAL ELECTRIC

161-19-8850

RADIO ENGINEERS ASKED FOR THEM!

Now here they are . . .

Resistors shown actual size



Globar LOW OHMIC RESISTORS from 1 to 24 ohms

REG. U. S. PAT. OFF. BRAND

1-, 1½- AND 3-WATT CAPACITIES IDENTICAL IN SIZE WITH THE NORMAL ⅓-, ½- AND 1-WATT, HIGHER OHMIC UNITS

● Because of the growing importance of space limitations in receivers and all other types of electronic circuits, engineers will welcome the introduction of reliable Globar Brand Ceramic Resistors in the new low ohmic values. These space-saving, load-carrying resistors will prove to be a valuable aid in simplifying your assembly problems, reducing your cost of manufacture and insuring reliability of performance.

You are cordially invited to write for samples of the new low ohmic Globar Brand Resistors which are available in 1-, 1½- and 3-watt capacities, from 1 to 24 ohms. Specify your values according to the R. M. A. preferred numbers system. A trial of these new resistors will convince you of their possibilities in your electrical circuits.

No matter what your resistor problem may be it will be worth your while to get in touch with us.

Globar Division

THE CARBORUNDUM COMPANY

REG. U. S PAT. OFF.

NIAGARA FALLS, N. Y.

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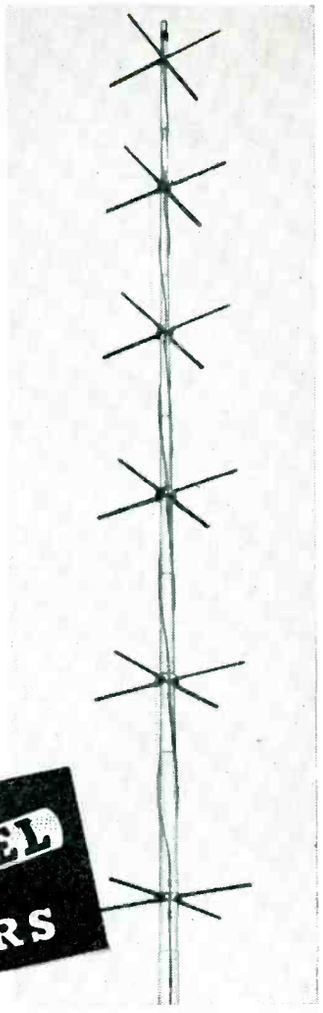
LINGO FOR FM TURNSTILE (PATENTED DESIGN) ANTENNA

The First and Only Antenna of its Kind in the Industry



IMPORTANT NEW FEATURES:

Radiates horizontal polarized signal with substantially uniform circular field pattern.

Custom built, factory adjusted to operating frequency. No field adjustments necessary.

Improved design greatly simplifies method of feeding and coupling.

Turnstile elements fed by coaxial lines. No open turnstile wires used.

Lighting equipment, climbing steps installed without interfering with operation of turnstile.

Heating elements may be used in turnstile arms for sleet melting where necessary.

Available with 2, 4, 6, 8 and 10 layers of turnstile elements, depending upon desired gain.

Now Ready to Quote on Turnstile for Any Station up to 50 KW

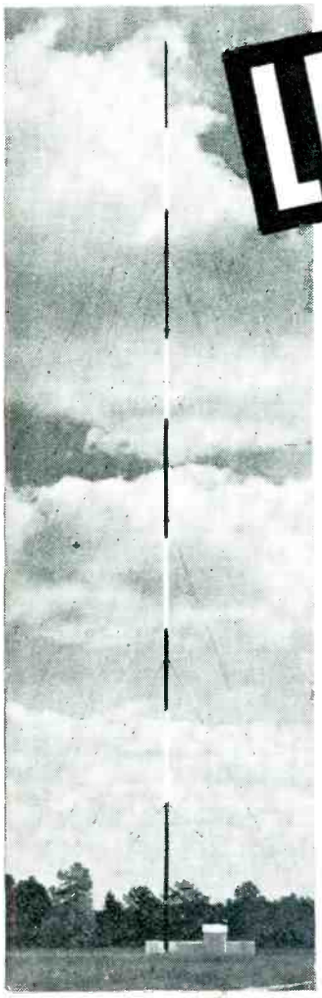
Improved in design—completely developed—the Lingo FM Antenna comes to you as a "finished product" offering distinct improvements over all previous designs. Lingo has a definite, important place in your FM plans and offers you antenna performance and efficiency based on *experience* and not experiment!

Quotations will be gladly submitted for individual applications only and will include the essential tubular steel mounting pole, turnstile elements, coupling equipment, transmission lines feeding the elements, etc. Climbing steps, lighting equipment and sleet melting units available as optional equipment. Erection on your supporting tower or building roof can also be included.

JOHN E. LINGO & SON, INC.

LINGO VERTICAL TUBULAR STEEL RADIATORS

Dept. E-4, CAMDEN, N. J.



LINGO FOR AM VERTICAL TUBULAR STEEL RADIATOR

Engineered to Give the Utmost in Antenna Performance

Reduces Maintenance Costs Increases Station Performance

If overhead costs are as important with you as performance is with your engineers—then all will enjoy the satisfaction of a Lingo Tubular Steel Radiator. Facts prove that you can expect highest efficiency and pay less for maintenance. The moderate initial cost and low upkeep cost, plus assured peak performance combine to give you more profits through better coverage.

PARTIAL LIST OF INSTALLATIONS:

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WIBW	Topeka	WMOG	Brunswick
WCSH	Portland	WOLF	Syracuse
WBOC	Salisbury	WGKV	Charleston
WWSW	Pittsburgh	WAOV	Vincennes
KTSW	Emporia	WSLS	Roanoke
WSAV	Savannah	WAJR	Morgantown
WFBG	Atlantic City	WIBM	Jackson
WBTH	Williamson	WLLH	Lawrence
WCOU	Lewiston	CFAC	Calgary, Alb.
WPID	Petersburg	CJKL	Kirkland Lake Ont.
WRJN	Racine	CKGB	Timmins, Ont.

★ Yes, we want to tell YOU our important story. Our engineering staff will be pleased to provide you with technical details as they apply in your own particular case—without obligation, of course. In writing please give location, power and frequency of station.

TWO "MUSTS" FOR PERFECT INSULATION

—you find them both in

TURBO

• VARNISHED TUBING •
• SATURATED SLEEVING •

TUBING and Sleeving, to give the best service, MUST be saturated *through-and-through* every fibre. That assures maximum *dielectric value, minimum moisture-absorption,* longest *life,* permanent flexibility. TURBO is made this way. The linseed-oil base varnishes used are inherently electro-chemical and moisture resistant, and induce the flexibility you want. In brief, if it's TURBO it's MORE than just INSULATION—its ability to meet your needs and standup in severe service,—the tubing that is a "MUST" for trustworthy insulation.

Write for new sample card with complete list of standard sizes

THE BRAND CREED

The Quality Factor

MUST BE CONSTANT

in electrical insulating materials

- BLOCK MICA
- MICA PLATE
- MICA FILMS
- MICA PLATE PRODUCTS AND SEGMENTS
- VARNISHED CAMBRIC
- COMPOSITES

WILLIAM BRAND & COMPANY

Block Mica, Mica Plate and products—Varnished oil tubing, Saturated Sleeving, Varnished Cambric, Cloths and Composites

276 FOURTH AVE., NEW YORK, N. Y. 217 NO. DESPLAINES ST., CHICAGO, ILL.

With This NEW R-F Measuring Circuit Up to 30 Mc You Can Measure

- CAPACITANCE OF CONDENSERS
- POWER FACTOR OF CONDENSERS
- INDUCTANCE OF COILS
- Q OF COILS
- RESONANT IMPEDANCE OF PARALLEL CIRCUITS
- SERIES TUNED CIRCUITS
- HIGH AND LOW RESISTANCES
- GROUNDED ANTENNAS
- COAXIAL TRANSMISSION LINES
- TERMINATED AND UNTERMINATED LINES
- MATCHING SECTIONS

THIS NEW G-R circuit is a null instrument for measuring impedances at high frequencies. While null methods give the most accurate comparisons, until now it has been impossible to use them for measurements at the higher radio frequencies since the accuracy of these measurements depends, among other things, upon the accuracy with which the impedance standards can be constructed and calibrated. The inadequacy of existing standards at the higher frequencies has restricted the use of bridge circuits to audio and the lower radio frequencies.

The new instrument is a parallel-T circuit which is used for a parallel-substitution measurement of the unknown admittance. Measurements can be made with satisfactory accuracy up to at least 30 Mc. The parallel-T circuit provides several features which make it particularly useful for r-f measurements: (1) a ground common to many points of the circuit eliminates the need for the shielded transformer required in bridge circuits and renders harmless many residual circuit capacitances; (2) the conductive component is measured in terms of a fixed resistor and a variable condenser which provide the equivalent of a continuously variable resistance standard. This combination is much freer from residual parameters than any variable resistor available.

Measurements with the new circuit are simple. The frequency range is 420 kc to 30 Mc and the capacitance range 110 to 1100 $\mu\mu$f, direct reading. The instrument has direct-reading conductance ranges at four frequencies: 0 to 100 μmho at 1 Mc; 0 to 300 μmho at 3 Mc; 0 to 1000 μmho at 10 Mc and 0 to 3000 μmho at 30 Mc. For other frequencies the range of the conductance dial varies as the square of the frequency.

Accessories required for operation comprise a suitable r-f generator (such as the G-R Type 684-A Modulated Oscillator with addition of a coaxial output jack, or the Type 605-B Standard-Signal Generator) and a well shielded radio receiver covering the desired frequency range.

Users of this new G-R instrument are enthusiastic over its performance, its ease of operation, its accuracy and its extended frequency range.

TYPE 821-A TWIN-T IMPEDANCE MEASURING CIRCUIT.....$340.00

● *Write For Bulletin 684 For Complete Data*

GENERAL RADIO COMPANY
CAMBRIDGE, MASSACHUSETTS
Branches in New York and Los Angeles

specify **Cornell Dubilier**

for the "EXTRAS"

UNITED AIR LINES USES C-D CAPACITORS

for that *extra* dependability so vitally important in air transport safety and dispatch. Cornell Dubilier Capacitors are standard equipment today in ground station transmitters. Each of the 67 luxury ships in the great Mainliner fleet, moreover, employs more than 100 C-D Capacitors in its elaborate radio equipment. Here is eloquent proof of the extra dependability built into C-D Capacitors!

★ ★ ★ *Remember—C-D's and other capacitors may look alike. Both may be in cans, cases, or cardboard . . . have lugs, leads, or terminals—but there, all "resemblance" ends! It's the hidden extras in Cornell Dubilier Capacitors that count. Get these extras, at no extra cost. Look for the C-D label.*

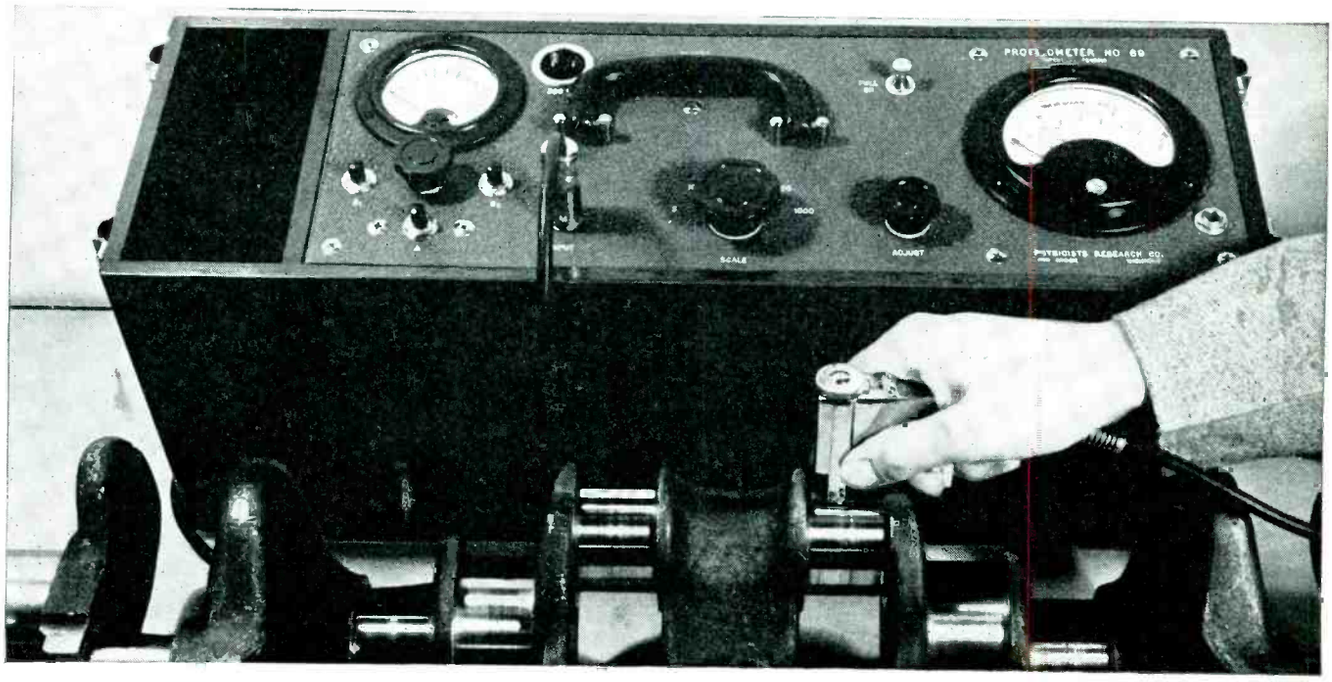
Only Cornell Dubilier capacitors give you *extra* Dependability, Long Life, and Uniformity. That's why there are more C-D capacitors in use today than any other make.

Cornell Dubilier

MICA • DYKANOL • PAPER • WET AND DRY ELECTROLYTIC CAPACITORS

Send for Catalog 185-A—Cornell Dubilier Electric Corp., 1006 Hamilton Blvd., South Plainfield, N. J.

The Most Microscopic Surface Roughness is Amplified up to Thousands of Times with the PROFILOMETER



P.R. MALLORY & CO. Inc MALLORY Parts Play a Vital Part in this Miracle of Sensitivity

Entirely apart from the accuracy of mere dimension, surface *roughness* is the important factor in initial wear, change of fit with wear, lubrication and life of mating surfaces (such as cylinders and pistons, pistons and pins, cranks and bearings).

That's why so many industries are using Profilometers, developed and manufactured by Physicists Research Company. These amazing devices "feel out" surface irregularities, automatically compute a running average of the height of the irregularities, and give a direct dial-reading of that height in millionths of an inch!

We are proud that Standard Stock Mallory Grid Bias Cells, jacks, plugs and switches have been original equipment since the inception of Profilometers. It prompts us to suggest that you, too, may rely on the operation of Mallory precision parts in your own products... in processing or in your experimental work.

P. R. MALLORY & CO., Inc., INDIANAPOLIS, INDIANA
Cable Address—PELMALLO

Send for the Mallory Catalog Today
Be sure that this important catalog is a permanent part of your source files.

CROSS TALK

► LETTERS . . . Two letters reproduced in these columns have evoked considerable comment. One published in December 1940, was from Arthur Van Dyck and dealt with the ability of engineers to solve problems involving the human equation, specifically relating to designing radio receivers which the public would buy. Dr. Paul G. Weiller writes as follows:

"In 1928 a group with investments in several radio companies retained me to find out for them why some radio manufacturers were so successful, others were not. There were more reasons for the failure of radio manufacturers than one could shake a stick at, but faulty appearance of their product claimed more victims than any other single cause. I knew that much. Therefore I made a rather tedious canvas of radio dealers to discover what sold best and why.

"Some of the findings were startling. It was the period of the radio highboy, a bulky breast-high piece of furniture. A tabulation of results showed that all good selling items differed by less than three inches in overall dimensions. This puzzled me. A very intelligent dealer in Plainfield, N. J. who served the more expensive trade had also wondered about the same thing. He discovered that his costumers with few exceptions hung a mirror over their set. The mirror would be useless if the set were too high. What the connection was between mirrors and radios we did not know.

"Often, coming trends can be partially predicted by determining which of the designs, differing from the fad of the year, are outselling the others. This method works fairly well because style changes are seldom quite sudden. Some clever duck brings out what looks like a freak today, but the public takes a liking to it and there, pronto, is your new style, or next year's fashion.

"After the results of my work had been duly collated and edited I thought it would be useful to some radio manufacturer but soon I found that I was totally wrong. I called on one manufacturer who was just entering the field with great fanfare and suggested that I could be useful to him as a liaison man between the sales department and the engineers because I understood the language of both. We engineers often itch to make things that can't be sold while salesmen love to ask us for things we cannot make—except at a price.

"The answer was typical of that day. Said he: 'Our set is so superior to all others, that we do not have to worry about anything. We will drive all others off the market within one year.' That receiver was peculiar. It never even reached Cortlandt Street. I called on another quite prominent company. It took an hour of persuasion to make the sales manager see the light. I believe he was quite sold on the idea of what would be called a commercial engineer. He wanted me to see the chief engineer before he decided. The chief was a man of some prominence, very intelligent, obviously capable and a nice fellow. He was interested in the general idea, but he also decided that the new sets he had designed for the company were so good, that they would drive all others off the market in one year.

"This company's make of receivers did better than the other one. It reached Cortlandt Street in great numbers as surplus merchandise.

"The moral of the story is, that engineers and the regular sales personnel are often poor judges of the sales appeal of a product. The engineer is too familiar with his own product, he has worried too much about it to have a detached point of view. The salesman, however, must be kept at a high pitch of enthusiasm over his merchandise. He should not be encouraged to bring in complaints or criticisms or stories of the excellence of competitors products. To the salesman his product must remain tops in its price class.

"Consequently sales research, collection of complaints and studies of competitive items should be carried on by men not attached to the sales department. The results of their work should be given great weight in any decisions concerning new models."

The other letter concerned difficulties in filing manufacturers' literature because of non-uniformity of format and size. O. Hugo Schuck acoustical engineer of G. C. Conn, for one, submits comments signed by 13 of his associates. They clamor for standardization of catalog sizes and shapes.

Groundwork Laid For Commercial Television

The F.C.C. hearing, held March 20, 21 and 24 to determine how and when television shall be placed on a commercial footing, indicates early action. Modified N.T.S.C. standards assured of acceptance, to be followed by issuance of commercial broadcasting licenses. Industry urged to move forward on a common front

THE hopes and fears of the television industry, following months of stagnation, were met with the Federal Communication Commission on March 20, 21, and 24, when the long awaited hearing on commercialization was held. Witnesses for 15 organizations appeared, and presented, almost without dissent, the solid front which the F.C.C. had previously stated was a necessary prelude to the establishment of television as a going business. As a result, the standards proposed by the National Television System Committee, modified in certain particulars since the last report, seemed virtually certain to be accepted by the government as the official basis for the art. At the time of writing the date at which commercialization would be authorized was still in doubt, but observers at the hearing believed it would occur before the end of the year, always provided that the state national emergency does not prevent it. The rules and regulations, proposed by the F.C.C. to govern commercial operation of television broadcast stations, were discussed at length. The only major point at issue was the number of programs hours which each broadcaster would be required to offer to the public each week. The Commission proposed 30 hours, but the broadcasters seemed to think that such a large number of hours would be an undue burden and might prevent the entry of many potential broadcasters into the field. Figures from 10 to 15 hours per week were urged, at least for the initial stages of the service.

Modifications of the N.T.S.C. Standards

The first organization to appear before the Commission was the National Television System Committee, whose proposed standards had been previously presented to the Commission at a "progress report" meeting on January 27th. Dr. W. R. G. Baker, chairman of the N.T.S.C., took the stand as the first witness to report certain modifications in the standards which had been made by the Committee since its last appearance (reported in ELECTRONICS February, 1941, page 17). The final recommendations of the N.T.S.C. contain two changes: the number of lines in the picture has been increased from 441 to 525, and the standard on synchronization has been broadened to allow the use of several alternative and interchangeable types of waveforms and modulation methods. It was pointed out that since the several synchronization alternatives can be utilized interchangeably by standard receivers, commercialization was possible without coming to an immediate decision regarding their relative superiority. When further tests have established which sync method is the best, that one will be established by the F.C.C. as the required method.

Dr. Baker then introduced D. G. Fink, managing editor of ELECTRONICS and a member of Panel 1, as the next witness for the N.T.S.C. Mr. Fink outlined for the Commission a brief which he had submitted to the N.T.S.C. urging the adoption of 525 lines as the standard. He pointed out that 525 lines, being 19 per cent greater than the previously established value of 441 lines, would entail the use of approximately 19 per cent more power in horizontal scanning generator circuits of the magnetic type, that ghost images would be displaced from the true image by 19 per cent additional distance on the screen, that the increase would result in 19 per cent additional vertical resolution and in 16 per cent decrease in horizontal resolution. He stated his belief that the economic factors involved in increasing the number of lines should take second place to the physiological factors of human vision, since the latter are fundamental and unchanging. The choice of 525 lines produces more nearly equal resolution in the horizontal resolution and vertical directions (although 495 lines would represent an even closer approach to equality in these resolutions). The principal reason that 525 is preferable is the fact that it presents a less visible line structure, that is, a more uniform field of illumination, than does any lower number of lines, other factors being equal. Mr. Fink reported that the N.T.S.C. had modified the standard primarily because of this consideration of line structure, since the relative degree of resolution vertically and horizontally has only a second-order effect on the apparent picture quality. It was pointed out that the use of 525 lines emphasizes the need to use the full television channel, but this was thought to be a sound requirement in setting up standards for the future.

David B. Smith, acting as the next witness for the N.T.S.C. explained the modifications of the synchronization standard. He stated that a receiver of the type adapted to the basic N.T.S.C. standard (waveform given in February, 1941, ELECTRONICS, page 19) transmitted by amplitude modulation could also be operated by the DuMont 500 kc waveform, furthermore that such a receiver would respond adequately to sync signals sent by frequency modulation (by the system devised by Loughren and first described in ELECTRONICS, February 1940, page

27), and finally that such a receiver would respond if the entire signal, sync and picture components together, were sent by frequency modulation. Since these alternatives are all receivable interchangeably on practical receivers, the N.T.S.C. recommended that no decision among them be reached until field tests had established the superiority of one system. The Loughren f-m sync signal method has been tested in modified form, known as the Hazeltine-Philco signal, with great success, producing very much more reliable horizontal synchronization in the presence of noise. The results are explained by the fact that the use of frequency modulation for sync develops approximately five times the synchronizing signal voltage, in the receiver, as does the use of amplitude modulation with the same modulating waveform. The reason why the N.T.S.C. did not immediately accept this superior system is that it might mitigate against another proposal of conceivably greater overall merit, that is, the use of frequency modulation for the entire picture and sync signals. The fortunate fact that the decision need not be made in advance of commercialization resides in the use of an attenuated carrier and a sloping pass band in standard receivers. The frequency modulation signals may run up and down the slope at the edge of the i-f pass-band, thus converting the f-m signal into an a-m signal without the need for any auxiliary circuits or apparatus. The F.C.C. seemed satisfied that the N.T.S.C. plan to leave the door open, pending further tests, was a sound one and that it need not interfere with early commercialization. The previous restriction of the N.T.S.C. standards to the first seven television channels (50 to 108 megacycles) was removed in favor of use on any channel commercialized by the Commission.

The only other modification of the N.T.S.C. report was in connection with its mention of the currently favored values of lines for color television pictures. In line with the increase in number of lines for monochrome images from 441 to 525, the color picture figure was increased from 343 to 375. Otherwise the recommendations of the N.T.S.C. stood without change.

Following the witnesses for the N.T.S.C., the Columbia Broadcasting System made an appearance, with Adrian Murphy, Executive Director of Television for C.B.S., testifying. Mr. Murphy gave approval to the N.T.S.C. standards as they apply to black and white images, but stated the desire that color television be given a chance to progress with opportunity equal to that afforded black and white transmissions. He believed that color transmission might be under a handicap under the proposed schedule of experimental field testing, since the best programs would be produced on a commercial basis for black and white transmissions only, leaving the experimental color transmissions with less desirable program material. Questioned as the minimum number of programs hours per week to be furnished by commercial television broadcasters, Mr. Murphy stated that he believed no requirement should be set up at all, and that program schedules be allowed to expand in response to the public demand, and as the expanding audience made it possible for the broadcaster to meet his expenses. The Commissioners, commenting on this proposal, made it clear that some mandatory minimum schedule was necessary, in their opinion, to encourage the public to buy receivers, and that broadcasters who were unwilling to meet such a requirement might, within the Communications Act of 1934, be liable to lose their licenses.

John Porterfield made the next appearance, as an individual, stating that he was working on a color television system quite different from those recently proposed. He urged that no decision on the color system be made at this time, since later developments might show the best system to be different from those now suggested for field test. On questioning from the C.B.S. counsel, Mr. Porterfield stated that his color television system was workable within the suggested standards for color transmission, that is, 375 lines, 60 frames per second.

DuMont Reiterates Stand on Flexibility

The next witness, Allen B. DuMont of the DuMont Laboratories, took issue with the N.T.S.C. standards dealing with lines, frames per second, and synchronization. He recommended specifically that the number of lines be variable between 375 and 800, interlaced two to one, that the number of frames per second be variable from 15 to 60, and that the synchronization standards be based on the waveform of the DuMont sync pulse, rather than on the N.T.S.C. (modified R.M.A.) type of pulse. These proposals are but slightly different from those made by Mr. DuMont a year ago. In the cross-examination it was brought out that the N.T.S.C. had considered these recommendations at some length, and had decided that they did not represent the best solution to the problem. A recommendation, made by Panel 1 of the N.T.S.C., was cited as specifically urging a single value of lines and frames per second, rather than a variable range. Mr. DuMont urged immediate commercialization, and stated that program costs, according to his findings, would not be so high that 30 hours per week could not be produced by each broadcaster.

The next witness, W. C. Eddy, representing Balaban and Katz of Chicago, gave assent to the N.T.S.C. standards, but stated that from the commercial standpoint his company favored vertical polarization, since a simple vertical antenna displays no directional properties in the horizontal plane, and hence would insure a maximum audience to all competing stations in a given area.

The Don Lee Broadcasting System, with Harry R. Lubcke as witness, concurred wholeheartedly with the N.T.S.C. standards and urged against any dual or flexible standard, stating that if flexibility were permitted, receivers slightly out of adjustment and otherwise marginal in operation would experience more difficulty than if a rigid specific standard were adhered to. Regarding the minimum number of program hours, Mr. Lubcke believed that 10 or 12 hours per week was the maximum which should be set at this time.

The Farnsworth Television and Radio Company, represented by Mr. Martin, then gave complete agreement to the N.T.S.C. standards. Mr. Martin said that whereas the Farnsworth Company had held differences of opinion during the deliberations of the N.T.S.C., they were prepared to trust the opinion of the majority

(Continued on page 70)

ELECTRON TUBES IN PETROLEUM RESEARCH—I

By C. J. PENTHER and D. J. POMPEO

Shell Development Co.

ELECTRONICS is finding increasing recognition as a branch of engineering because both research and industry are constantly finding new applications for vacuum tubes in measurement and control problems. Although most applications involve standard electrical and radio engineering practice, many tubes are used in circuits and under conditions far different from those for which they were originally designed. It is the purpose of this paper to describe several such instruments designed or constructed for use in research investigations and pilot plant operations at the Emeryville Laboratories of Shell Development Company.

Particular attention has been given to the use of vacuum tubes of the inexpensive radio receiving type. During the past few years we have used radio receiving tubes in the control of temperature; to measure potential at practically zero current (less than 10^{-12} ampere); to measure the dielectric constant of liquids, solids and gases; to establish a highly accurate 60 cycles per second current source for time measurements; and to measure and record the rapid variations in cylinder pressure in internal combustion engines. They have also proved useful in a study of lubrication where it was desired to continuously measure the electrical resistance between two bearing surfaces and at the same time record the deceleration of the member carried by the bearing. Another mechanical application is the measurement of the polish on metal surfaces to within a few millionths of an inch. Similarly, good use has been made of tubes in the control of the alkalinity of solutions during the manufacture of chemicals. We have also had occasion to employ tubes in the construction of frequency meters, photographic and welding timers, capacity operated relays, and stroboscopes, one application of the latter being the measurement of ultra-centrifuge speeds of the order of 10,000 revolutions per second.

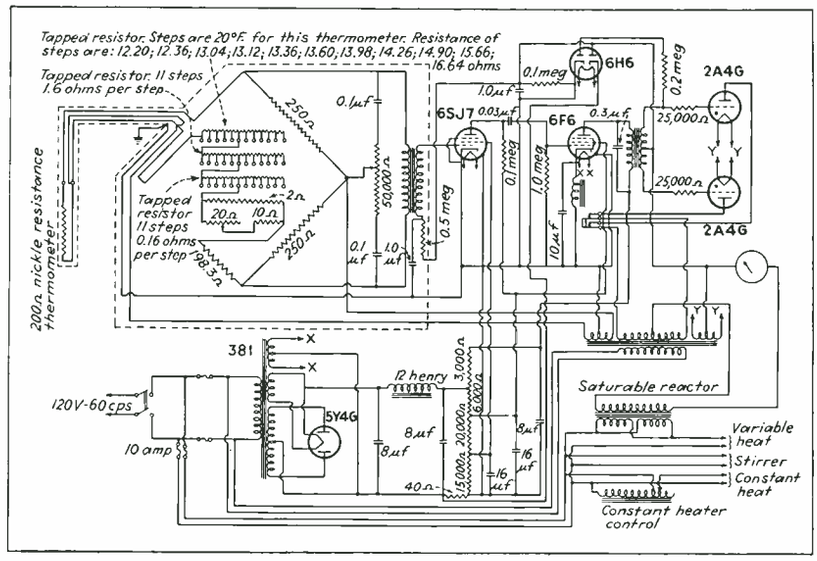


Fig. 1—Circuit diagram of the Resistotherm temperature regulator which will maintain constant temperature within a few thousandths of a degree for an unlimited time at any temperature from zero to 240 degrees F

Temperature Control

Much of the chemist's work involves the use of an enclosure maintained at a constant temperature. The enclosure may be filled with air, oil or water and the temperature, in certain cases, must be held constant within a few thousandths of a degree. Some form of temperature-sensitive device is required which will apply additional heat when required and be sufficiently sensitive to maintain the temperature within the required limit. The bimetallic strip is frequently used, controlling the heater directly on its contacts or through a relay. This method is useful only where the temperature does not have to be held to close limits.

Another type employs the expansion of mercury, having either a fixed or an adjustable contact in a fine capillary supplied by a large mercury bulb. This type is capable of very fine control, but has the disadvantage that the mercury surface soon becomes dirty, leading to erratic operation.

A third temperature-sensitive system is the resistance thermometer type which is stable, convenient to use, and requires no servicing, but which does require some method of amplifying the exceedingly small voltage changes to values where they can be made to control heat input.

Benedict[1] describes an amplifier for this work, using a type 57 tube controlling an FG-57 thyratron. Sturtevant[2] describes improvements on this unit, adding a power stage to supply the grid current of the thyratron and replacing the batteries with an a-c power supply. This unit was tried in our laboratories and found to be quite satisfactory. It is now in use in a bath used for the calibration of thermometers. For general use, it was felt that the necessary thyratron and its attendant time delay relay made the cost of this unit prohibitive. Both of these amplifiers are capable of maintaining control over only a limited range, losing it completely if the temperature goes a few tenths of a degree higher than the control temperature. It was therefore de-

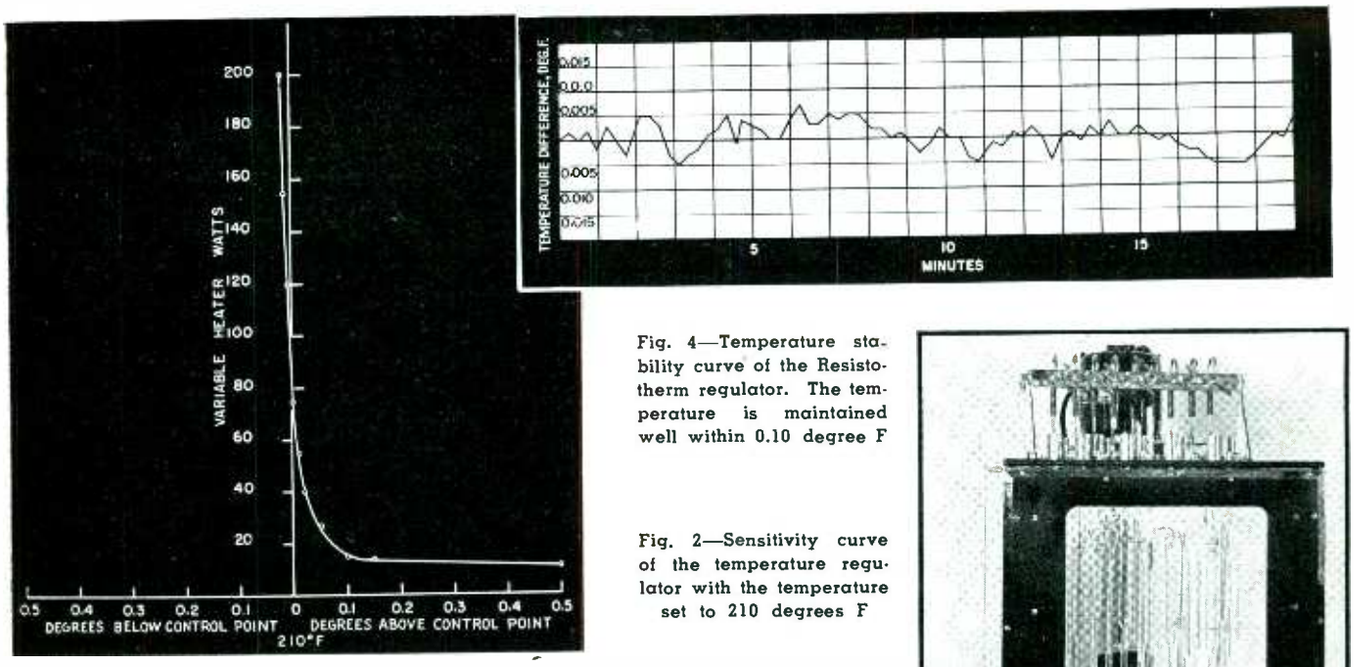


Fig. 4—Temperature stability curve of the Resistotherm regulator. The temperature is maintained well within 0.10 degree F

Fig. 2—Sensitivity curve of the temperature regulator with the temperature set to 210 degrees F

Fig. 3—The constant temperature bath mounted atop the regulator. The four knobs at the bottom control the temperature setting

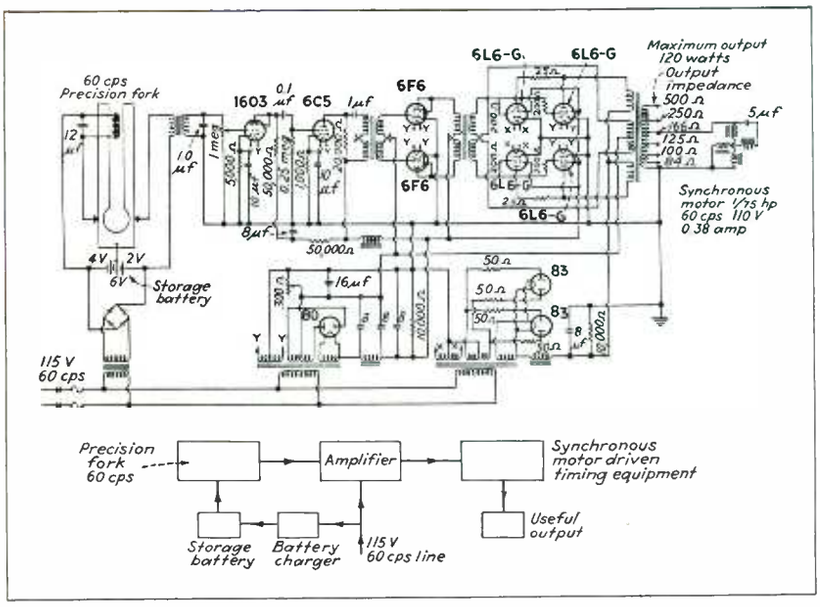


Fig. 5—Circuit diagram of the precision timing source for 60 cycles per second current. This unit is capable of driving 48 magnetic counters calibrated in seconds and tenths of seconds

cided to use only inexpensive receiving type tubes and control the a-c power by means of saturable reactors, and also to devise a method of maintaining control over an unlimited range.

The first step tried was to modify the Sturtevant circuit, by substituting a pair of full wave miniature thyratrons type 2A4G and a saturable reactor for the power thyratron. In the Sturtevant circuit the resistance thermometer forms one arm of a simple resistance bridge fed by a low voltage source of alternating current, the output of the bridge is coupled to the first amplifier tube by means of an impedance matching transformer. The first and second amplifier tubes are impedance-resistance coupled with the impedance tuned to 60 cycles per second. We substituted a push-pull output transformer driving a pair of miniature thyratrons whose plate current served to saturate the core of the saturable reactor. The circuit worked satisfactorily except that, like its predecessors, it lost control if the temperature of the bath went a few tenths of a degree too high.

An analysis with a cathode ray oscilloscope showed that while the circuit normally operates by means of a phase shift of the thyratron grid voltage, a secondary shift occurrs when the bridge continues to move off balance as the bath temperature increases. It was found that this secondary phase shift was caused by the large current amplitudes in the off balance conditions, overloading the tubes and transformers.

An idea of the critical control necessary is given by the fact that a bridge unbalance of only 0.0002 volt, corresponding to a temperature differential of 0.02 degree F., is sufficient to double the heat input, while a temperature differential of 2 degrees F. results in an amplifier output of approximately 100 volts. An output voltage of up to 50 volts, corresponding to about 1 degree F., was found to result in no secondary phase shift. Higher voltages do so and, therefore, the limit of control is a maximum of 1 degree F. To overcome this very serious limita-

tion, it was decided to use automatic gain control. Figure 1 is a diagram of the final unit, showing the automatic bias voltage obtained from one-half of the output transformer and applied to the first amplifier stage. The impedance coupling of the previous circuits has been replaced with straight resistance coupling, because considerable trouble was experienced with the tuned impedance, both from stray field pickup and phase shift distortion with change of plate current.

Figure 2, a sensitivity curve, shows that with this circuit, although a decrease of bath temperature of 0.02 degree F. still doubles the heat input, an increase of bath temperature of any value from 0.1 degree F. to 40 degrees F. reduces the heater current to a minimum. Thus there is no danger of losing control.

The thyratron plate meter has been calibrated in heater watts input for a given heater and line voltage. When the temperature has been set at the desired value and the variable heater input established, a deviation of this meter in an upward direction indicates that the bath temperature is low by a few thousandths of a degree. The deviation can be roughly estimated from the reading considering that a deviation of 0.02 degree F. doubles the heat input.

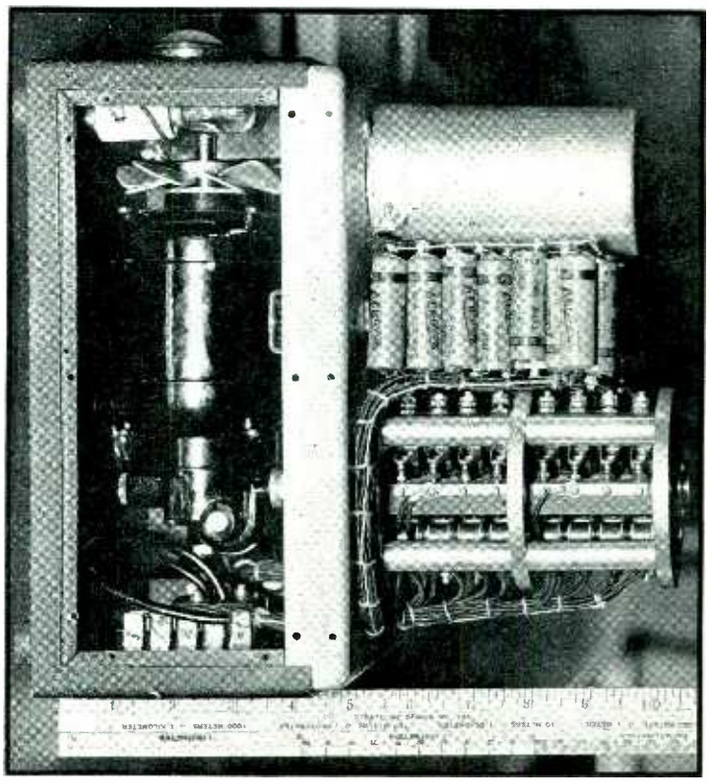


Fig. 6—Contactor unit of the timing source. The amplifier supplies power to the synchronous motor which drives the contactor

Fig. 7—Circuit diagram of apparatus used to measure the loss in kinetic energy of a flywheel to determine the lubricating qualities of oils

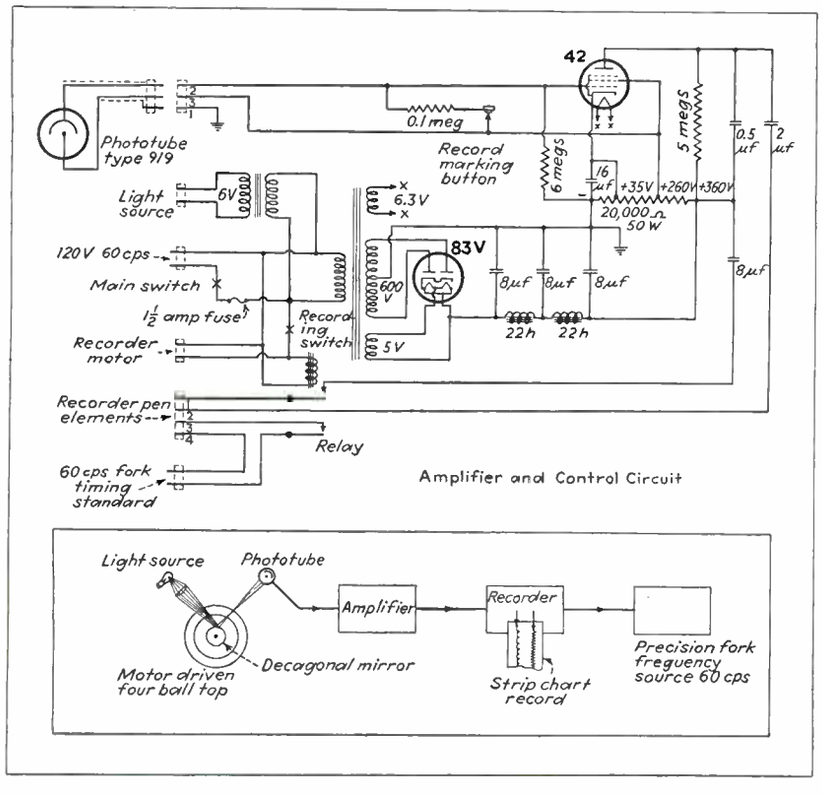


Figure 3 is a picture of this unit which has been called a "Resistotherm" (from the words resistance thermometer) Thermoregulator incorporated in a Kinematic Viscometer Bath unit. Figure 4 is a chart of a temperature run on this bath, indicating that temperature is held well within plus or minus 0.01 degree F. at 210 degrees F.

Precision 60-Cycle Timing Source

The measurement of kinematic viscosities of oils involves the accurate measurement of time intervals from 150 to 1500 seconds. Considering that the allowable error is only 0.1 per cent, the time on the 150 second interval must be read to within 0.15 second. While stop watches with 0.1 second divisions are available, they are easily damaged and require frequent checking to maintain their accuracy. Various clocks and counters are available which depend upon the line frequency for constancy of time, but since electric power locally available does not always have controlled frequency (tests in our laboratories have shown that errors up to 0.4 per cent in short intervals are possible) it became necessary to build a highly accurate source of 60 cycle per second alternating current having

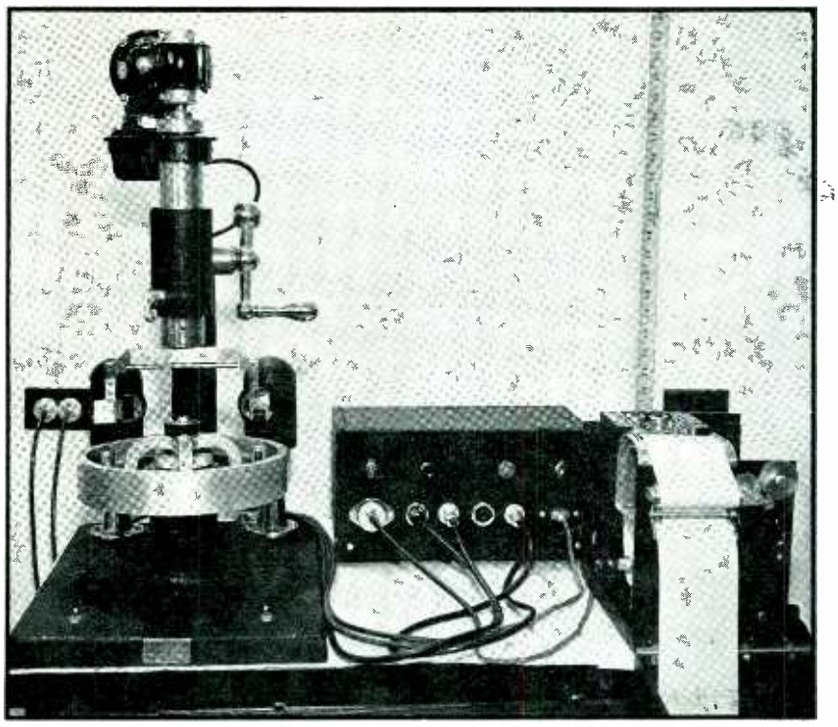


Fig. 8—Apparatus whose circuit is shown in Fig. 7. A light source and phototube are mounted so that light is reflected from a decagonal mirror on the flywheel shaft into the phototube

sufficient power to operate a small Bodine synchronous motor.

The basis of this system, as indicated in Fig. 5, was a General Radio 60 cycle per second tuning fork having a frequency of 59.9997 (± 0.001 per cent) cycles per second at 74 degrees F. and a temperature coefficient of 8.4 parts per million per degree F.

The output of the fork was amplified by four stages of audio frequency amplification, the output stage of which consisted of four type 6L6G tubes in parallel push-pull. A variable impedance output transformer was provided for load matching. This amplifier was used to drive the motor of the contactor unit (Figure 6) which is capable of operating 48 magnetic counters calibrated in seconds and tenths. Experimental work has shown the feasibility of supplying an entire laboratory building with 1/10 second pulses by wired radio on the power lines so that any laboratory, by means of a receiving unit plugged into the line, could obtain these accurate 1/10 second intervals.

Four Ball Top Apparatus

Another use for accurate 60 cycles per second current was in measuring the loss of kinetic energy of a rotating flywheel top used for testing the lubricating qualities of oils. The loss of kinetic energy manifests itself through the decrement of rotational speed, so an apparatus was built which made it possible to accurately measure rotational speed from several hundred revolutions per minute to zero occurring during a time of several minutes.

The equipment, shown schematically in Fig. 7, consists of a motor-driven four ball top to which has been added a light source and phototube, a decagonal mirror mounted directly on the flywheel, an amplifier and the precision 60 cycles per second fork, and a Brush two-element crystal pen recorder. One face of the mirror is partially masked so as to identify every full revolution of the wheel and to make easier the counting of a long series of pulses. The completed apparatus is shown in Fig. 8.

The measurement of the electrical resistance of the oil film between the balls of this machine is also obtained simultaneously with the other measurements by the circuit given in Figure 9. An accurately regulated low voltage a-c source is applied, in series with a fixed resistor, to the primary of a coupling transformer, across which the balls are shunted. The resistance between the balls thus affects the voltage drop across the transformer. This voltage is amplified and then rectified and read on a meter directly calibrated in resistance from zero to 260 ohms.

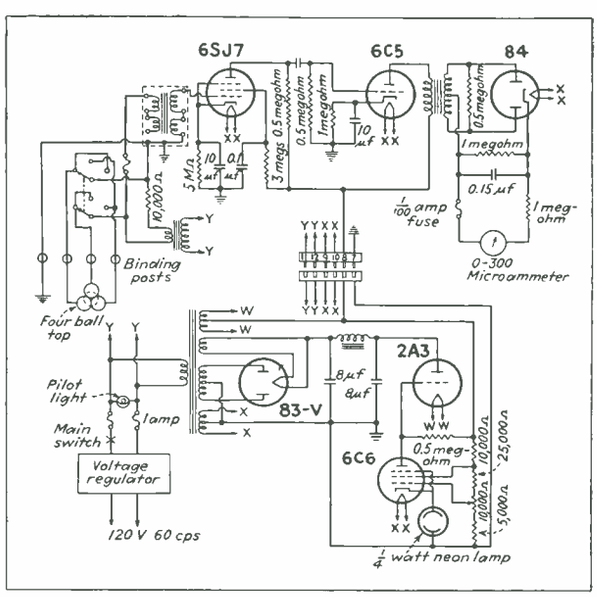


Fig. 9—Circuit used for measuring electrical resistance of oil film between the balls of the apparatus shown in Fig. 8. This measurement may be made simultaneously with the measurements of lubricating quality

The concluding part of this article, to appear in an early issue of ELECTRONICS, describes such instruments as a pressure indicator for internal combustion engines, apparatus for measuring dielectric constant and an electronic voltmeter.

(1) Benedict, M., *Rev. Sci. Inst.* **8**, 252 (1937).
(2) Sturtevant, J. M., *Rev. Sci. Inst.* **9**, 276 (1938).

Water-Cooled Resistors

By G. H. BROWN and J. W. CONKLIN
RCA Manufacturing Company, Inc., Camden

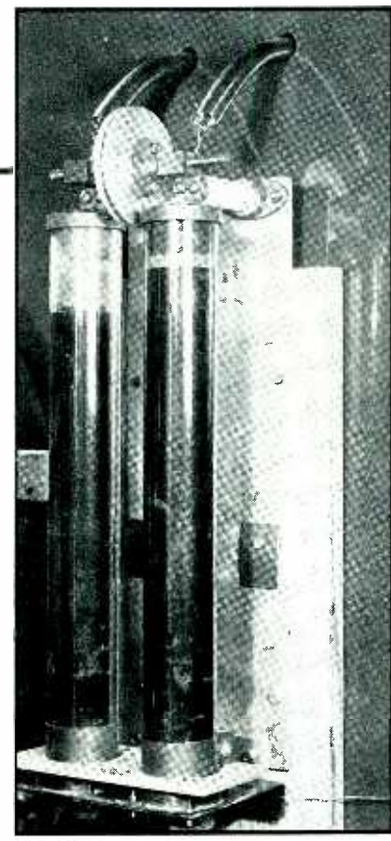
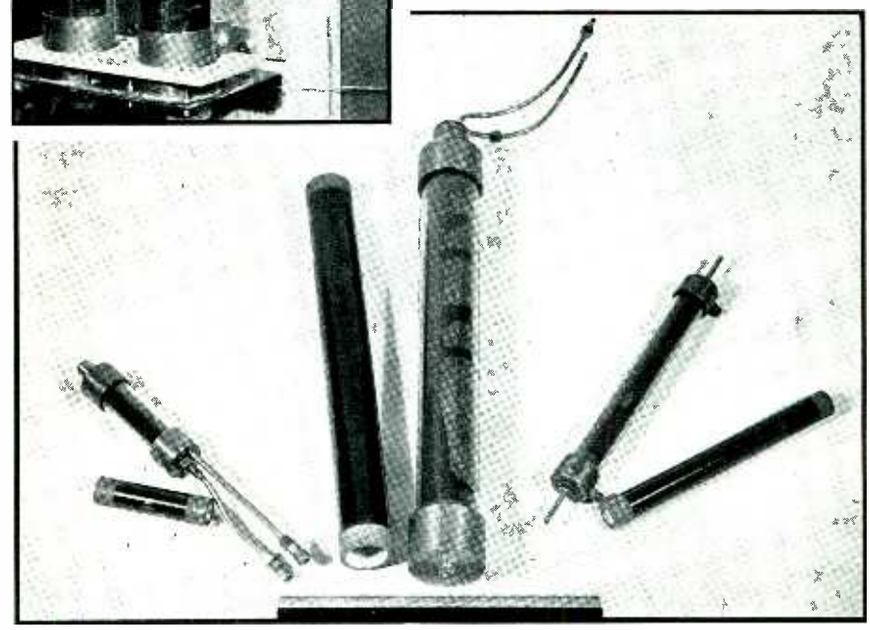


Fig. 1—Ceramic-tube water-cooled resistors used as a dummy antenna for a television transmitter, in service over a year without deterioration

Fig. 2—Water-cooled resistor assemblies, with ratings of one, ten, and four kilowatts. The shunt capacitance averages only one micromicrofarad



TELEVISION transmitter applications have made necessary the development of special types of water-cooled resistors both for radio and video-frequency purposes. In both cases the general qualifications are similar, requiring a constant resistance over a large range of frequencies, low stray capacities, and low distributed reactance. The last-mentioned qualification has presented a particular problem in some of the radio-frequency applications. Owing to the very short wavelengths involved, the resistors may be a sizable fraction of a wavelength long and it is necessary to take account of the distributed reactance. It is the purpose of this discussion to describe resistors which have been developed to provide constant resistance, free from reactance.

Some of the applications in television transmission where high-power, water-cooled resistors are used are: circuit-loading resistors for damping or broadening tuned circuits; "dummy" antennas for testing and power measuring; terminating resistors in antenna filter networks; and coupling resistors for video-frequency circuits. In the radio-frequency applications it is generally essential that the resistors function as constant pure resistances over a band of ten megacycles at carrier frequencies ranging above 50 megacycles. In video-frequency applications the resistors must function as constant pure resistances from zero to nearly five megacycles.

A number of types of resistors were investigated for these purposes. All of the commonly considered non-inductive wire types were found to have unsatisfactory frequency characteristics arising from residual inductance, skin effect on the resistance conductor, and the bypassing effect between adjacent conductors when the resistors were immersed in water for cooling purposes. Resistors of the carbon rod type also have poor frequency characteristics, particularly in the higher values.

Resistors of the so-called "metallized" type, on the other hand, were found to have satisfactory frequency characteristics. These resistors consist of a microscopically-thin coating of metal or resistive material on a glass or ceramic base, and achieve their resistance from the small effective cross-sectional area of conductive material. By virtue of their construction, these resistors have substantially constant resistance up to several hundred megacycles and exhibit reactance only from the distributed L and C inherent from their physical size. Several means

for Ultrahigh Frequencies

Television transmitter development and other u-h-f services require the use of resistors capable of dissipating large amounts of power over a wide band of frequencies, without displaying inductive or capacitive effects. A water-cooled coaxial design which serves the purpose adequately is here described

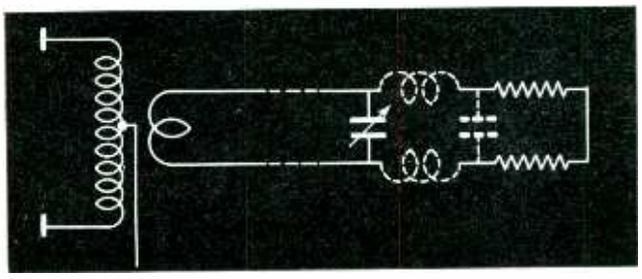


Fig. 3—Typical dummy antenna circuit, of the transmission-line type, used as a basis for the resistor design

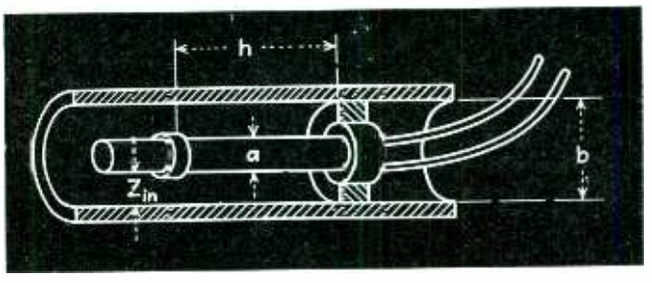


Fig. 4—Structure of the "coaxial" water-cooling assembly. The water enters and leaves the assembly at ground potential

were developed for overcoming this defect, depending on the particular applications for which the resistors are used. By resorting to liquid cooling, power capabilities were increased many fold, to the order of 100 watts per square inch, so that very compact units have been possible.

A number of types of "metallized" resistors were tried experimentally with varying degrees of success. The principal difficulty was in obtaining a mechanically satisfactory coating. There is now commercially available a "metallized" type of resistor in a number of large sizes. Since these were found to be generally satisfactory for the present purposes, no further search was made. The resistor units referred to, consist of a resistance coating on a ceramic tube covered with a protective coating of varnish. Terminal connections are provided in the form of a silver coating at each end of the unit.

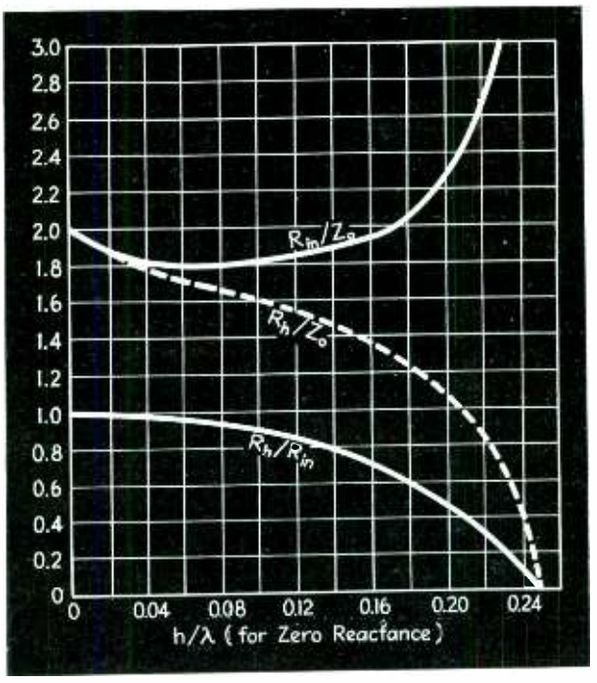


Fig. 5—Graphical data for designing a resistor to have zero reactance at a given frequency

It was found that suitable water cooling increased their normal air ratings fifty to eighty times. These resistors were never intended for operation under water and occasional mechanical failures of the coatings occurred either due to erosion or poor adhesion. These failures generally occurred during initial operation. It was found that resistors which survived the first few hours' service lasted indefinitely. The resistors shown in Fig. 1 have been in service for over a year as a dummy antenna for a television transmitter and are still in perfect condition.

In the development of the method of cooling, circulating water inside the ceramic tube was first used. This procedure was found unsatisfactory as the heat conduction through the ceramic was poor and the differential expansion cracked the ceramic. The method finally adopted uses cooling water in direct contact with the coated surface. It was found to be unimportant whether or not the inside of the tube was cooled since, by this method, the

heat developed is removed directly at the source. The thermal storage capacity of the coating is, of course, very small and momentary overloading or stoppage of the water flow will result in immediate failure of the resistor. It is of peculiar interest that resistors tested would stand fifty per cent more power at ultra-high frequencies than at sixty cycles. This was believed to be due to the comparatively short duration of the peak of the cycle at ultra-high frequencies.

In Fig. 2 are shown several water-cooled resistor assemblies, together with their component resistors. The water-cooled ratings are approximately one, four, and ten kilowatts for the three sizes shown. The resistors are assembled in glass tubings which allow approximately a one-sixteenth-inch water wall. This water wall must be kept as small as possible to minimize the shunt capacity which, in the resistors shown, averages about one micro-microfarad. This is not serious as most of the radio-frequency applications require low values of resistance. When the water wall was made much less, it was found difficult to clear the surface of the resistor of air bubbles. Water flow rates of one-half to two gallons per minute are used, depending on the size of resistor and the amount of power to be dissipated.

Metal-end caps with internal contact fingers serve to seal the units and provide electrical connections to the resistor element. These end caps are fastened to a bakelite tension rod passing through the center of the resistor. Two types of housings were developed. In one type the inlet and outlet water connections are at opposite ends, the water flowing over only the outer surface of the resistor. In the other type the inlet and outlet water connections are at the same end, the water returning through the inside of the resistor. The choice of type depends primarily on electrical considerations of the applications involved.

For video-frequency applications the resistor assemblies may be considered non-reactive and they have been found very satisfactory as output coupling resistors in television

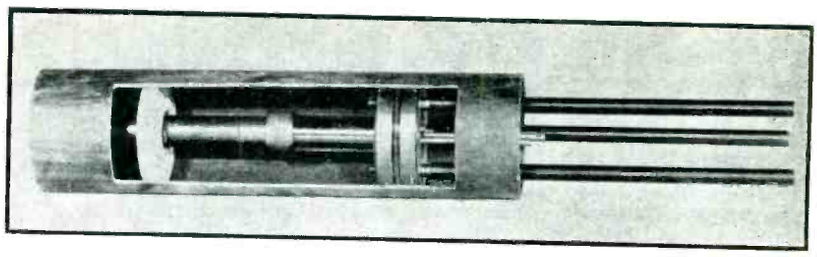
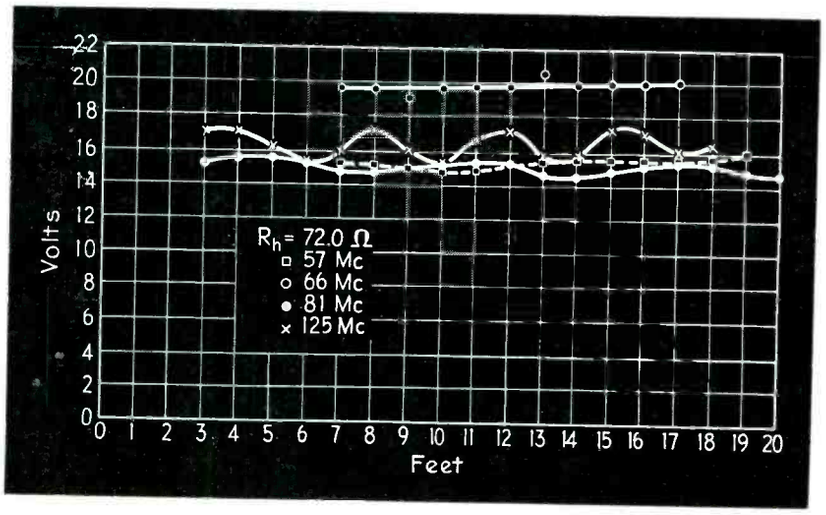


Fig. 6—A resistor unit designed to match a 77-ohm transmission line, capable of dissipating over one kilowatt between 40 and 50 Mc

Fig. 7—Voltage distribution along a transmission line terminated by a water-cooled resistor of the type described in this article



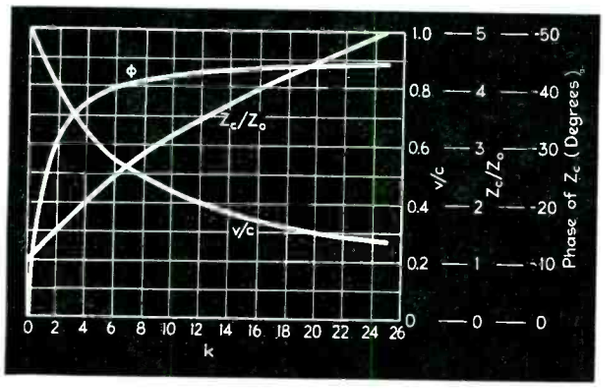
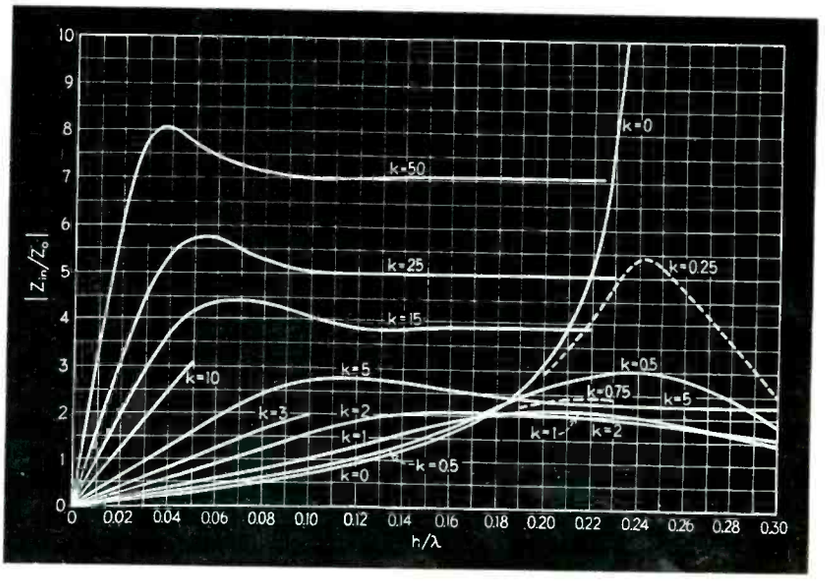


Fig. 8 — Characteristic impedance of a high-resistance line, which simulates the water-cooled resistor

Fig. 9—Magnitude of the input impedance, in terms of the characteristic value, for various lengths relative to the wavelength



modulators. The resistors are used also in television transmitters as loading resistors for "line" type excitation circuits to minimize r-f voltage regulation during modulation. In these cases high-resistance values are used at high-voltage positions and the cooling water is conveniently connected through the circuit conductors. This method of water connection proved advantageous in that it also cools the conductors and avoids warm-up tuning changes which are often quite objectionable in high-power circuits.

Figure 3 represents schematically the "dummy" antenna illustrated in Fig. 1. Two large resistors of low resistance values are used in effect to form a "high-loss" line-type tank circuit. In this case the electrical length involved is sufficient to cause the load to be quite inductive and it is necessary to tune the load to resonance by means of the small disc-type variable capacitor shown above the resistor assembly in Fig. 1. By proper design it is possible to make such a load very effectively simulate a real antenna and, in addition, it furnishes a very accurate means of measuring the power output of a transmitter. A known rate of water circulation is maintained. By noting the difference in temperature between the inlet and outlet cooling water, the power output can be readily computed. Coupling to the resistors at intermediate points can be effected by means of metal bands encircling the glass housing. This was found to be a very convenient method of obtaining variable r-f voltages for metering and observation equipment.

In the cooling of these resistors, it is not necessary to use distilled water. Where ordinary tap water is used, it is desirable to be sure that the water does not contain a large amount of sediment.

Zero-Reactance Resistors as Terminations

In the cases just discussed, it is not important that the resistors have exactly zero reactance since tuning means were provided to take care of a certain amount of reactance, nor is it imperative that the resistance value be known accurately. However, when a resistor is used to form a termination to a transmission line in such a way that no reflections will be present on the transmission line, it is necessary that the terminating resistor have no reactance and that its resistance be known quite accurately.

The type of resistor previously described lends itself to this application admirably. The resistor, in its glass mounting and end fittings, is used to form the inner conductor of a concentric transmission line. The cooling water goes in at one end of the resistor, flows through the central part to the other end of the resistor, and returns to the starting end over the surface of the resistor. Thus the cooling water enters and leaves at the same end. A shorting plug connects this end of the resistor to the metallic outer conductor (Fig. 4). This is of advantage since the water enters and leaves the resistor at a zero-potential point, thus involving no complication when extremely high powers are to be dissipated in the resistor.

The resistor and the surrounding metal tube, together with the shorting plug, form a transmission line which has high distributed series resistance and is short-circuited at the remote end. Since the resistance film is extremely thin, the high-frequency resistance per unit length is essentially the d-c value. However, because of the transmission line effect, the series inductance and shunt capacitance have an effect on the input resistance, which accordingly is dependent upon the length. If the resistance per unit length were low, the line would be resonant when it was close to one-quarter of a free-space wavelength. However, the high resistance per unit length decreases the velocity a great deal, so that this resonant length may become only a small fraction of a free-space quarter wavelength. By choosing the constants of the resistor properly, we may make the resistor of the proper length, diameter, and total d-c resistance to furnish the correct radio-frequency resistance for correctly terminating the feed line.

Before proceeding further with the design relations, let us define some of the significant quantities.

Let h = length of the resistance tube.

R = resistance per unit length along the tube.

R_h = the total d-c resistance of the unit.

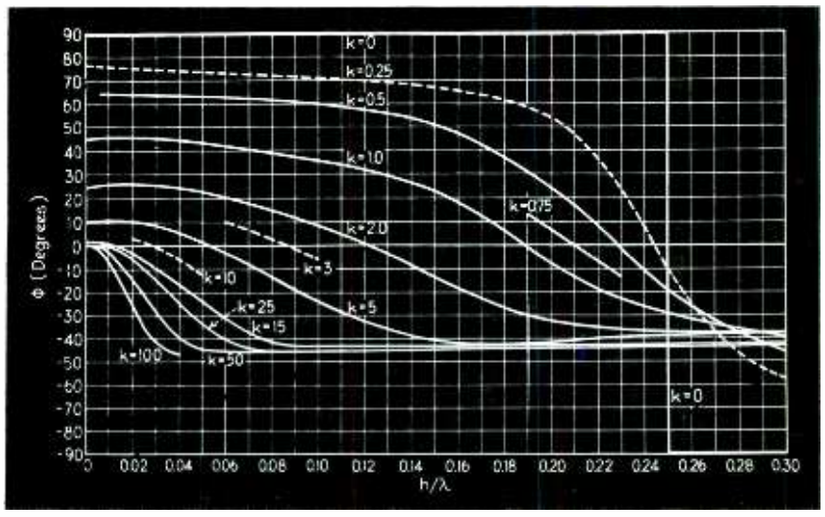


Fig. 10—Phase angle of the input impedance, for various values of the parameter k (compare with Fig. 9)

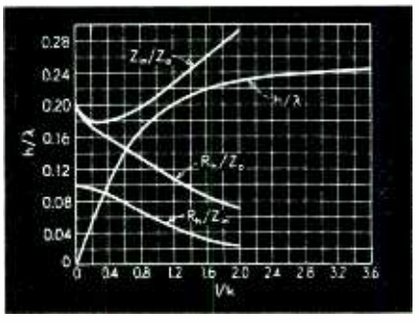


Fig. 11—The relative length of resistor which gives zero reactance, according to the value of $1/k$, together with various corresponding impedance ratios

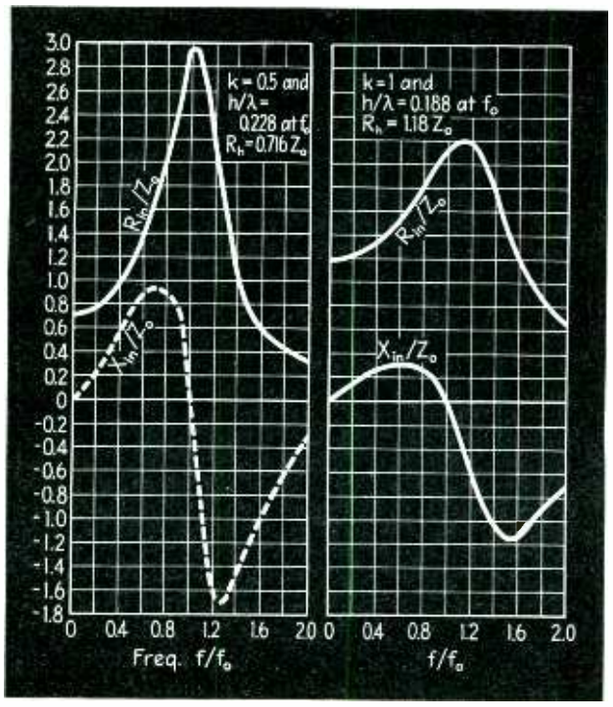
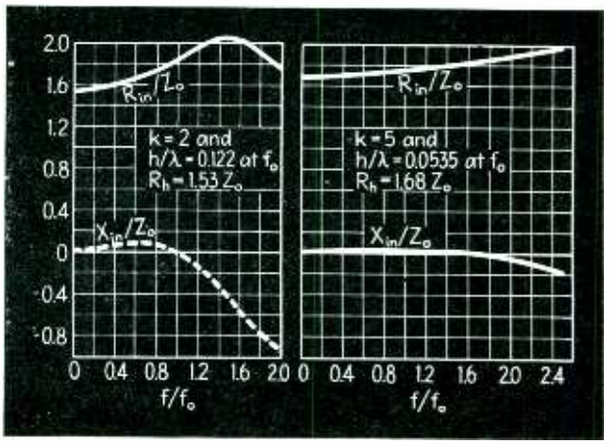


Fig. 12—Left, impedance variation as a function of frequency, based on the specified values of k and relative length. The impedance is critical near the resonant frequency. Fig. 13—Right, impedance variation curve for other parameter values, showing flatter characteristic, that is, less reactive effects

Fig. 14—Below left, impedance variation curve for a shorter resistor than those represented in Figs. 12 and 13. Fig. 15—Right, impedance variation showing very little change with frequency, characteristic of shortening the resistor



R_{in} = the resistive component of the impedance at the input terminals of the resistor (Fig. 4).

b = inner diameter of the metallic outer conductor of the high-resistance transmission line.

a = outer diameter of the resistor.

$Z_o = 60 \log_e \frac{b}{a} = 138 \log_{10} \frac{b}{a} =$ the characteristic impedance which the high-resistance line would have if the resistance per unit length were zero. Since this characteristic impedance is a function of geometry alone, it is a useful quantity in calculations.

λ = free-space wavelength of the operating frequency.

The choice of units in which lengths are measured is arbitrary, as long as all lengths are measured in the same units.

Figure 5 gives all the information necessary for designing a resistor to have a given input resistance, with zero reactance, at any given frequency[1]. The abscissa values give the values of h, measured in wavelengths, which will produce the zero reactance condition. The three curves show R_{in}/Z_o, R_h/Z_o, and R_h/R_{in} as a function of h/λ. In designing a resistor, we first decide on a length to be used. This will generally be determined by cooling considerations. For extremely large power, the length will be increased to allow larger cooling surfaces. R_{in} is known, so we turn to the lower curve of Fig. 5 and find the ratio R_h/R_{in}. This gives us the value of the total d-c resistance, R_h, required. From either of the other two curves we next find the necessary Z_o. Then the values, b and a, are proportioned to obtain the proper Z_o.

From Fig. 5 we may observe several interesting facts. Because of transmission-line effect, the input resistance differs from the total d-c resistance of the unit. As we might suspect from physical reasoning, these two resistances become equal to each other as the unit approaches zero length. Also, for this condition of zero length, the desirable characteristic impedance becomes one-half of the input resistance.

For a given frequency, h/λ may be made to have any value between zero and 0.25. However, for values of h/λ in excess of about 0.05, the input impedance will vary considerably with frequency. If we wish to have a good termination over a band of frequencies, it is best to make h/λ equal to or less than 0.05 for the highest frequency involved. Then the resistor will remain practically a constant resistance, with essentially zero reactance from zero frequency to the highest frequency involved.

Also, for values of h/λ less than 0.05, it is not necessary to hold Z_o close to the values shown by Fig. 5. In fact, Z_o may depart from the most desirable value by a ratio of 2/1 without serious effects.

Figure 6 shows a resistor unit which was designed to terminate properly a transmission line which had a characteristic impedance of 77.0 ohms[2]. This particular unit will easily dissipate one kilowatt, with a water flow of one-half gallon per minute, without harmful effects. This unit was designed to operate between 40 and 50 megacycles. Actually, it is operable at much higher frequencies. In an experimental arrangement, the unit was used to terminate a 77.0-ohm transmission line in which holes had been bored at one foot intervals.

(Continued on page 104)

[1] The reader who is interested in the relations on which the curves of Fig. 5 are based is referred to the material at the end of the article.

[2] The unit shown in Fig. 6 is one of six employed in the vestigial side-band filter in use with the television transmitter at Empire State Building. These resistors, used in tests in New York in the Fall of 1938 and early in 1939, have been in regular service since March 1, 1939, without a failure occurring.

A NEW USE FOR X-RAYS IN INDUSTRY

Whereas x-rays have been utilized for making photographs or for direct visual observation on a fluorescent screen, the industrial process described here uses the ionization of air caused by the presence of x-rays to pass a minute current which controls a pass-or-reject relay

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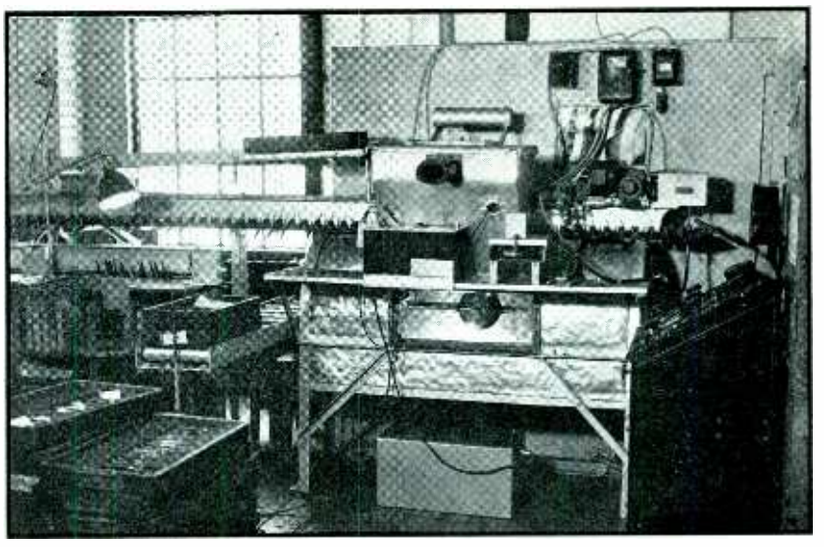
Bell Aircraft Corporation

and L. PIERCE KENNA
Oneida, Ltd.

THE ionization of air by means of x-rays has been applied in an unusual manner to the routine inspection of soldered joints in the interior of table knives in the plant of Oneida, Ltd., Oneida, N. Y. The installation is of more than usual interest because it involves certain techniques which are becoming increasingly important to industry. First, a natural phenomenon which is little known outside the field of the physicist is used. Also, electric currents of the order of 10^{-9} ampere, or one milli-microampere, are utilized in the control of a routine industrial process. The control quantities are so small that complete elimination of all stray x-ray radiation and electrostatic fields is necessary to proper operation. The apparatus to be described has been in continuous use for about a year with complete satisfaction.

The problem involved inspection of the soldered bonds between blades and hollow handles in table knives. In Fig. 1, *A* is the blade of the knife, *B* is the tang extending down into the hollow handle *D*. To fasten the two firmly together, molten solder is flowed around the tang so as to fill the space *C*. However, in a very small percentage of cases, some solder escapes and leaves an imperfect joint, as in Fig. 2A or B. Figure 2C shows a porous joint, the result of an imperfect melt. While these conditions are relatively rare, when present they are instantly detected by the method to be described and can be corrected immediately. Figure 3 shows radiographs of two knives, *A* with a good lead solder bond and *B* with an insufficient amount of solder in the handle.

Unfortunately, conditions such as these are not always detected by the usual inspection methods. It is not



Equipment used to test an interior lead soldered joint in table knives by means of x-ray gas ionization. The x-ray tube is shown beneath the bench and the knives to be tested pass through an opening to a ionization chamber. The amount of lead in the joint determines the degree of ionization of the air in the chamber

Fig. 1—Cross section of a table knife. The purpose of the inspection is to insure a proper amount of solder in the joint at C

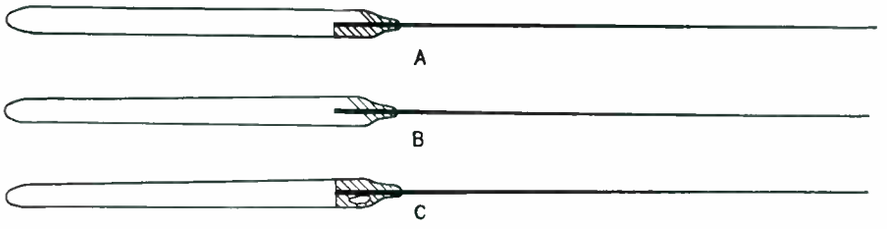


Fig. 2—Typical imperfect joints in the knives. The presence of less than the normal amount of solder causes the knife to be rejected

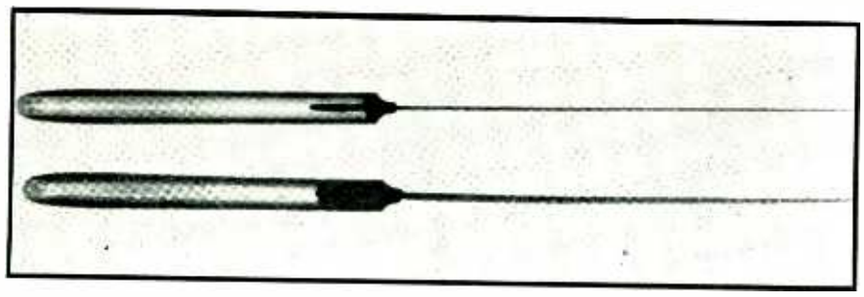


Fig. 3—Radiographs of two knives, one with a proper lead solder joint and the other with an imperfect joint

until the knife has been in service for a considerable time that there is any likelihood of failure. The only really satisfactory examination would be some way of actually looking through the knife handle and seeing the internal joint condition. That, of course, means the use of x-rays and a method was devised for visual fluoroscopic inspection of knife assemblies passing through an x-ray beam on a conveyor belt. This was efficient and practical, but it was felt that if the job could be done entirely automatically, it would be a more economical tool as well as a considerable engineering advance. Accordingly, experimental work was begun on an apparatus for automatic selection and rejection of good and bad knives.

A photocell activated by the fluoroscopic image was first tried, but changes in brilliancy were found insufficient for satisfactory operation. Therefore, recourse was made to the method of gas ionization by x-rays. Before any clear idea of this unusual application can be obtained, the general subject of x-ray ionization must first be discussed.

As a start, let us consider the micro aspect of this phenomenon, and to do so we must think of x-rays as photons, or discrete quantum bundles. When a number of such corpuscles traverses a volume of gas, most of the energy originally existing as x-ray particles is transformed into energy of other types. While the final result of these transformations is always the production of gaseous ion pairs, it is rarely accomplished without an intermediate step. It may help somewhat to imagine an x-ray bullet scoring a direct hit on a *K* orbit electron of an air atom, so that the electron is dislodged and ejected into the surrounding space. In this instance, energy of the x-ray photon has been

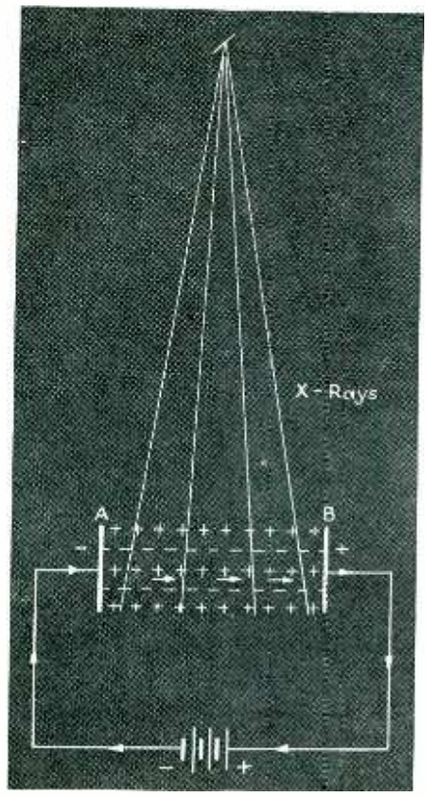


Fig. 4—Diagram showing the presence of positive ions and negative ions (direction shown by arrows) in the chamber

wholly transformed into kinetic energy of the ejected electron, less a small quantity dissipated to release the photoelectron from its atomic bonds. This electron, in turn, then strikes and dislodges an outer orbit electron from some adjacent atom which is thus left in an electrically unbalanced state. The result is the existence of one atom positively charged by loss of an electron and one free negatively charged electron. The electron originally responsible for all this damage passes on with reduced energy and probably produces at least one more ion pair by impact with a second gas atom.

The only other way in which x-ray energy in a gas is dissipated, and a rare one, is by excitation of whole atoms rather than of atomic constituents. These excited atomic states are short-lived, however, and generally result in the emission of more photoelectrons which again lose their energy through ion production. So in any event, ion energy is always obtained from primary x-rays by indirection, through the agency of photoelectronic impact.

Suppose then, a limited volume of gas is undergoing ionization by an x-ray beam. Wherever the rays pass, there will exist numbers of positively and negatively charged ion particles which, if left to their own devices, will recombine to form neutral atoms. If, however, two objects, such as metal plates, are placed in the gas and charged at opposite polarities, the positive ions will quite naturally move towards

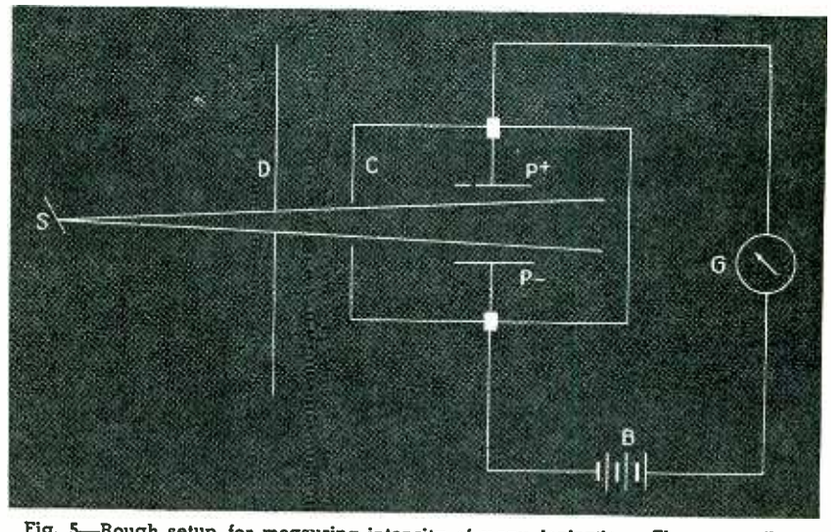


Fig. 5—Rough setup for measuring intensity of x-ray ionization. The x-rays flow through the opening in the lead sheet *D* into the chamber *C* where ions are formed. The ions migrate to the charged plates to cause a current flow which is measured by the galvanometer *G*

the negative pole while the negative particles will be attracted to the positive plate. When the potential drop between the plates is sufficient, all these electrified particles will complete their journeys and deposit their charges on the proper electrode so as to form an electrically conducting medium, as in Fig. 4.

The number of such ion pairs produced in any given gas volume is, within practical limits, independent of the energy associated with the x-ray photon itself. It does, however, depend almost entirely on the number of x-ray photons present in the gas. In short, the more x-ray quanta present, regardless of their individual energies, the greater is the mass production of ion pairs. The amount of current passed between *A* and *B* in Fig. 4, at any given potential, is proportional to the availability of ions, so it follows that the current is also proportional to the intensity of the ionizing beam. Thus, if a dependable means for measurement of ionization current can be found, accurate determination of x-ray intensities can be made.

In Fig. 5 is illustrated a rough set up for making x-ray intensity measurements. *S* is the x-ray source, *D* a lead diaphragm to confine the beam, *C* is an ionization chamber of brass or other suitable material, and P+ and P— are two metal plates charged by battery *B*. When no x-rays enter the chamber, this circuit is open at the air space between P+ and P—. However, when x-rays are present in *C*, ions are formed which migrate toward the electrodes and cause a current flow whose magnitude can be read on the galvanometer.

Pressure and temperature of the ionized gas also influence the current, since these factors directly affect the numbers, mobility, and kinetic energy of gas molecules from which ions are produced. Change in potential between the collector plates likewise varies the number of ions which finally reach their destinations and deposit their charges. In these respects, the behavior of gas and electrolytic ions in solutions is not too dissimilar and if the engineer's only task were to deal with the straightforward measurement of definite quantities of gas ions, industrial applications would long since have become routine. Such, however, is not the case.

Stray x-radiation can produce undesired ionization currents in the chamber, in connecting cables, or in the electronic measuring device. Likewise, the chamber and cables act as excellent antenna for pickup of electrostatic fields generated by the x-ray equipment or nearby electrical apparatus. In short, a large problem in an ionization setup consists in experimental work aimed to establish proper x-ray and electrostatic shield systems.

The method by which all these troubles have been overcome is as follows: A narrow pencil of x-rays is directed at the knife handle area where inspection is desired. The ionization chamber is situated immediately behind the knife, so that when sufficient lead is present in the joint, x-rays are completely blocked and do not reach the chamber at all. On the other hand, wherever solder is absent, or porous, x-rays pass through into the chamber and allow a current to pass between the charged plates. Since the magnitude of this current depends on the intensity of x-rays received by the chamber, and this qantity in turn is regulated by the amount of solder in the handle, it then follows that measurement of the ionization current will indicate the size of defect in the knife. From here on, the problem is purely one of amplification so that changes in current can be made to actuate a galvanometer relay for operation of the rejection circuit.

Figure 6 shows the electron tube circuit used. The tube is an acorn type 954 developed primarily for ultrahigh frequency applications at

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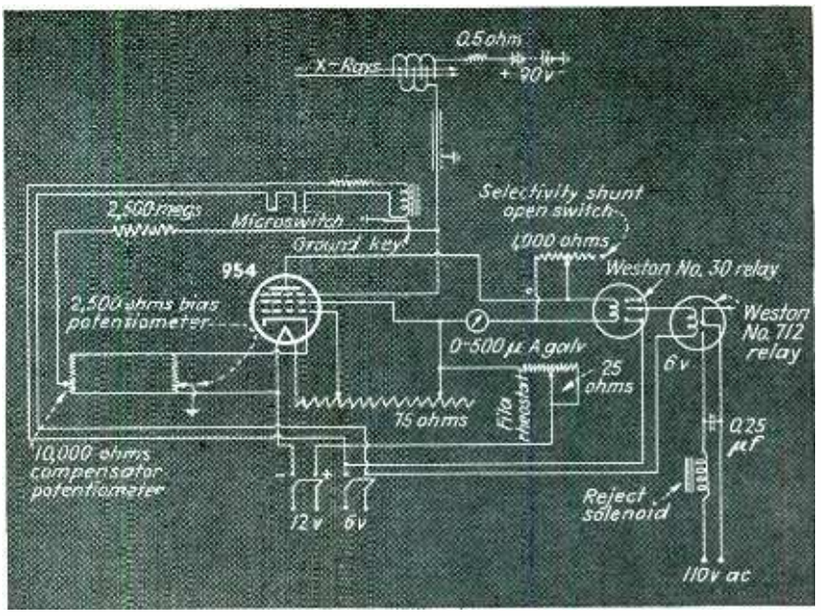


Fig. 6—Circuit diagram of the amplifier and relay unit used to pass or reject the knives. The input is applied to the suppressor grid and a plate voltage of 7.7 volts is used

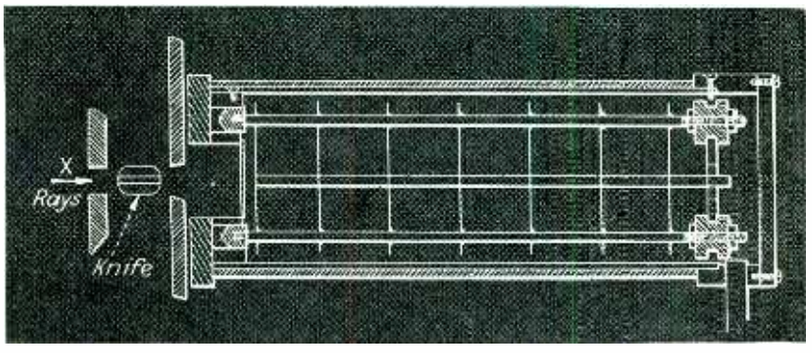


Fig. 7—Cross section of the ionization chamber showing the knife in place for inspection. The metal plates in the interior of the chamber increase the number of ions available to operate the relay

Inductive Tuning at Ultrahigh Frequencies

A continuously variable inductive tuning system applied to frequencies greater than 20 megacycles is described. The inductive unit is a coil tightly wound on a rotatable form and a contactor carriage makes contact with the coil

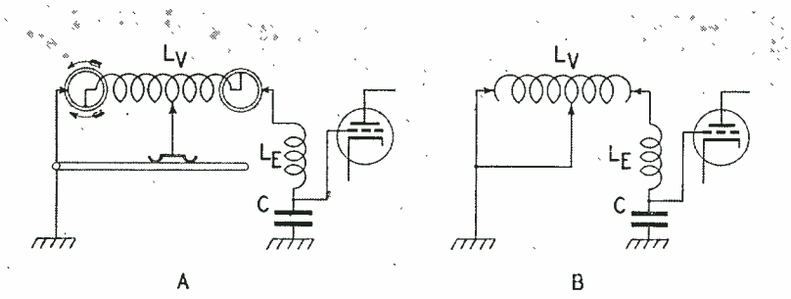


Fig. 1—Basic circuit of the Inductuner. Because the coil form rotates connections are made by continuous contact surfaces at each end of the coil form

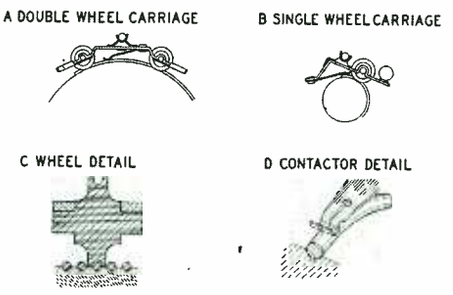


Fig. 2—Details of the method of making contact. The single wheel carriage has the advantage over the double wheel unit of approaching much closer to the high frequency end of the coil

By B. V. K. FRENCH
P. R. Mallory and Co., Inc.

THIS paper summarizes recent development work extending the application of the Mallory-Ware inductive tuning system to the region of the radio spectrum above twenty megacycles. The "Inductuner" or continuously variable inductor employs a rigid coil assembly which rotates on its own axis by direct drive. A contactor carriage assembly which maintains a resilient contact of almost constant pressure is constrained to slide directly along the length of the coil wire as the coil is rotated. The coil form is grooved and the wire is wound under tension with approximately two-thirds of its diameter above the surface of the form. The contactor carriage is guided by a grooved insulated pulley whose flanges ride upon the coil form, straddling the wire. A rod parallel to the axis of the coil against which an "antler" shaped spring of the carriage presses acts as a guide for the motion of the carriage and provides a ground connection for the contact point.

The contactor itself is bifurcated in a direction parallel to the wire, thus providing two separate points of contact. The contact reliability is increased several hundred times over a single contact due to the diversity effect introduced by the bifurcation. The carriage assembly is compressed between the guide rod and the coil form and thus the contactor spring is not called upon to perform any other function than supplying contact with the wire.

Since the coil form rotates, the high potential and ground terminals of the coil are commutated by continuous contact upon surfaces at the ends of the coil form (Fig. 1).

Thus, three points of moving contact are involved in the design of this tuning inductor. The perfection of operation of these contacts to such a degree that contacting discontinuities which might cause electrical noise are eliminated has involved mechanical, metallurgical and chemical engineering. The coil and contact rings employ a new silverizing technique which provides a higher density and surface hardness than has been previously available. The wire is hard drawn with a similar smooth, hard silver surface. These contacting surfaces are chemically treated to retard indefinitely the formation of compounds inimical to contact reliability.

The proof of the practicability of this treatment is that coils in use over a period of three years and under severe atmospheric conditions indicate no tendency to become noisy in high gain receivers. The mechanical life of the coils as determined by motor driven life tests under varied conditions indicates that the contact mechanism will operate for tens of thousands of

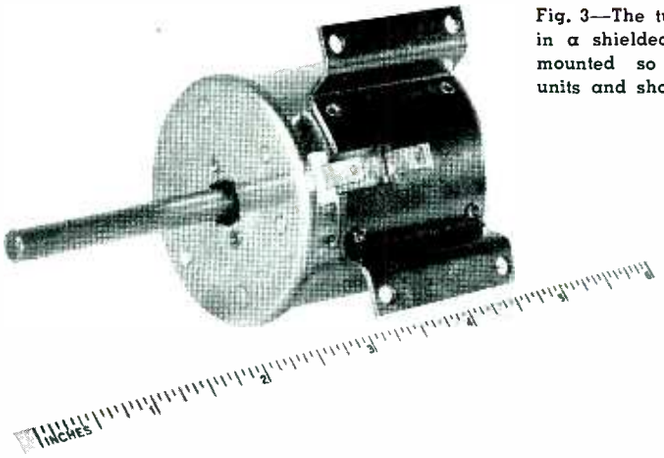


Fig. 3—The tuning unit is contained in a shielded unit which may be mounted so that closely spaced units and short leads may be used

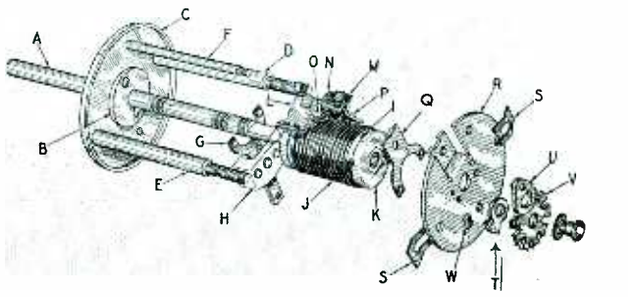


Fig. 4—Construction details of the Inductuner. The entire unit is supported by the end plate C through the shaft *A* and tie rods *D* and *E*

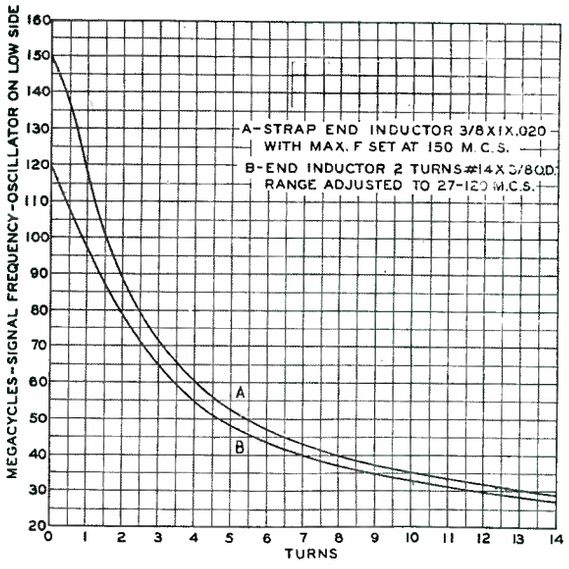


Fig. 6—Curve of turns vs frequency for a 14-turn coil. In curve *A* the series end inductance is the lowest possible making use of a strap between the high potential circuit terminals. In curve *B* a two turn end inductor of soft copper is used

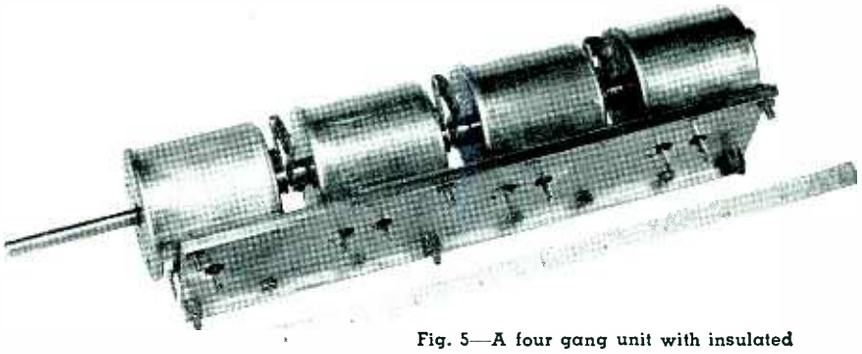


Fig. 5—A four gang unit with insulated couplings. It is necessary to use insulated couplings to avoid undesirable circuit coupling at ultrahigh frequencies

turns before noticeable wear occurs.

Inductively tuned oscillators have been constructed commercially covering a frequency range of 22 to 150 megacycles (6.8-to-1 frequency ratio) and experimental receivers covering 35 to 150 megacycles (4.3-to-1 frequency ratio) investigated with satisfactory r-f circuit performance. Receiver ranges of over 5-to-1 appear to be possible.

Since the usual variable condenser employs only 180 degrees of primary tuning motion, the accuracy with which it can be reset to a desired frequency is dependent not only on its bearing and end-thrust tolerances, but also upon the backlash of whatever type of gearing is employed to multiply its primary motion for scale reading or automatic tuning stop mechanisms.

In the inductive tuning system, the number of turns of primary tuning motion may be varied by design and by considerations of range, upper frequency limit and drive requirements. As an example, the 22 to 150 megacycle oscillator mentioned previously had 32 times the primary tuning motion of a condenser or 5,760 degrees of continuous rotational control.

Acoustic Modulation

One of the most aggravating problems of receiver design is that of eliminating or suppressing acoustic feed-back or microphonism. The sustained acoustic howl caused by mechanical modulation of the frequency determining system of the oscillator of a high gain u-h-f superheterodyne by sound pressure from the loud speaker is a phenomenon too well known to require further elaboration.

The variable tuning inductor described here is inherently non-microphonic. Unlike the condenser its mechanism is symmetrical with respect to rotation and all contacting parts are under definite spring tension.

In the design of receivers employing the Inductuner it is not only preferable but desirable to mount the unit rigidly to the chassis base. Rubber grommets or other flexible mountings are unnecessary.

Frequency Stability

The requirement of high stability of the oscillator and input tuned circuits of u-h-f receivers has recently received considerable attention. The technique of temperature frequency compensation employing such expedients as negative coefficient condensers or bimetal controlled condensers is well known.

In condenser tuned circuits such

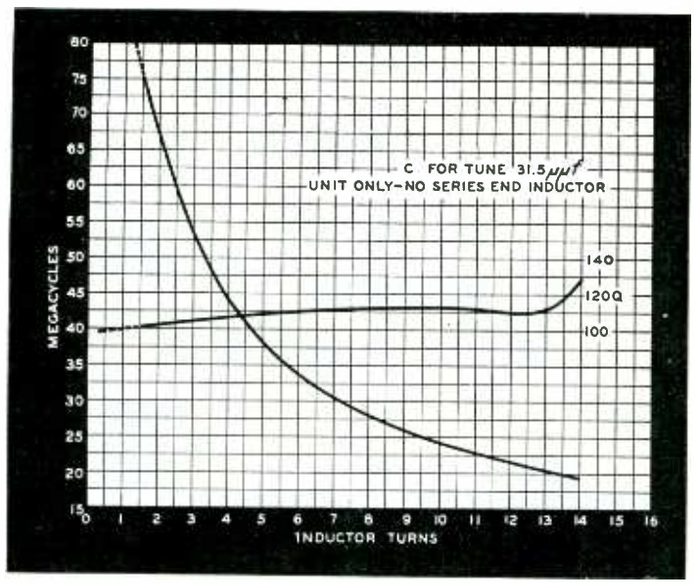
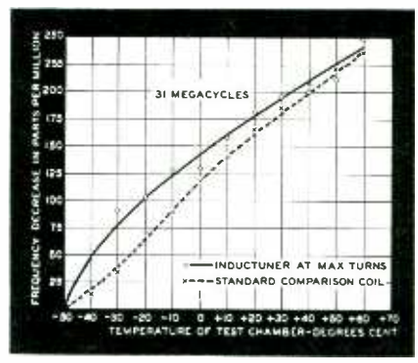


Fig. 7—Curve showing the Q of the Inductuner. Except for the portion of the curve between 13 and 14 turns the Q varies less than 10 per cent

Fig. 8—Curve of frequency change vs temperature at 31 megacycles. The temperature coefficient of frequency is about 2.5 parts per million per degree C



compensation can be exact for only one setting of the tuning condenser, usually at the high frequency end of the tuning range. In the inductive tuning system the capacitance of the circuit is fixed and capacitance compensation would be perfect at all frequencies if the inductor could be assumed to have a zero temperature coefficient of frequency. By suitable design the temperature coefficient can be made very low and the controlled stability of the oscillator system of a high order at all frequencies in its tuning range.

Characteristics of U-H-F Inductuner

Consideration of the u-h-f requirements listed above has resulted in the development of a tuning unit suitable for use at frequencies above 20 megacycles and for certain narrow band applications at lower frequencies. Its design features such as size, mounting details and materials were determined by the space and operation limitations imposed by mobile and aircraft applications.

In the latest design a single wheel structure has been designed in which the contactor nib can approach very close to the high frequency end of the coil. This construction is shown in Fig. 2B. The balance of forces necessary to produce rotational stability and position the contactor spring properly are provided by the triangle formed by the antler spring contact, the wheel contact on the coil form and the fulcrum point of the carriage tail stock on the support rod Fig. 2B. This point of contact would, if not insulated, present a ground circuit in parallel with the main coil ground of the antler spring. An insulated button in the tail stock of the carriage prevents a multiple ground path.

The trolley wheel and its bearing design are directly involved in the problem of the attainment of a high degree of reset accuracy. Backlash of the carriage and contact mechanism in a direction parallel to the axis of the coil has been kept at a minimum by close tolerances of the machined wheel with respect to wire diameter and bearing end thrust.

While earlier multi-gang inductive tuner assemblies were constructed with a common shaft extending through a number of coils similar to the sections of a variable gang condenser, a consideration of the problems of u-h-f receiver construction led to the present individual unit construction with insulated couplings between the units of a multiple gang assembly. A common shaft in either a condenser or inductive tuner presents an increasingly serious problem of undesirable circuit coupling as the frequency is

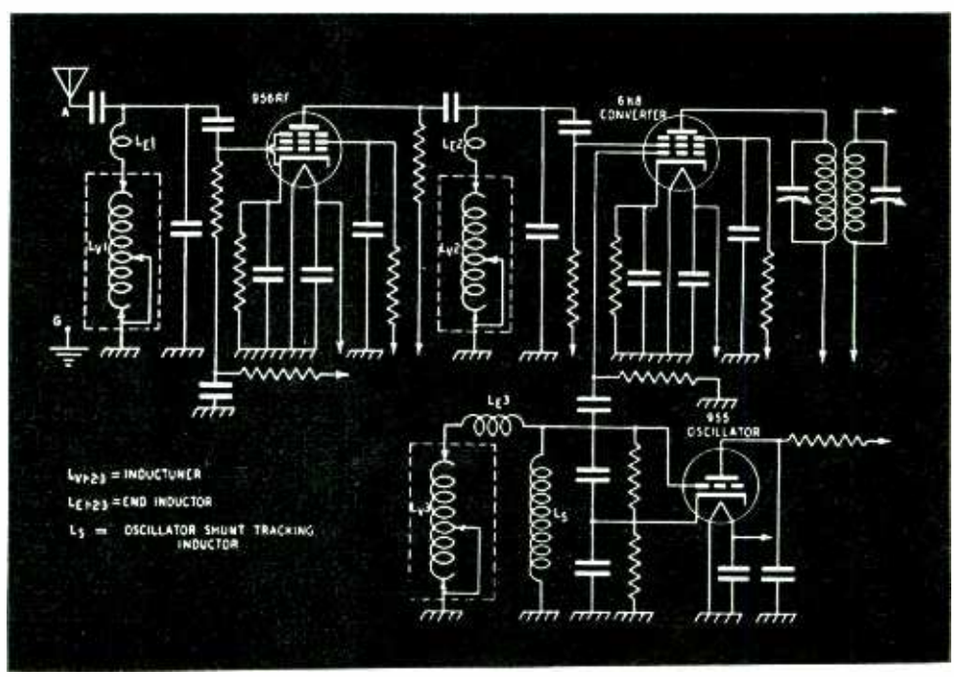


Fig. 9—Typical receiver circuit using inductance tuning units with the oscillator frequency on the high side of the signal frequency

increased since the reactance of ground contactors in individual assemblies is higher than the reactance of the common shaft itself.

Figure 3 shows such a self contained shielded tuning unit as viewed from the terminal and mounting bracket side. A rigid mounting bracket provides a low inductance ground for the unit. A ground terminal lug is formed from this bracket in close proximity to the high potential terminal of the unit. Since the unit may be mounted directly on the side of a compartment containing the tube and other components of the r-f tuning system, it is practicable to construct circuits with closely spaced units and short inter-connecting leads.

For greater clarity a "pull apart" drawing (Fig. 4) serves to disclose the assembly details of the unit. The shaft *A* of a machinable high conductivity copper alloy passes through an insulated bearing *B* in end plate *C* which serves to support the entire unit. This end plate carries tie rods *D* and *E* as well as the silverized ground contact rod *F*. It also acts as support for the higher potential contact spring and terminal *G* and its ceramic insulator *H*.

Coil form *I* employs a ceramic having an extremely low coefficient of expansion to keep the inductance-temperature coefficient as low as possible. The highly polished silver clad wire *J* is wound under tension in an accurate thread groove in the ceramic form and attached to lugs on the silvered end caps *K* at either end of the form. It will be noted that neither of these caps make connection with the shaft. The low potential end of the coil is commutated to the end plate by the silver contacts of spring *Q* and not through the shaft bearing in this plate.

The carriage *L* carrying insulated trolley wheel *N* antler spring *M* and bifurcated contact *O* have been previously discussed. The contact point on the wire is connected to the frame by way of the silvered rod *F*. Thus the unused wire is connected upon itself and to ground.

Since the units are closed and self-contained, it is necessary to provide within the device a stop system which will protect the contact nib from striking the lug at the end of the wire and also provide a method of proper alignment of units when tightening the insulated couplings between the units of a multiple gang. Such a stop system is in the nature of an intermittent or Geneva movement. In the present instance, the requirements of shearing force of the stops and limitations of size necessitated a compound device. The notched wheel *V* is advanced one tooth by each revolution of the single toothed driving member *U* which is attached directly to the tuner shaft. After nine revolutions a projection of wheel *V* picks up stop piece *T* which finally is driven against projection *W*, extruded from the end plate. By changes in parts *T* and *W* the same mechanism can be made to stop the

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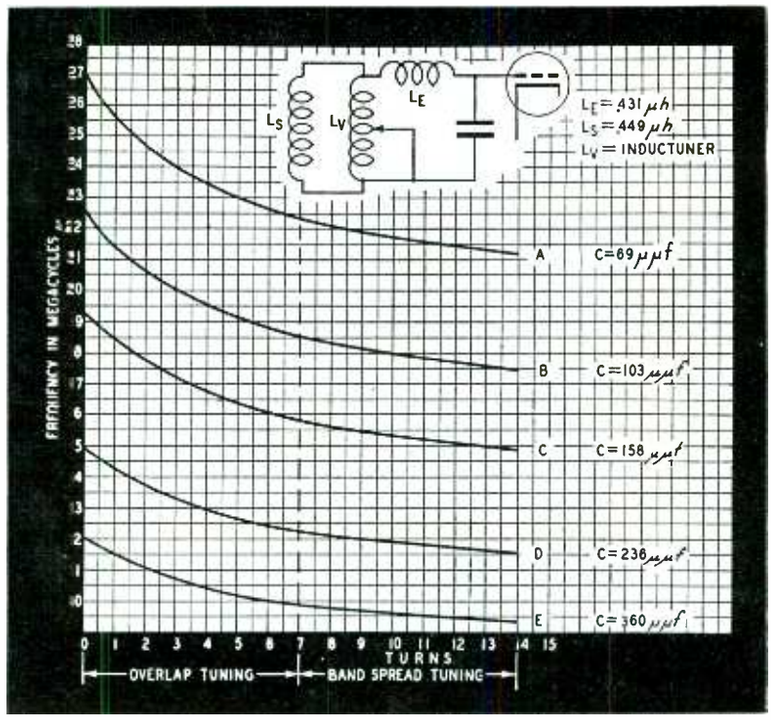


Fig. 11—Circuit which allows expanded band spread tuning. The constants chosen so that a number of short wave bands are covered using one half of the tuning motion and the other half is used to overlap the adjacent band

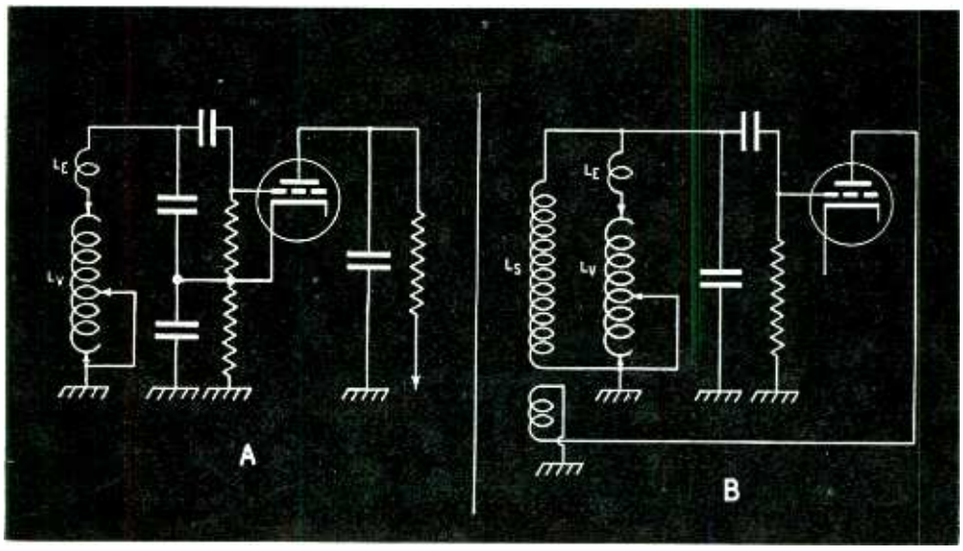
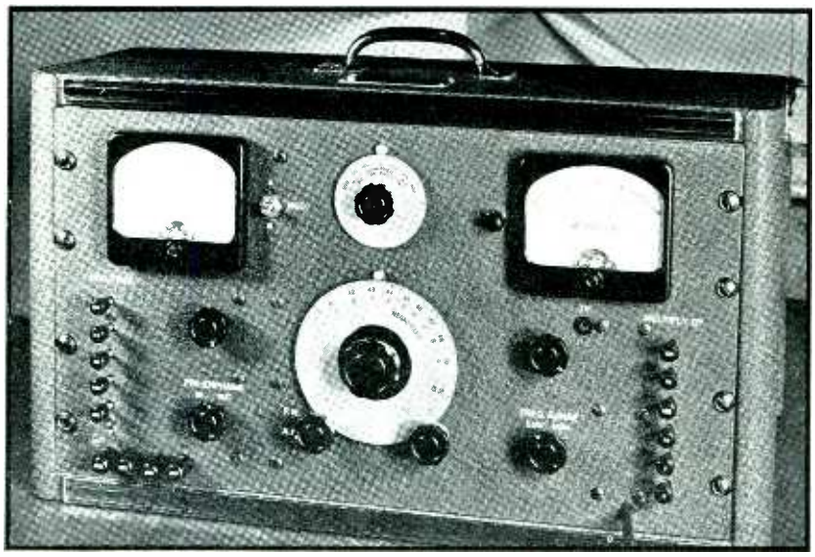


Fig. 10—Two basic oscillator circuits suitable for inductive tuning. *A*, the Colpitts circuit is a two terminal oscillator to which the feedback ratio is dependent only upon the capacitance ratio. *B*, the tickler feedback circuit uses a shunt inductor which may also be used as the parallel tracking coil

A SIGNAL GENERATOR FOR FREQUENCY MODULATION

The problem of obtaining 75-kc frequency deviation for receiver testing at intermediate frequencies, without distortion, has been solved by beating a variable-frequency unmodulated oscillator against a fixed frequency-modulated one. Details of a new design



External appearance of the generator. Push button selection of the audio modulation frequency and output voltage level is provided

By ALFRED W. BARBER, C. J. FRANKS, and A. G. RICHARDSON

Boonton Radio Corporation

THE concept of a standard signal generator as a simple, low powered, miniature transmitter whose output voltage is known and adjustable over a wide range, has been widely accepted as a result of present practice in amplitude-modulation systems. From this it might be supposed that a signal generator for frequency-modulation testing would be a small edition of an f-m transmitter, but this is only partially true. In testing an f-m superheterodyne receiver there is need for an intermediate frequency signal which has no transmitter counterpart, since the intermediate frequency deviation ratio is a result of the type of receiver and not of the transmission employed. In amplitude-modulation receivers the modulation characteristics of the signal are unchanged by the transformation from carrier frequency to intermediate frequency, but in f-m receivers the ratio of total deviation to carrier frequency is changed by a transformation from carrier to intermediate frequency. This raises difficulties for the signal generator designer. No simple means of obtaining deviations of the order of 75 kilocycles at low carrier frequencies is known at this time.

The two frequency-modulation generating methods in common use are the phase-shift plus frequency-multiplication system of Armstrong, and the direct generation of a frequency-modulated signal by means of a reactance variation circuit due originally to Chireix. Both methods require a considerable amount of apparatus and care in adjustment to secure appreciable deviation even at normal (40 to 50 megacycles) carrier frequencies, with low distortion. The prospect of attempting to extend either of these systems to give directly the large swings at low carrier frequencies required for i-f testing was unattractive indeed. To get around the difficulty, Alfred W. Barber suggested the beat-frequency generating method, which was adopted for use in the generator described here. The elements of this system are shown in Fig. 1.

It will be noted that in this beat-frequency method the output frequency is never directly generated, but is always the result of a beat between two separate oscillators. One of them has a fixed mean frequency, but is frequency-modulated by an associated reactance tube. The frequency of this oscillator is chosen high enough (20 megacycles) to permit obtaining sufficient deviation with low distortion. The other oscillator is adjustable as to frequency, by means of a calibrated panel control dial, but is unmodulated. It corresponds in function to the local oscillator in a superheterodyne receiver. Both oscillators feed into a mixer tube, in the output circuit of which appear the sum and difference frequencies. With the variable oscillator covering the range 21 to 30 megacycles, the sum frequency covers the carrier range from 41 to 50 megacycles, while the

difference frequency covers the i-f range from 1 to 10 megacycles. Suitable filter circuits in the amplifier chain following the detector select the frequency range while attenuating the other range and the fundamental oscillator frequencies. This system thereby circumvents the design difficulty of obtaining wide swings at low carrier frequencies by generating them in the same way that they are generated in the receivers to be tested.

It was found possible, taking advantage of the fixed operating conditions, to obtain very good modulation linearity by proper adjustment of the frequency-modulated oscillator. At swings of plus and minus 75 kilocycles, the departure from linearity does not exceed one per cent. This is for the modulator only. In order that the overall distortion of the complete signal generator shall not greatly exceed this figure, it has been found necessary to drive the reactance tube modulator from a low-impedance source. A power driver stage employing a medium power audio pentode, operating with a large amount of negative feedback, satisfies the requirements.

The modulation indicator, or deviation meter, is a rectifier-type voltmeter connected across the secondary of the driver transformer. It measures the voltage impressed upon the reactance tube modulator, and has a scale calibration constant of 10 kilocycles deviation per audio volt. The reactance tube must of course be set to give this value of 10 kc per volt, and to permit this adjustment it

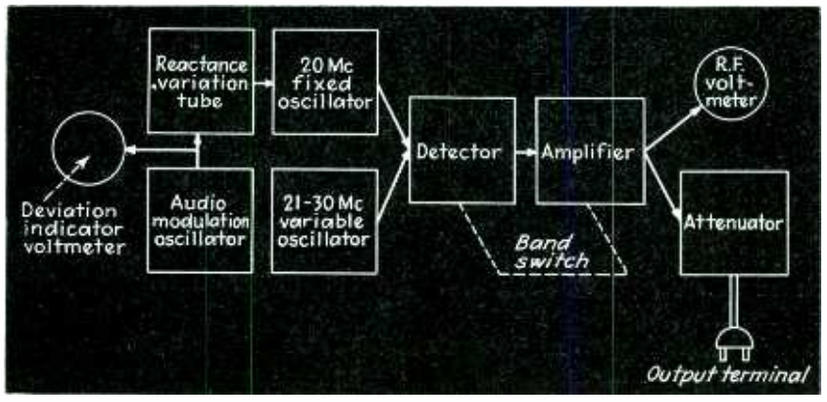


Fig. 1—Block diagram of the signal generator, showing the method of combining two oscillator outputs, one of which is frequency modulated

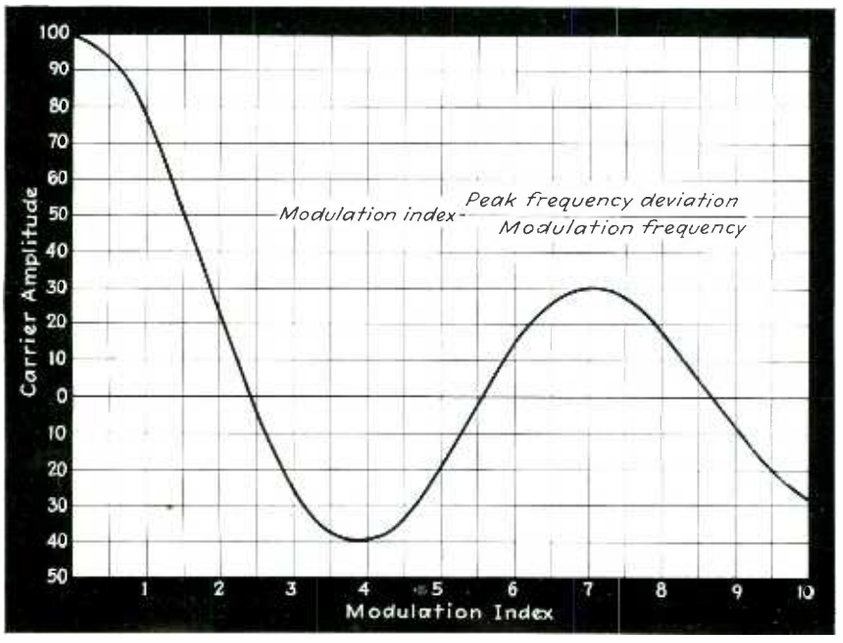


Fig. 2—Method of calibrating the frequency deviation scale of the instrument. The carrier voltage goes to zero periodically, as the modulation level and frequency deviation are increased (after Crosby)

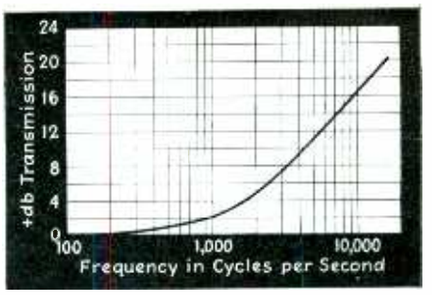


Fig. 3 — The standard pre-emphasis characteristic incorporated in the generator is removable by means of a selector switch, whenever overall "flat" measurements are to be made

is provided with a deviation control in the form of a small air-dielectric trimmer capacitor, capable of varying the deviation sensitivity over a range of about two to one. The procedure employed in setting this control will be outlined here, for not only is it a very important factory adjustment of the instrument, but it also is of general interest to workers in the frequency modulation field, for it is based on one of the fundamental properties of frequency-modulated waves.

The procedure has been outlined by Crosby in the *RCA Review* for April 1940, page 473. For a more detailed explanation of the phenomena involved, reference should be made to that article. The method is based upon mathematical analysis of a frequency-modulated wave, which shows the wave to be made up of a number of amplitude-modulated waves symmetrically disposed about the mean or carrier frequency. Considering only the carrier, when sine wave modulation is applied and increased slowly from zero, the amplitude of the carrier will be found to vary, as shown in Fig. 2, passing through zero a number of times. The deviations at these zero points bear a definite relation to the audio modulating frequency; the ratio between the deviation in kilocycles and the audio frequency in kilocycles is called the modulation index, and the carrier null points always occur when the modulation index has one of the values 2.40, 5.56, 8.65, 11.8, and so on. For example, if the modulating frequency was 10 kilocycles, the first carrier zero would occur when the peak frequency deviation was exactly 24 kilocycles.

In practice, the requirement of a measurement of carrier amplitude only, without influence from any side

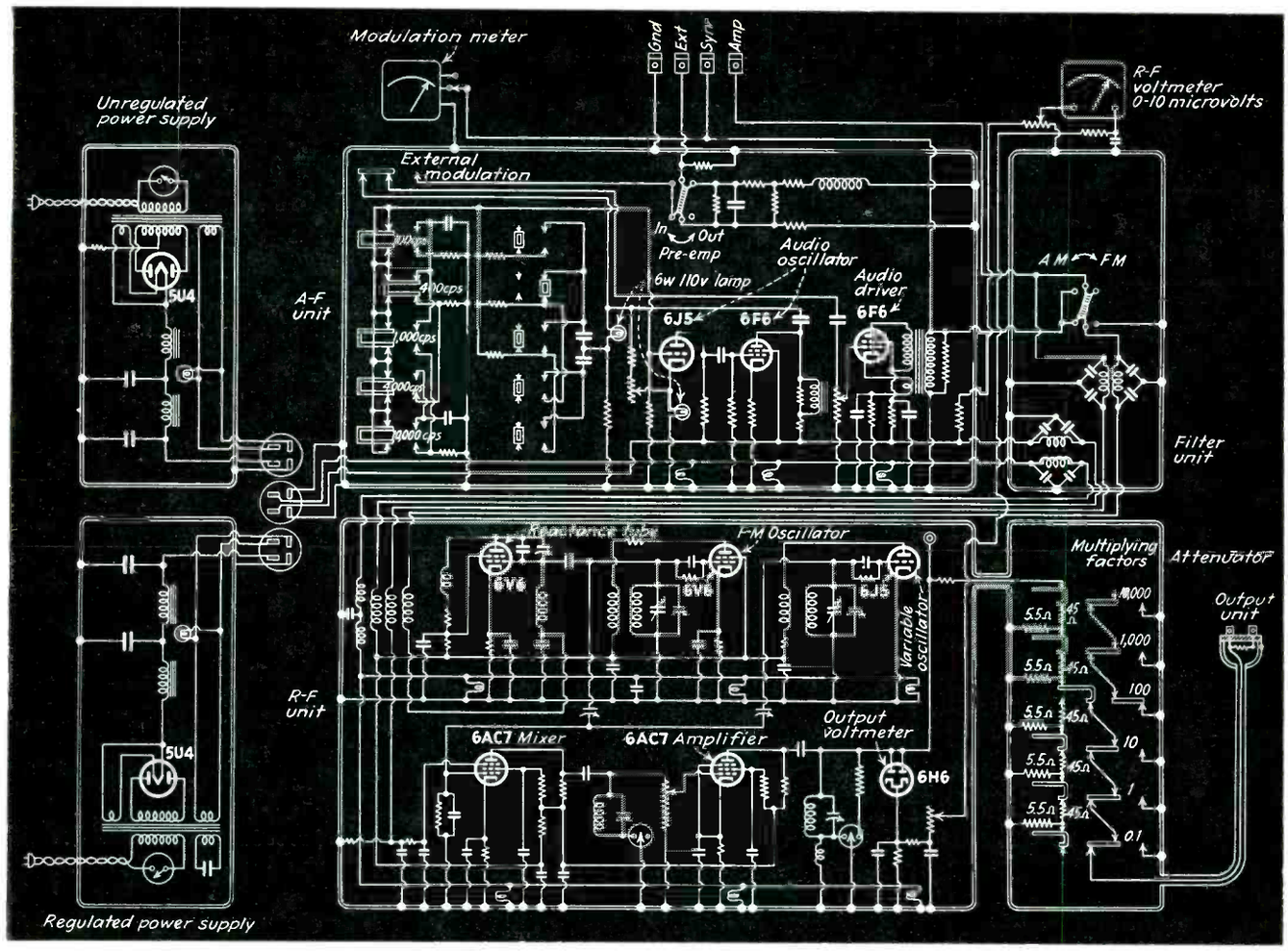


Fig. 4—Circuit diagram of the signal generator. Two alternative power supplies are shown, one (the lower) incorporating a voltage regulation power transformer

frequencies, can be met by the use of a moderately high audio frequency and a reasonable amount of selectivity in the receiver. A good "communications" type receiver plus some audio selectivity obtained by the familiar heterodyne method will readily accomplish the desired result.

Even in an instrument for f-m testing, it is convenient and useful to have amplitude modulation available, so provision for it was included in the design shown. One of its uses is in an inquiry into the behavior of limiters and discriminators when subjected to an amplitude-modulated signal, or to combined amplitude and frequency modulation using different audio frequencies for the two types of modulation. The signal generator design problem involved here is to avoid any frequency modulation due to amplitude modulation, since any frequency modulation present would tend to mask the discrimination against amplitude modulation. It is evident that amplitude modulation of the variable or heterodyning oscillator would not be satisfactory, because of the great difficulty of eliminating residual frequency modulation from an oscillator. The solution was found in amplitude modulation of the detector, by a combination of suppressor and control-grid modulation. No attempt was made to obtain great linearity or a wide modulation capability since in this signal generator the amplitude-modulation function is merely auxiliary, and strictly subordinate to the primary function of generating high-quality f-m signals.

Method of Detection

One of the important circuit elements of this instrument, not found in conventional designs, is the mixer or detector which combines the fixed and frequency modulated oscillator outputs. Some inquiry into its action is justified. As with all non-linear circuit elements, a most important question is: when two frequencies are fed in, what comes out? Suppose the two oscillator fundamentals are 20 and 25 megacycles. In the detector output will appear the difference frequency 5 megacycles, the sum 45 megacycles, their harmonics, the two oscillator fundamentals 20 and 25 megacycles, and their harmonics, of which only the second harmonics fall within the pass band of the amplifier. By choosing proper operating conditions for the mixer so as to obtain square-law operation, the second harmonics will be about one fourth of the desired beat frequency in amplitude. These harmonics are easy to identify, for that of the f-m oscillator is fixed at 40 megacycles, while that of the variable oscillator carries no frequency modulation. Probably the worst possible condition arises when the carrier frequency is such as to make the corresponding difference frequency equal to the intermediate frequency of the receiver being tested. For example, with a receiver having an intermediate frequency of

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A Simple Television Preamplifier

By

RICARDO MUNIZ and ANDREW TAIT

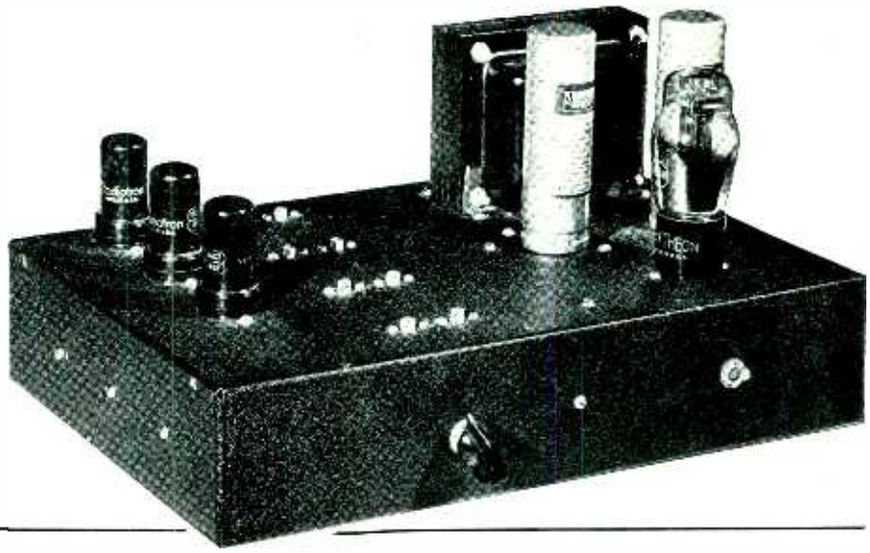


Fig. 1—The booster amplifier and associated power supply. Three sharp cutoff high-transconductance pentodes are used

A description of a straightforward three stage r-f "booster" amplifier capable of an overall gain of from 20 to 1000 times, depending on the video signal bandwidth required. Useful in raising the sensitivity of television receivers in areas of low signal strength, or in overcoming transmission line losses

IT is the purpose of this article to describe a specific method of improving the signal strength and the signal-to-noise ratio delivered to the antenna terminals of a television receiver. In the "twilight zone" of reception, far from the transmitter, the reasons for improving the signal fed to the receiver are obvious. Here we deal with signals attenuated by distance, intervening obstacles and the quasi-optical effects. Such a signal picked up in the conventional manner and fed directly to the receiver may well be either too weak to produce a picture, or so mixed with noise as to mar the picture or spoil the synchronism.

There are equally good reasons for such signal improvement even near the transmitter. In a large city there are indeed few locations for the television antenna which are in "line of sight" with the transmitter. Sometimes these locations can be reached only with the use of an excessively long lead-in. The losses incident to transmission over the lead-in may so reduce the signal strength as to impair the received image. In either case, a simple solution to the problem is the use of a radio-frequency preamplifier between the end of the antenna transmission line and the receiver.

Making up for transmission line loss by means of a radio frequency preamplifier preceeding the television set is often the only answer to the problem of antenna location in a large city. An antenna restricted to within 100 feet of the television set may be located in a "shadow" or in a location afflicted with reflected signals of great strength or with a high level of local noise. Since it is not usually convenient to have the prospective user of the television set move to a better location, and since it would be hardly practical, when television becomes widely used, to abandon the use of television in apartments not favorably located, some other solution is decidedly in order. There is almost always some location within a reasonable distance from the required location of the television set where line of sight conditions prevail unmarred by noise and reflections. By locating the antenna in the clear and using a high grade of lead-in it is often possible to get excellent reception even with a long transmission line. Often however, when difficult conditions have been encountered, it is found that the clean signal picked up by the antenna is attenuated below the level of noise generated in the receiver.

In attempting to solve this problem, it was decided to build a radio-frequency preamplifier having a gain of at least 20 as this would increase the sensitivity of a receiver originally having 1 millivolt per meter sensitivity to 50 microvolts per meter. It was considered desirable to incorporate some additional gain, if possible, so that advantage might be taken of unusually low noise conditions considerably beyond the normal service range of the vision transmitter.

Choice of Circuit

The design of a radio-frequency amplifier for use with the television signal involves many problems not usually encountered. The preamplifier must have practically a flat response for a bandwidth of 5.5 megacycles. It must be possible to switch from one television band to another. Reasonable gain per stage must be obtained.

The characteristics of the 6AC7 high-transconductance pentode (sharp cut-off type) suit it to the function of r-f preamplification. The

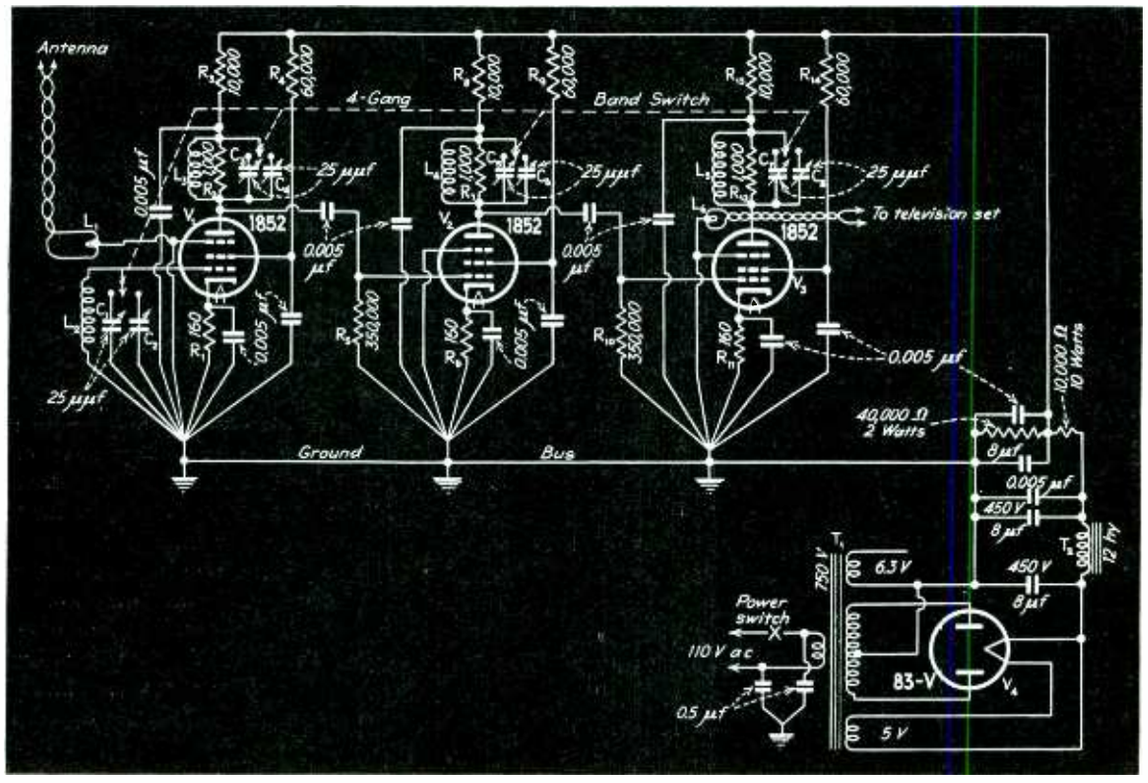


Fig. 2—The circuit diagram of the amplifier. By varying the values of the resistors shunting the tuned circuits, the gain may be varied approximately inversely as the bandwidth covered

number of stages required depends on the type of coupling used, because the gain for a given bandwidth response depends on the effective plate load impedance offered by the coupling circuit. A single tuned circuit with adequate resistive damping yields less gain than a closely coupled circuit. A coupled tuned circuit having a tertiary winding, all three windings closely coupled, requires less resistive damping to obtain the necessary bandwidth and therefore offers higher gain. However, consideration reveals the desirability of using the damped single tuned circuit. Among the reasons are simplicity of switching from one television band to the next, reduction of distributed constants in apparatus and wiring, reduction in cost and number of parts, and greater ease of construction.

The equation for the gain of a single r-f stage using a single tuned circuit for coupling is:

$$g_o = \frac{0.48\, S_m}{\Delta\omega C_T}$$

where $C_T = C_1 + C_2$

C_1 = output capacitance of previous tube

C_2 = input capacitance of the stage tube

$\Delta\omega$ = bandwidth.

Typical values are as follows:

Bandwidth	*Gain per stage*
5.5 Mc	6
4.5 Mc	7
3.5 Mc	9
2.5 Mc	13
1.0 Mc	33

For flat amplification of the entire television signal, including the sound carrier, a bandwidth of 5.5 megacycles is needed with the corresponding calculated gain of 6 per stage. Since this figure does not take into consideration any of the distributed constants of the apparatus, wiring, mountings, sockets, in practice a gain of about 2 to 2.5 can be realized at this bandwidth. However, some compromise in bandwidth is allowable. In most commercial televisors the sound sensitivity is much higher than the picture sensitivity, the sound usually not needing amplification in locations where the picture signal is too weak to produce a satisfactory image. From the practical point of view, therefore, it is not too serious a fault if the preamplifier does not boost the sound part of the signal as much as the picture portion. In the design described here it was found possible to take advantage of the circumstances and obtain increased gain by letting the response drop off considerably at the sound frequencies. Thus, a bandwidth of about 3.25 megacycles was found ample and a gain per stage of about 3.2 was realized.

It was decided to build a three-stage radio-frequency preamplifier, having a gain of slightly more than 20. It was found possible, during the course of testing, to develop a gain of 20, or slightly more, without impairing picture detail or sound reproduction. Gains as high as 1,000 were found possible with sacrifice in picture detail.

Used in conjunction with a DuMont receiver at Monmouth Beach, N. J. with a low antenna many practical tests were made to supplement those made with the Ferris 18B Microvolter. It was found that with the gain adjusted to 1,000 (by increasing the resistance of the damping resistors) the test pattern indicated that the horizontal detail of the image was better than 150 lines and not too badly marred by tube noise. The antenna used in this instance was a dipole, one foot long on each side, located on the floor of the bungalow.

The preamplifier was also tested

in the building of the Brooklyn Technical High School, where a high prevailing local noise level due to industrial instructional equipment is present. There are also high obstructions on the building which block the line of sight from the roof to the transmitting radiator. With the antenna located on this roof reception is possible only at night, when the elevators and other machinery are shut down. To locate the antenna in the clear requires a 600-foot lead-in. With an inexpensive twisted-pair lead-in the otherwise insufficient signal is brought up to a useful level by the preamplifier.

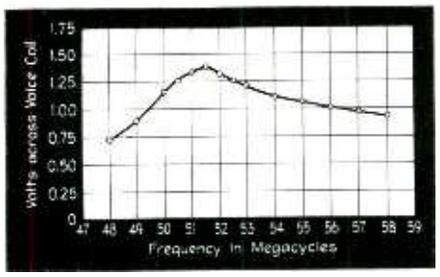


Fig. 3—Calibration curve of the communications receiver used to determine the overall gain of the television preamplifier

Ultrahigh frequency design problems differ considerably from those met at lower frequencies. Grounds must be short and tied to a common bus. The grounding bus should be securely grounded to a single point on the chassis.

The best results are obtained by mounting all parts, where possible, directly on the tube socket. This arrangement readily lends itself to both short leads and to one common ground for each separate stage. These common stage grounds are then connected together by the grounding bus and the bus grounded to the chassis at one point.

Four single-circuit six-position rotary switches were utilized in building up a four-gang band switch. The gang switch was mounted on an amplifier chassis in a position directly under the air padding condensers which were used for tuning the various tuned circuits. The tube sockets were in turn mounted as closely as possible to the padders so as to assure short leads. The large filter condensers were by-passed with small mica condensers. The effect is to reduce any tendency to break into oscillation on the part of the preamplifier. The line filter condensers also reduce the tendency to oscillate. With the precautions taken it was found that the amplifier was very stable.

The coils L_2, L_3, L_4, L_5 are self supporting coils of number 14 copper wire, 6 turns on ½-inch diameter, each. Coils L_1 and L_6 were wound on polystyrene forms. Ten turns were used, center-tapped, of number 28 silk covered wire on a ½-inch form. The forms of coils L_1 and L_6 fit snugly into the grid coil L_2 and the final plate coil L_5. The degree of coupling may be conveniently varied by sliding L_1 and L_6. The wire was secured by means of a polystyrene-base coil dope.

Shielding was found to be absolutely necessary. The amplifier was first built without shielding, but could not be restrained from oscillating. The photographs indicate that the shielding is in four sections. The first isolates the grid circuit of the first r-f tube from the plate circuit. Each of the other sections encloses a complete stage. The shield pins of the 6AC7 (1852) tubes are grounded.

An antenna attenuator must be used when testing the preamplifier on strong signals, to prevent overloading the input tube in the television receiver and possibly the last stage in the preamplifier.

Measuring Response

In measuring the response and plotting the curve of response vs frequency use was made of a Ferris 18B Microvolter and a calibrated receiver. An eight-foot piece of twisted pair 74-ohm surge impedance transmission line was attached to the input terminals of the receiver (Hallicrafters S 27) and the receiver calibrated with this cable in place.

Since the output impedance of the microvolter is in the neighborhood of 10 ohms a pair of thirty-ohm re-

(Continued on page 103)

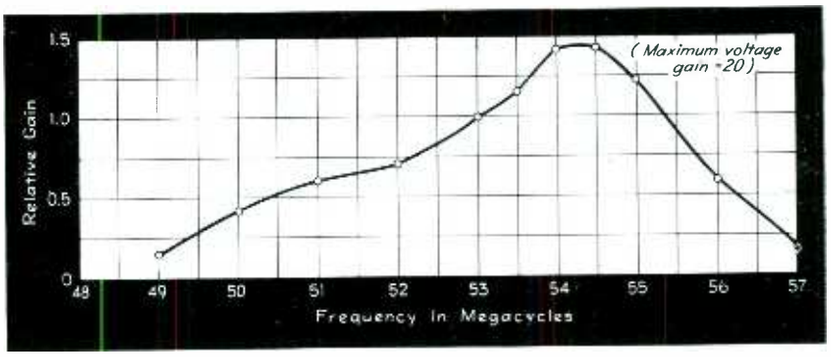


Fig. 4—Overall response characteristic of the television preamplifier, using damping resistors of ohms. Over the picture sideband, the gain varies about plus or minus 3 db, with a maximum gain of 20

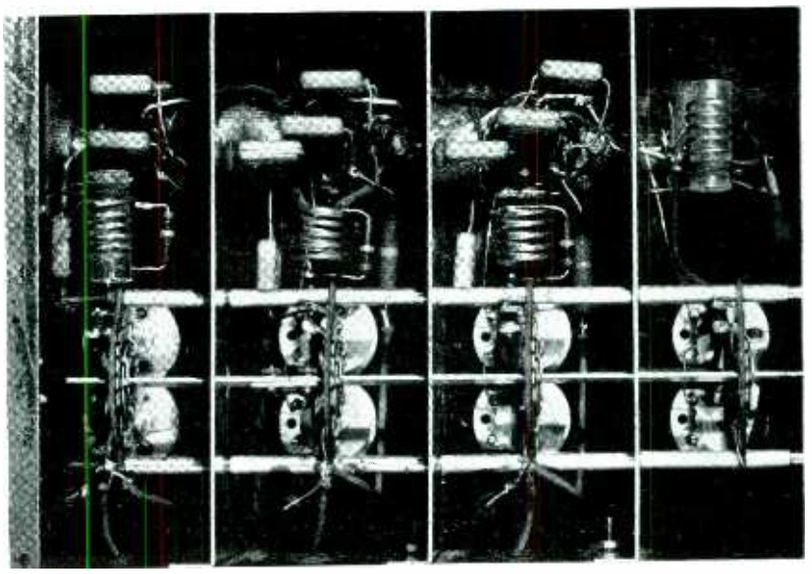


Fig. 5—Tuned circuits and shielding construction. The parts are mounted as near the tube bases as possible

GRAPHICAL SOLUTION OF RECTIFIER CIRCUITS

A practical, simplified method of computing the output voltage, percentage ripple, and regulation of choke-input or condenser-input half-wave rectifier and filter power supplies, which takes into account the leakage reactance of the power transformer, as well as the filter and load circuit constants

By W. K. H. PANOFSKY
California Institute of Technology
and
CHARLES F. ROBINSON

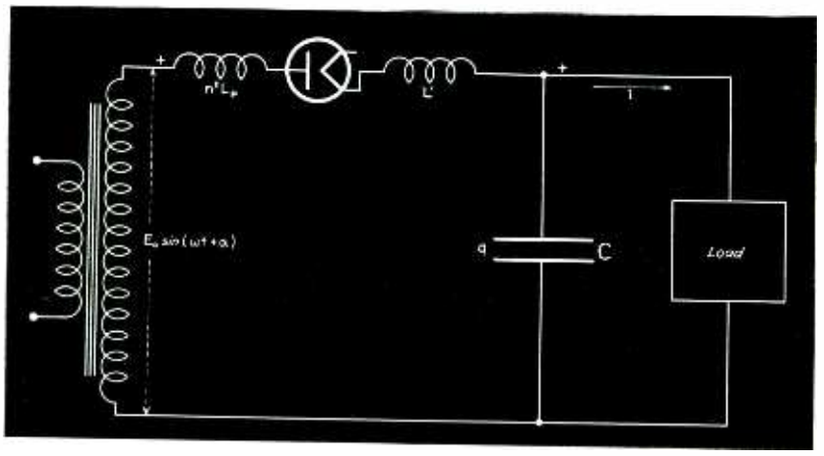


Fig. 1—Single-phase half-wave rectifier circuit on which the solution is based

IN the design of rectifier power supplies it is essential that the performance characteristics shall be accurately predictable. In particular, in the design of high-voltage rectifying equipment, such as is encountered in x-ray and television work, this requirement is especially important, since the transformers used in such work have a necessarily high leakage reactance and the effect of this reactance must be known in advance.

In using the results of previous investigations[2, 3] on this subject, it is necessary for the designer to make a graphical solution of a rather involved transcendental equation, or to rely on charts which have been computed for only some circuit parameters commonly encountered in receiving tube power supplies[1]. This paper, within the range of validity of its approximations, removes these restrictions. The approximations are:

1. The load current is considered to be essentially constant. This is justified in the following cases: (*a*) Where the input condenser is followed by a choke of reasonable size, (*b*) where the load consists of the plate circuits of pentodes and tetrodes, (*c*) if the load current is small enough that a quantity S, to be described later, is less than 25 per cent, and (*d*) where the load consists of x-ray and other tubes operating under conditions of voltage saturation. It will be noted that these conditions are practically always fulfilled.

2. The resistive component of the rectifier circuit impedance is small compared to the inductive component. Although the exact solution is based on the supposition that $R = 0$, a simple approximate correction given later enables the results to be applied with satisfactory accuracy to cases where R is comparable to ωL.

Figure 1 shows the conventional half-wave single-phase rectifier circuit. The notation used in this diagram and in the remainder of this paper is as follows:

$L = L' + n^2 L_p$
L' = inductance of filter input choke, if present
n = turns ratio of transformer
L_p = equivalent primary leakage inductance
C = input capacitance
ω = angular frequency of power source
$\omega' = 1/\sqrt{LC}$
$\rho = 1/(\omega\sqrt{LC}) = \omega'/\omega$
i = load current
q = charge on condenser
E_o = peak no-load transformer voltage
$S = 2\pi i/(E_o \omega C)$ (twice the approximate fractional ripple voltage amplitude)
α = starting phase angle (see Fig. 2)
θ = conduction angle
R = total power supply resistance, including equivalent tube resistance.

The differential equation for q, the charge in the first filter drop, valid in the range $0 < \omega t < \theta$ and subject to the above approximations, is:

$$L\frac{d^2q}{dt^2} + \frac{q}{C} + \frac{1}{C}\int_0^t i\,dt = E_o \sin(\omega t + \alpha), \quad (1)$$

the solution of which is:

$$q = -it + \frac{E_o C \sin(\omega t + \alpha)}{1 - \frac{1}{\rho^2}} + A\cos\omega' t + B\sin\omega' t. \quad (2)$$

The boundary conditions determining A and B are:

(1) at $t = 0$, $q = CE_o \sin\alpha$,

(2) at $t = 0$, $\frac{dq}{dt} = -i$. (that is, the current through the inductance is zero)

On applying these conditions, the solution becomes:

$$q = -it + \frac{CE_0}{1 - \frac{1}{\rho^2}}\left\{\sin(\omega t + \alpha) - \frac{1}{\rho^2}\sin\alpha\cos\omega' t - \frac{1}{\rho}\cos\alpha\sin\omega' t\right\}. \quad (3)$$

The rectifier will stop conducting

at an angle θ given by the condition:

$$\frac{dq}{dt}(\theta) = -i. \qquad (4)$$

On substituting this condition into Eq. (3), there results:

$$\cot \alpha = \frac{\sin \theta - \frac{1}{\rho} \sin \rho \theta}{\cos \theta - \cos \rho \theta} \qquad (5)$$

A second condition, resulting from conservation of charge over the entire cycle, is:

$$q(\theta) - q(0) = \frac{i}{\omega}(2\pi - \theta). \qquad (6)$$

Substituting this expression into Eq. (3) and simplifying, we obtain:

$$S \operatorname{cosec} \alpha = -1 + \frac{1}{1 - \frac{1}{\rho^2}} \times \left[\left(\cos \theta - \frac{1}{\rho^2} \cos \rho \theta \right) + \left(\sin \theta - \frac{1}{\rho} \sin \rho \theta \right) \cot \alpha \right], \qquad (7)$$

where cot α is given by Equation (5).

Equations (5) and (7), being independent, may be solved simultaneously to determine α and θ, and the values of these two angles provide complete determination of any functions of current or voltage. In the case $\rho = 1$, the equations are indeterminate in form. However, the solution shows no peculiar behavior in the neighborhood of $\rho = 1$; in fact, it is not to be expected that this case would give rise to any singular behavior, since the current is interrupted during each cycle and resonance in the usual sense of the term cannot occur.

It will be observed that in the two equations just given, (5) and (7), the circuit constants are combined in such a way that the equations contain only the parameters S and ρ explicitly. This fact and the form of the equations make it possible to obtain a graphical solution in the following way: If log cosec α is computed from Eq. (5) and log (S cosec α) from Eq. (7) for various values of ρ, and plotted as a function of θ on transparent paper, the values of α and θ satisfying the two equations simultaneously may be obtained by simply superposing the two graphs with their θ axes separated by log S and the ordinate axes collinear, and then reading the coordinates of intersection of curves corresponding to the same value of ρ. In this way, the values shown in Fig. 3, 4, and 5 were obtained, and from these figures the angles α and θ can be read directly as functions of arbitrary design parameters.

From Fig. 2 it is evident that for small ripple voltages the d-c output voltage is given to sufficient accuracy by:

$$E_{dc} = E_0 (\sin \alpha + S/2), \qquad (8)$$

and hence Figs. 3 and 4 give directly the voltage regulation curves of the rectifier. An exact expression, applicable to any ripple voltage, is obtained by integration of Eq. (3) and elimination of the variable α by means of Eq. (5). The result is:

$$E_{dc} = E_0 [\sin \alpha (1 + P) + S (\tfrac{1}{2} - \theta/2\pi)], \qquad (9)$$

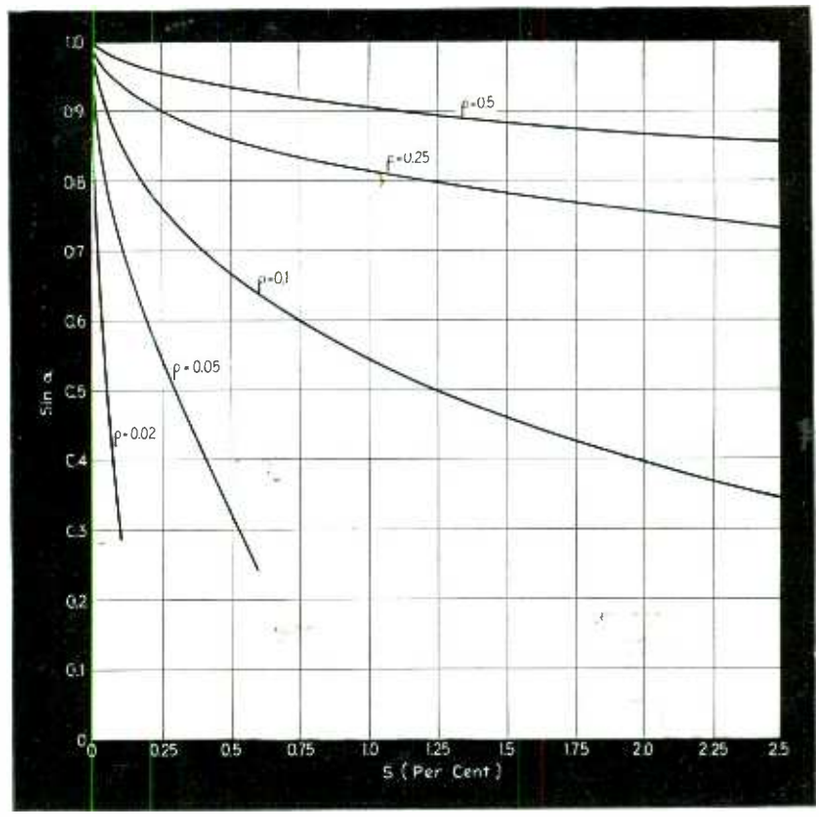


Fig. 3—Chart of the sine of the starting angle versus twice the fractional ripple voltage for low ripple voltages

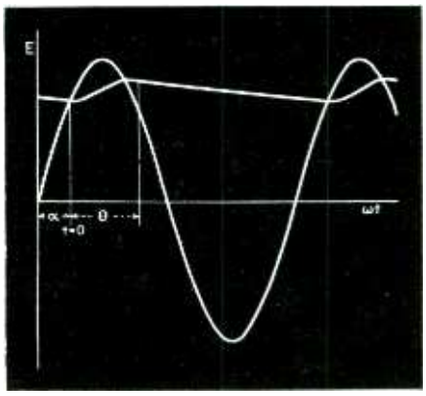


Fig. 2—Left, input and output voltages of the rectifier, showing starting phase angle and conduction angle. The series choke prolongs the condenser charge

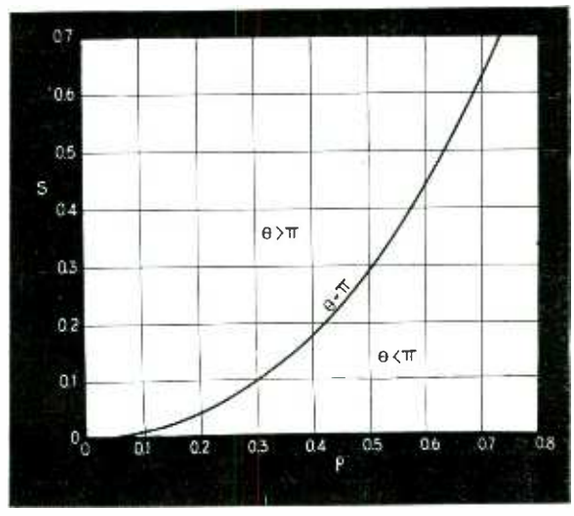


Fig. 7—Conditions of conduction greater or less than a half cycle

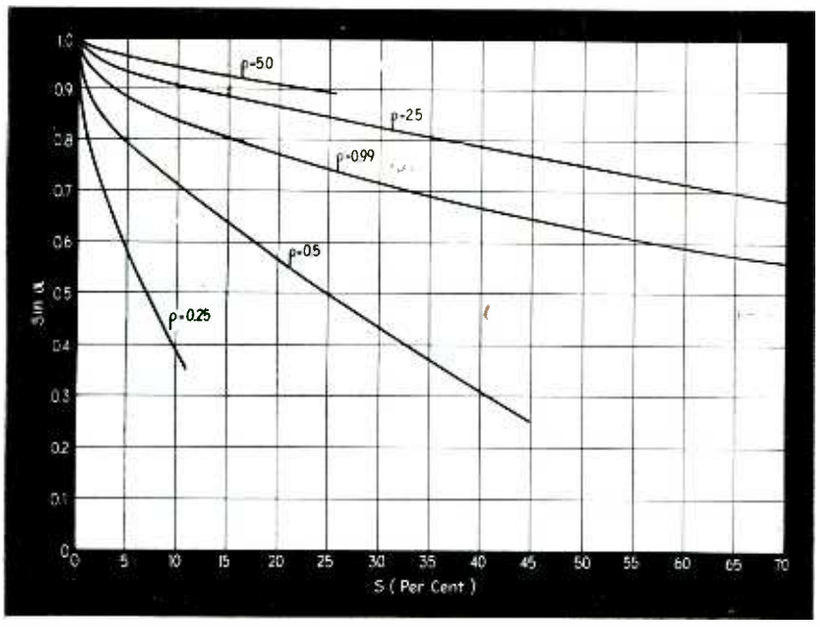


Fig. 4—Chart of the sine of the starting angle versus ripple voltage for large ripple voltages

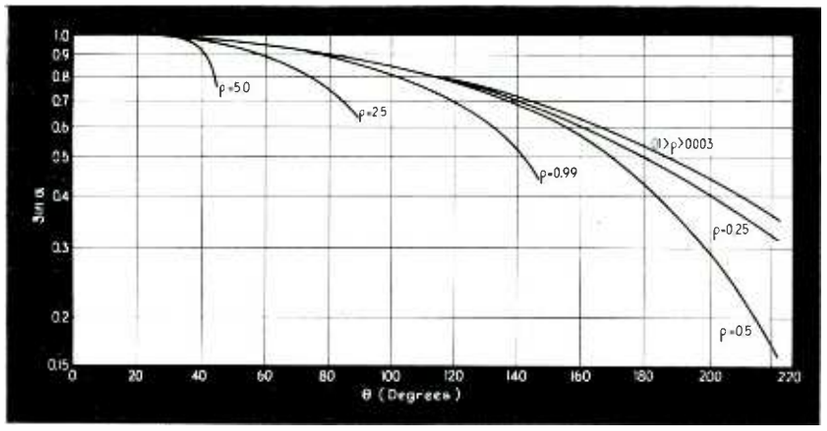


Fig. 5—The sine of the starting angle versus conduction angle

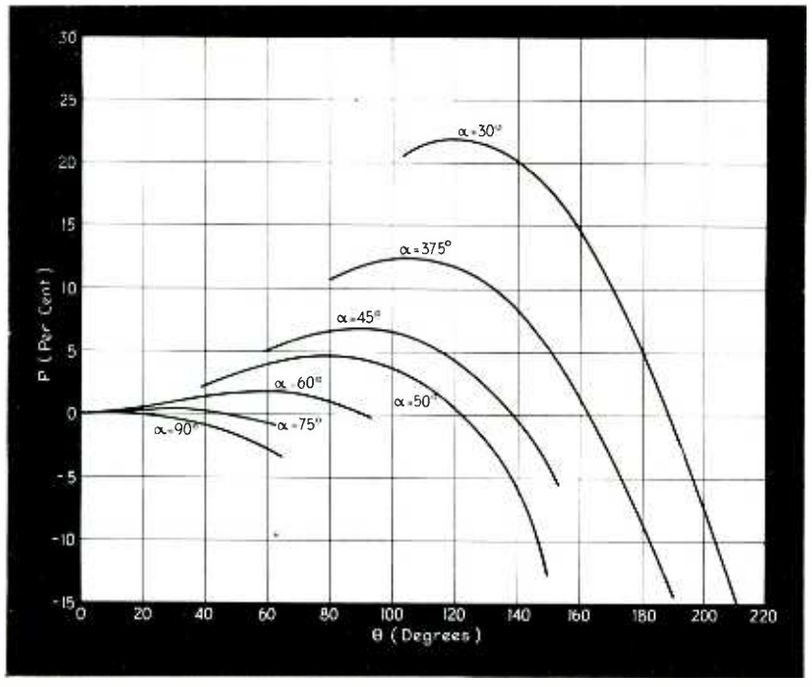


Fig. 6—The output voltage correction factor, *P*, versus the angle of conduction for cases where the rectifier resistance is appreciable

$$P = 1/(2\pi)\ (2 \sin \theta/2 \sin (\alpha+\theta/2)/\sin \alpha-\theta) \quad (10)$$

Figure 6 shows the values of P for various values of θ and α. It will be noted that P is usually very small, and since θ is usually much less than 2π, Eq. (8) will be accurate enough for most applications.

These results may be applied directly to full-wave rectifiers provided that $\theta < (\pi - \alpha)$, and provided that half the load current be substituted for i. If the filter input inductance is very large compared to n^2L_p, the restriction becomes $\theta < \pi$. The case $\theta > \pi$, current flowing continuously, has been treated by Prince and Vodges[1] and, neglecting leakage reactance, by Wallis[2]. The results may be applied to voltage doubling circuits with the single restriction $\theta < \pi$. Figure 7 shows this condition graphically.

These results may also be extended to circuits in which the effect of the rectifier circuit resistance is not negligible, by the following considerations:

The average current flowing in the conducting part of the cycle is $2\pi i/\theta$; hence, if the waveform could be assumed to be entirely unaffected by circuit resistance, the voltage would be lowered by the amount $2\pi iR/\theta$. However, any decrease in average voltage results in an increased charging interval, and the voltage loss mentioned above is partly compensated for by the fact that a larger charge is delivered to the condenser during the conduction time. Empirically, good agreement with the data of Freeman[1] is obtained by using half this correction; namely, by subtracting a quantity ΔV given by:

$$\Delta V = i R \pi/\theta \quad (11)$$

from the d-c output voltage computed by Eqs. (8) or (9). The error in the correction in this form has been found to be not more than 25 per cent of the correction itself, so long as $iR\pi/\theta$ is not greater than 20 per cent of $E_0 \sin \alpha$. Actually, the voltage loss due to the resistance is always somewhat less than predicted by the above expression. The final equation,

$$E_{dc} = E_0 \left[\sin \alpha\ (1+P)+S\left(\frac{1}{2}-\frac{\theta}{2\pi}\right)\right] - \frac{i R \pi}{\theta}. \quad (12)$$

The large range of usefulness of this method and of the charts pre-

(Continued on page 109)

Facsimile Design Chart

The design of the mechanical portion of a facsimile scanning unit depends upon a number of factors presented in nomographic form on the following page. The text below discusses the problem and derives the fundamental equations

By

RAYMOND R. HAUGH

LaSalle Designing Co.
Chicago, Ill.

THE construction of a facsimile system involves the design of considerable mechanical equipment as well as electronic circuits. The characteristics of the scanning units of both the transmitter and receiver are determined by a number of factors which are listed below.

E = length of picture element (inches)
A = rate of scanning (square inches per minute)
L = length of scanning line (inches)
v = velocity of scanning (inches per second)
n = rate of line scanning (lines per minute)
N = line pitch (lines per inch)
f = scanning frequency (cycles per second)

The relationship of the various factors can be expressed in three fundamental equations as follows.

$$E = \frac{L \times n}{120 \times f} \qquad (1)$$

$$A = \frac{L \times n}{N} \qquad (2)$$

$$L = \frac{60 \times v}{n} \qquad (3)$$

Equations (1) and (2) can be rearranged to include the factor v. They then appear as

$$E = \frac{v}{2f} \qquad (4)$$

$$A = \frac{60 \times v}{N} \qquad (5)$$

All three equations now include a factor for velocity of scanning. Therefore, by selecting a definite value for the velocity of scanning, it is necessary only to assume a value for one variable in each equation and solve for the other. To reduce the work of solving these equations the nomogram chart on the following page was constructed.

Use of the Chart

There are two general classes of equipment used in facsimile transmission. In the first class the transmitted picture is of the same dimensions as the received picture. Here, one solution is sufficient for both transmitting and receiving scanning units. In the second class the picture may be enlarged or reduced in the process of transmission. Here, the dimensions are different, but the proportions remain the same. Thus, the product LN and the rate of line scanning n must be equal in the transmitter and receiver.

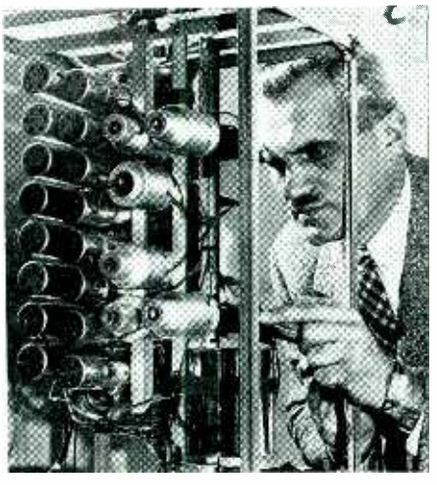
To illustrate the use of the chart the following examples are given: After a suitable velocity of scanning is selected as indicated above, a straight edge is placed at the proper value on scale v. The intersections of the straight edge and scales E and f indicate the solution of Equation (4) for the length of picture element and the scanning frequency respectively. By rotating the straight edge about the point v_1, and by proper interpretation, the optimum values of E and f can be obtained. Equations (3) and (5) can be solved by following the same procedure making use of scales L and n, and A and N respectively.

Where the transmitted and received pictures are of different sizes, the method of solution is as follows. The characteristics of either the transmitting or receiving scanning unit are determined as described above. A straight line is established through the points on scales L and N which satisfy the first scanner. The intersection of this line and scale K gives the product LN which must be equal in the two scanning units. The straight edge is then rotated about the point on scale K to give new values of L and N. This will now produce pictures of a different size, but of the same proportions.

A straight line between the new value of L and the value of n for the other scanning unit (n must be equal in both cases) will determine a new value of scanning velocity on scale v. The new rate of scanning is determined by the intersection of a straight line between the new values of v and N and the scale A. The remaining factor, the length of the picture element E, is determined by the intersection of the line between the new value of S and the original scanning frequency on scale f (the scanning frequency is the same in both cases), and the E scale.

• • •

TUBES AID COSMIC RAY RESEARCH



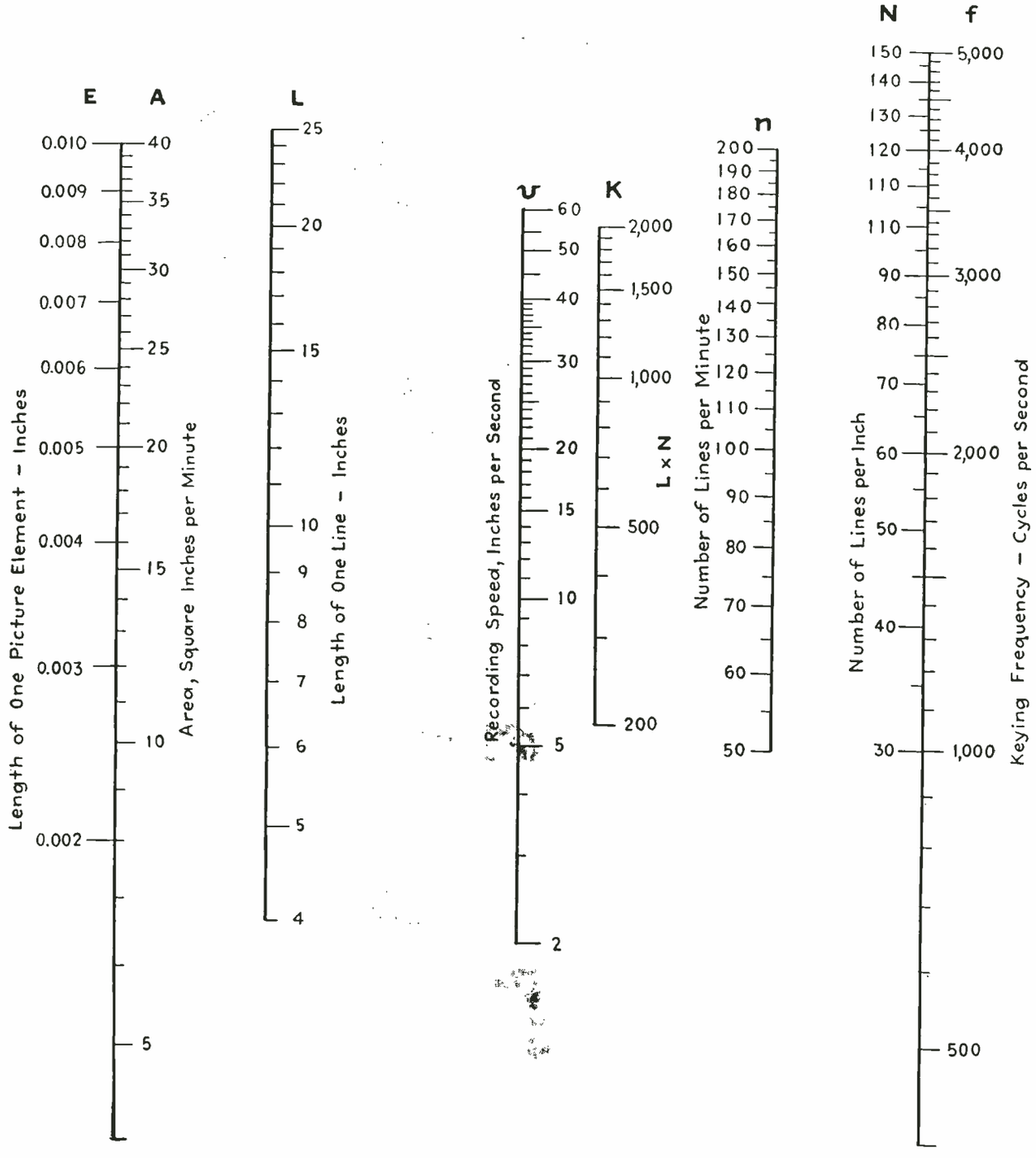
Dr. Arthur H. Compton, Nobel prize physicist at the University of Chicago and pioneer in cosmic ray research, makes a last minute adjustment of his high altitude cosmic ray counter before attaching the equipment to an experimental balloon set aloft in the study of cosmic rays

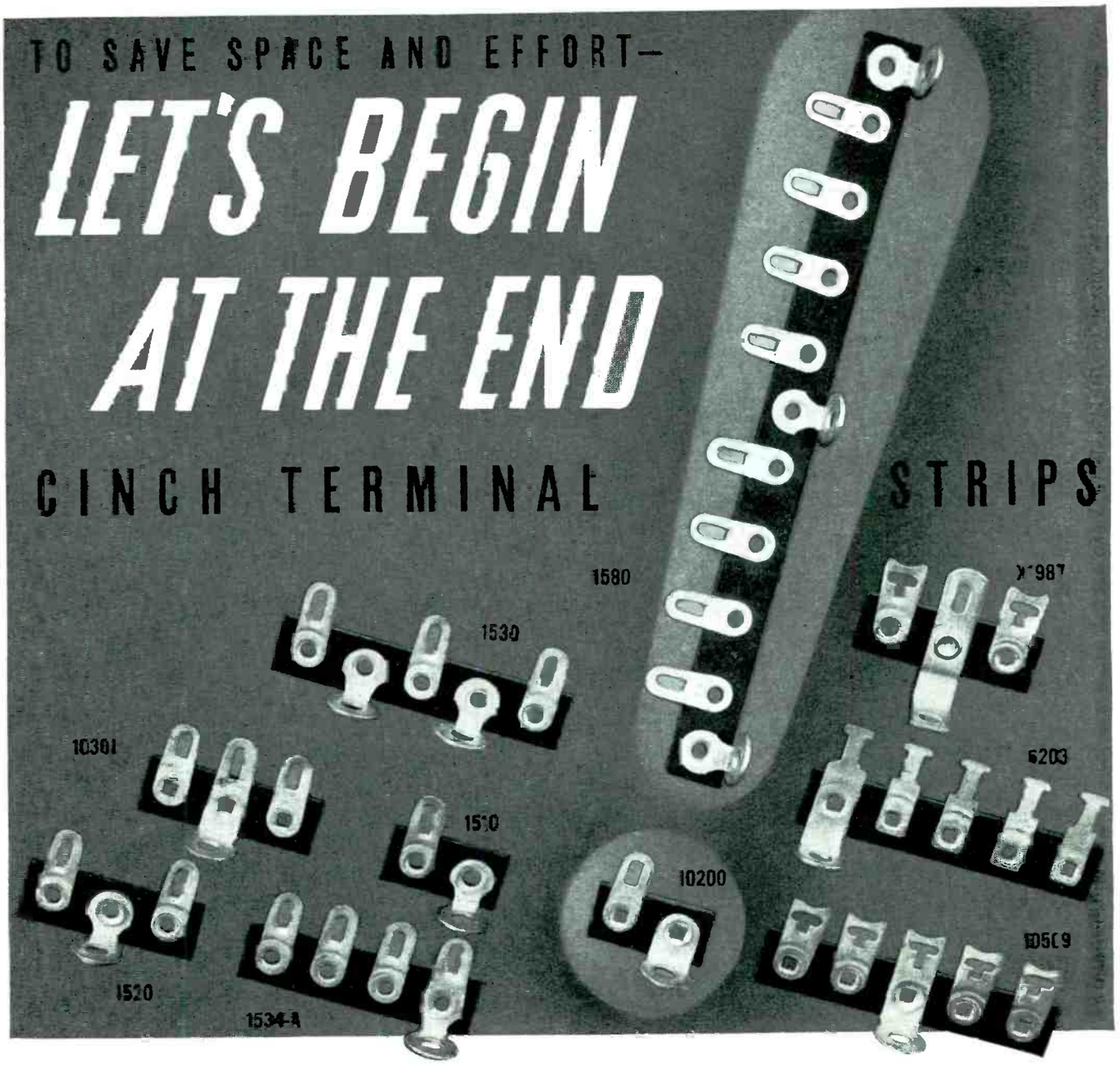
FACSIMILE DESIGN CHART

BY

RAYMOND R. HAUGH

LaSalle Designing Co.





CINCH Terminal Strips actually *save time and labor costs . . . and save space.* Neat and compact, these may be had with one to fourteen lugs, 3/8" or 1/2" centers. Note particularly T slotted concave top lug providing space for maximum number of wires. Hundreds of variations; Terminal strips are designed and made to so satisfactorily fill their place in the set that "You come out right in the end".

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New Books

Television—Today and Tomorrow

By S. A. MOSELEY and H. J. BARTON-CHAPPLE. *Fifth Edition. Published by Pitman Publishing Company, New York, London, 1940. 179 pages, 80 illustrations. Price $3.00.*

THIS SHORT BOOK has had considerable success in England, having reached the fifth edition in the present work. The new edition has been brought up to date as of 1939, prior to the cessation of television service in England. The book is descriptive rather than technically detailed, but it contains much interesting material not to be found elsewhere. For example, the first chapter gives an account of the functional development of television, from the earliest experimenters to the time of publication. This chapter is followed by seven others entitled "General Principles", "Dissecting a Television Picture", "Generating the Picture Signal", "Ultra-Short Waves and Aerials", "Cathode Ray Tubes and Television Receivers", "Big-Screen Television", and "Special Television Methods".

In a book of this length (180 pages) there cannot be sufficient detail to attract the specialist in television, but for the general technical reader further removed from the field, it gives a good account of the methods of television engineering as practiced in England. For the latter reader, the principal defect of the book is the occasional lack of sharp discrimination between modern and antiquated methods.—D.G.F.

Elements of Acoustical Engineering

BY HARRY F. OLSON, *Acoustic Research Director, RCA Manufacturing Co. D. Van Nostrand Co., Inc., New York, 1940. 344 pages. Price $6.00.*

THE FUNDAMENTAL PRINCIPLES of acoustics and descriptions of a great variety of acoustic instruments in use at the present time form the basis of this excellent treatise by Dr. Olson. The text was developed as a series of thirty lectures which were presented by the author in a course in acoustical engineering at Columbia University. The author states that a knowledge of acoustic principles is not required for an understanding of the subject material. The text may be read and understood by anyone familiar with the principles of elementary physics and simple electric circuit theory.

It is the purpose of the book to present to the practicing engineer the elements and principles of acoustics which have thus far been largely in the hands of the applied scientist. That this purpose has been well worked out is testified by the viewpoint used in tackling problems in the text. For instance, many acoustical devices have been studied making extensive use of analogies between electrical, mechanical and acoustical systems. This has been done because, as the author states in the preface, engineers have found that the reduction of a vibrating system to the equivalent electrical circuit is a valuable tool in the analysis of vibrating systems. He further states that these methods will become increasingly important as the front of engineering acoustics is broadened. In each case where the analogies are used the three systems, i.e., electrical, mechanical, and acoustical, are shown in diagrammatic form.

This book is outstanding in the completeness with which it covers the field of acoustics. The fundamentals of the subject are developed in the first chapters of the book. These fundamentals are then applied to a variety of acoustic transducers, each with its set of analogies. The most important transducers, of course, are loudspeakers and microphones of which there are a great number of types. Miscellaneous transducers such as, telephone receivers, phonograph pickups (crystal, magnetic and dynamic), electrical musical instruments, hearing aids, sirens and seismic detectors are also discussed. Methods of measuring the characteristics of acoustical devices are described in considerable detail. The collection and dispersion of sound and their relation to architecture are discussed in a chapter containing much "meat" which will be found very useful by many engineers. The book closes with a chapter describing the characteristics of speech, music and hearing. This book will be found to be well worth its cost to any engineer whose work has to do with sound.—C. W.

Television Receiving Equipment

By W. T. COCKING. *Published by Iliffe and Sons, Ltd., London, 1940 (Available in the U.S.A. from Nordeman Publishing Company, New York). 298 pages. Illustrated. Price $2.25.*

THIS IS AN EXCELLENT PRACTICAL volume, based on Mr. Cocking's articles which have appeared in *The Wireless World*. The treatment is complete and up-to-date to the latter part of 1939, based on British practice prior to the beginning of the present War. The twenty chapters cover practically all of the subject matter of interest to the television receiver constructor and engineer, with particular emphasis on practical methods. Some mathematical treatment is included, but in general theory is subordinated to the "why and how". The 34-page chapter on sync separation contains a wealth of material which has not previously appeared in book form, and the other chapters are informative and accurate. The fact that the subject is treated from the British point of view is not a drawback for American readers, since the British television signal is sufficiently like the American to allow substantially the same circuits to be used. The only major difference, in fact, is that of tube types. While the circuit diagrams do not give specific values in all cases, the accompanying text usually makes clear the manner in which the values may be chosen.

The chapter list includes the television signal, cathode ray tubes and power supplies, electrostatic and electromagnetic deflection, sawtooth oscillators, video amplifiers, i-f and r-f amplifiers, frequency converters, the superheterodyne interference problem, sync separation, audio circuits, special television circuits, aerials, television faults and remedies, and servicing. While the book does not pretend to give an exhaustive text-bookish treatment of the subject, it does contain a refreshingly large amount of practical information. As such it should be welcomed by all workers in the field.—D.G.F.

Radio Operating Questions and Answers

By ARTHUR R. NILSON and J. L. HORNUNG, *7th Edition, McGraw-Hill Book Co., 1940, 415 pages, Price $2.50.*

FOR TWENTY YEARS this modern version of the early "how-to-pass" books has aided would-be operators get their tickets. Now that there are new methods of ascertaining the qualifications of candidates for licenses with new types of questions and new methods of stating the questions and requesting answers, the book has been redone completely. It is now in new pocket-size format. Although the book is intended to be used for review purposes, rather than as a text, there is a lot of meat in it, in question and answer form, and one can easily test his own knowledge by covering up the answer while he reads the question and endeavoring to perform his part of the catechism. There are approximately 1300 questions and answers in the book. They cover the entire scope of commercial radio operator license examinations as now conducted by the F.C.C.—K.H.

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MOTOROLA F-M FREQUENCY MODULATION

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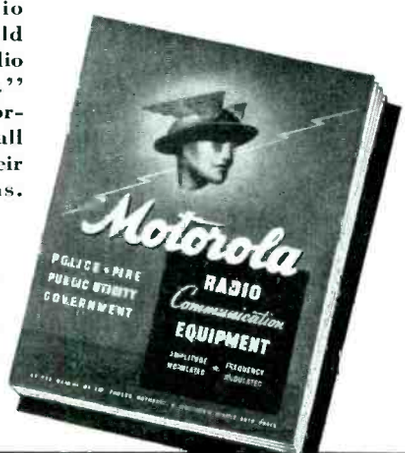

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FREQUENCY MODULATED ★ AMPLITUDE MODULATED ★

TWO-WAY RADIO COMMUNICATION EQUIPMENT

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TUBES AT WORK

German planes downed over England reveal simplified radio equipment used by the Nazis. A new grid wire for tubes, a field broadcast pick-up installation for excluding unwanted music, and an electronic attenuator are also reported

Radio Equipment of German Air Raiders

By JOHN H. JUPE

OF THE LARGE NUMBER of German aircraft sent to raid Britain since the war started, many have been brought down and from these it has been possible to obtain very complete details of the machines and equipment, including the radio equipment.

In the purely fighter type of craft (Messerschmitt 109), very simple radio equipment is installed, consisting of a single waveband transmitter and receiver, continuously variable between 2.5 megacycles and 3.7 megacycles. It is mounted behind the pilot and the frequency is preset before flight. No adjustment is possible while the machine is in the air. The range is 30 to 40 miles. In the larger machines such as are used for bombing (Messerschmitt 110, Heinkel 111, Junkers 88, etc), the radio is far more elaborate and the standard type weighs some 358 pounds.

The unit principle of construction is used, with a die cast chassis of approximately cubical form, honeycomblike cells being arranged to house the various parts of the apparatus. Generally, the high voltage generator, direction finding receiver and loop, blind approach receiver and aerial matching unit are placed in the tail, with the remainder of the equipment near the instrument dashboard.

Continous tuning is possible but arrangement is made for the selection of four pre-chosen frequencies in each waveband. In appearance, the tuner unit is somewhat similar to a cash register. A handle is turned and the tuning scale appears on a cyclometer type counter.

The transmitter power is 65 watts and the antenna feed is through a low impedance line and matching unit. Switches, operated magnetically by remote control, select a suitable transformer for trailing wire or fixed antenna. Tuning by means of motors controlled from the dash is also applied to the antenna couplings. Primarily, the transmitters are designed for continuous wave telegraphy, but telephony transmission is also possible.

Besides a trailing antenna let down during flight, there is a fixed antenna supported by a hollow streamlined spar of Bakelized laminations, which also houses the vertical rod of the Lorenz blind landing receiver. The dipoles for the marker beacon receiver are fixed under the fuselage.

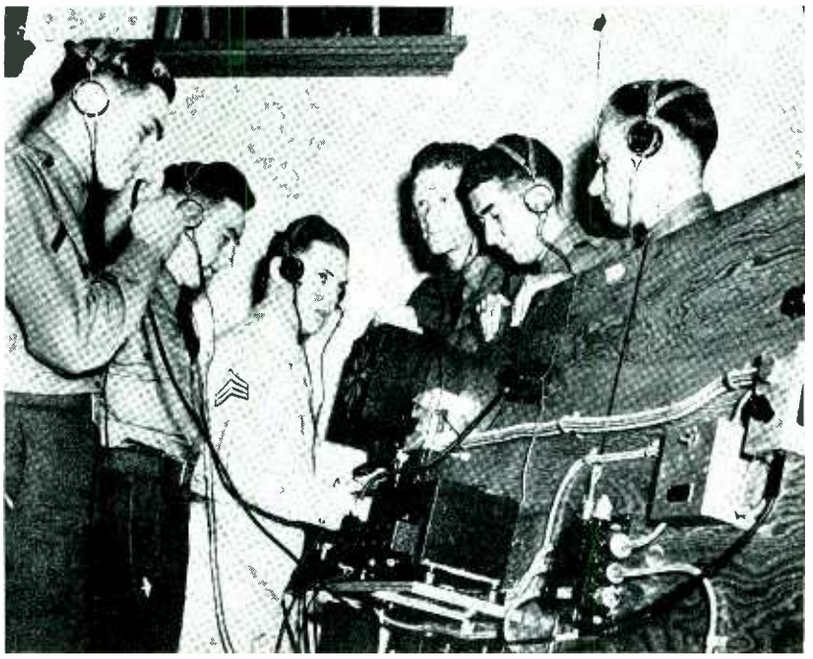
Direction Finding

The apparatus for direction finding is designed to be as comprehensive and yet as compact as possible. Foremost in interest is the very small frame, utilising the properties of powdered iron. It is oval in section and is wound at intervals with sectionalized windings, the dimensions being about 12 inches long and 3 inches in diameter, while the performance is nearly equal to that of a large frame.

Two systems of direction finding are employed in each of the large planes, the figure-of-eight, polar diagram, for general use, and the cardioid response for direction finding or homing. When the latter is operating, the loop is set at zero and a reversing cam changes the sense of the frame for the reception of interlaced "A" and "N" signals. If necessary these homing signals, which are normally audible, can be fed into a visual indicator. The tuning

Emergency transmitter and radiator carried by German bomber plane

AERIAL AUDITIONS



A ground school instructor, with stripes, at Randolph Field, Texas explaining the intricacies of a communication set to a group of student flyers. Later when piloting planes equipped with the two-way radio equipment, these new flyers will maintain contact with the control tower at the "West Point of the Air"

of the direction finding receivers and also the rotation of the frame, is controlled by means of flexible cables.

A compass is of course necessary for use in conjunction with the direction finding apparatus and for general navigation. It is the usual practice to mount the master compass in the tail, away from magnetic interference, with a repeater compass in the navigating quarters.

Only two types of tubes are in use, one for transmitting and another for receiving. The receiving tube (Type RV 12P) is a pentode which can be used as a triode, or tetrode. The tube has side contacts and a ring type seal. Inverted holders, with built-in sockets for the top contacts, are standard. Since the tube bases are flush with the chassis special screw knobs are supplied to extract them for replacement.

General Specifications

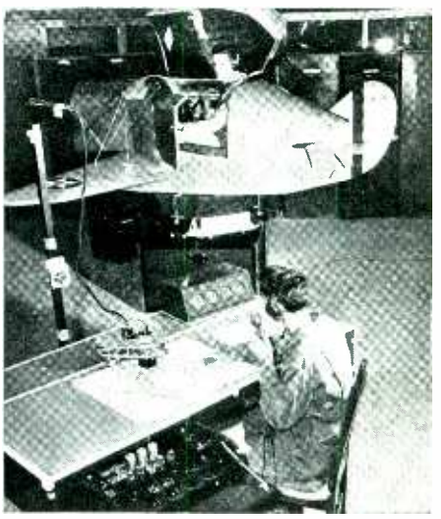
The data given below summarize the radio equipment of a German bomber:

Radio Communication Units (Continuous Waves)

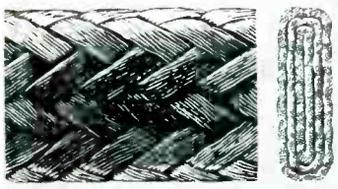
Long Wave Transmitter—300 to 600 kilocycles
Long Wave Receiver—300 to 600 kilocycles
Short Wave Receiver—3 to 6 megacycles

• • •

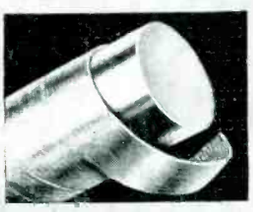
KEEPING IN TRIM



Graduate pilots at March Field, Southern California's flying center, keep in trim for flying by making imaginary flights in the Link Trainer shown above. This mechanical device simulates and records actual flying conditions. The cockpit of the little plane is covered, and although stationary, the ship rocks, dips and turns as in actual flight. The heart-shaped device on the desk records the flight on a chart. When the pilot climbs from the cockpit he can tell exactly from the chart how far he has flown, whether he was on the beam and other information



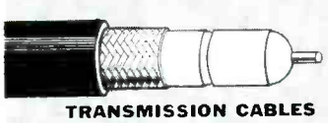
BRAIDED CABLES



MAGNET WIRES

MICROPHONE CABLES

SPARK PLUG WIRES



TRANSMISSION CABLES

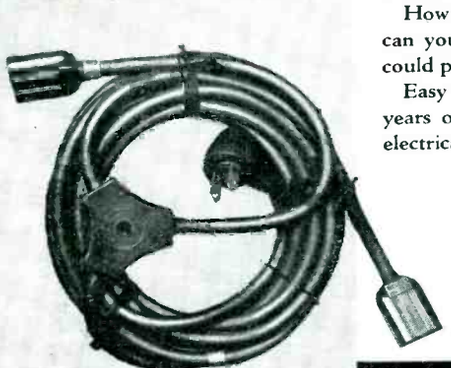
SHIELDING

HOOK-UP WIRES

FIBERGLAS NEON SIGN CABLE

LAMP CORD

ASBESTOS COVERED



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Short Wave Receiver—3 to 6 megacycles
Short Wave Transmitter—3 to 6 megacycles
Remote control unit for aerial matching

Navigation

Direction Finding Set—165 to 400 kilocycles and 400 to 1000 kilocycles
Remote control for wave range and polar diagram selection
Compass Repeater

Blind Approach Apparatus (Lorenz)

Pre-set receiver for landing beam
Pre-set receiver for marker beacon
Visual indicator and remote control selector unit

Intercommunication. Audio Amplifier Unit

Crew intercommunication telephone amplifier
Side tone generator 1000 cycles per second for c-w keying
Modulator amplifier for telephony transmission
Pulse generator for night-error-free direction finding from ground

• • •

Improved Alloy Wire For Grids

By JACOB KURTZ
Callite Tungsten Corp.

OF MORE THAN PASSING INTEREST and importance to the tube manufacturing field is a new molybdenum alloy wire, covered in U.S. Patent number 2,207,380, issued in recent months. This new wire is designed to overcome the non-uniformity in vacuum-tube grids resulting from variations in turns per inch and excessive spring-back after the wound grid leaves the mandrel.

In order to maintain a uniform pitch on the grid, rather high tension must be used. In this case, however, common grid wire will hug the mandrel so tightly that, frequently, the grid becomes distorted as it leaves the mandrel. If the tensile strength of the wire is too low or variable, grid winding is accompanied with excessive breakage.

The improved wire compensates for these irregularities in an unusual manner which is best explained by reference to the curve of Fig. 1. This represents actual measurements on a typical sample of 0.005-inch Calmolloy wire and shows the load-elongation characteristics as obtained on a Scott inclined plane tester. The feature of the curve is the knee which begins at a load value of 700 grams (in the particular type represented by this sample). As the load is increased to about 780 grams the wire stretches about 5 per cent. But from about 780 grams to 840 grams there is practically no stretch, due to the exceptional work hardening properties of the alloy. This "knee action" imparts just the right amount of stiffness in the wire to enable the grid to

slide off the grid mandrel with practically no distortion.

Now assume that this wire is employed on a grid-winding machine having a tension on the wire at 810 grams. It will be noted that tension variations over a range of 780 to 840 grams will vary the amount of stretch only about 0.4 per cent, a quite negligible amount. Were it not for the

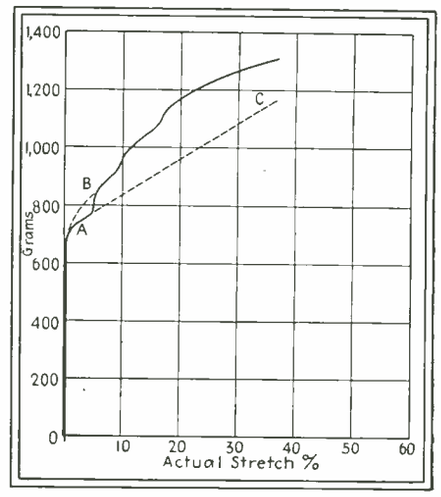


Fig. 1—Per cent stretch measured in terms of stretching force

knee, that is, if the curve were as shown by the dotted line *AB* (which is simply a projection of the trend of the balance of the curve and is similar to the characteristic presented by many conventional alloy grid wires) the variations in stretch would be approximately six times greater.

The advantage of the new wire is

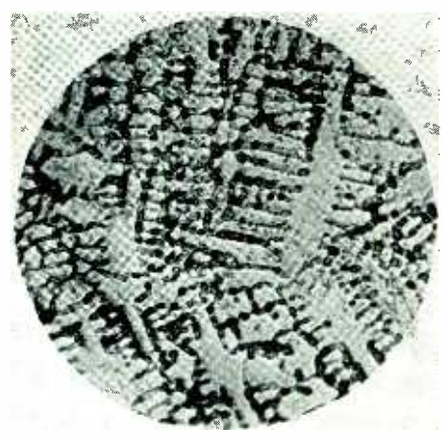
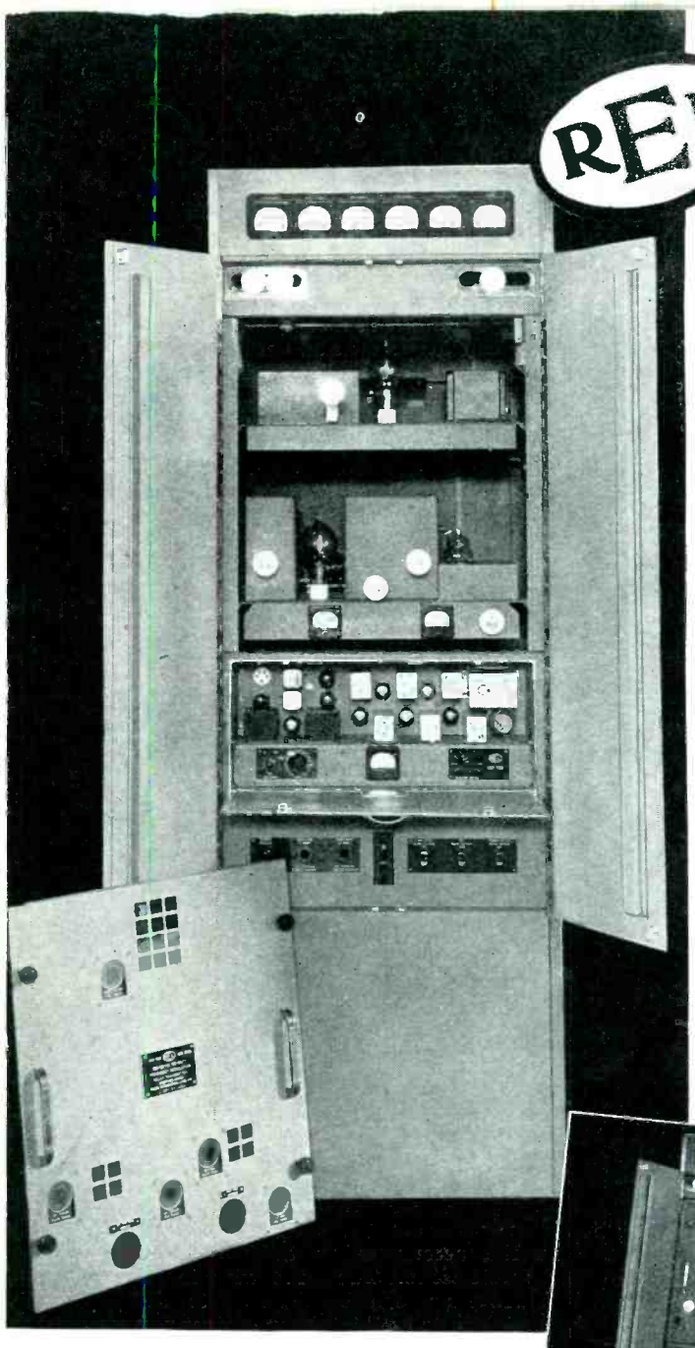


Fig. 2—Magnified section *(A)* of the alloy before heat treatment

even more marked when compared with a wire which offers an elongation-load characteristic such as the projection *AC* of the initial trend of the knee of Fig. 1. The elongation in the load range of 780–840 grams would in this case amount to about 5 per cent,



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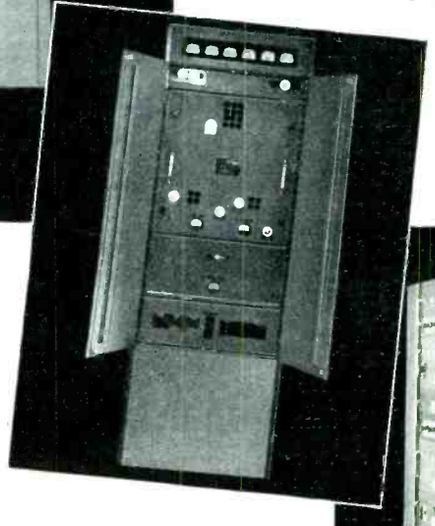
HERE'S THE R.E.L. MODEL 538 150 W. F-M RELAY TRANSMITTER

SPECIFICATIONS:

Operating Frequency: 156-161 MC
Frequency Stability: plus minus 500 cycles at 161 MC
Fidelity: plus minus 1 db. 30-16000 cycles
Distortion: Below 100 cycles 1%
Above 100 cycles less than 1%
Noise Level: 76 db. below 100% modulation—hum included.
Frequency Swing: 100 KC max. for 100% modulation

Contained in single cabinet with necessary power supplies for operation from 220 volts 60 cycles—associated relay pick-up receiver furnished with self-contained power supply for operation from 115 Volt 60 Cycle.

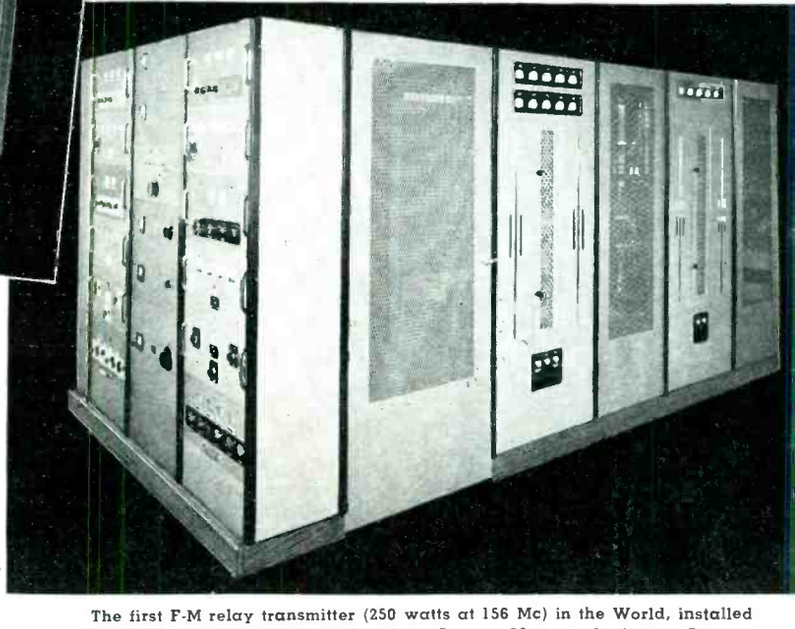


SOON TO BE ANNOUNCED:

The New Model 560 50 WATT F-M Relay Broadcast equipment for operation in the 330-344 megacycle band. Here is the perfect circuit for studio-to-station F-M program relaying AND ARE ADVANCED SPECS:

Operating Frequency: 330-344 MC
Frequency Stability: Plus minus 1000 cycles at 344 MC
Fidelity: Plus Minus 1 db. 30-16000 cycles
Distortion: Below 100 cycles 1%
Above 100 cycles less than 1%
Noise Level: 76 db. below 100% modulation—hum included
Frequency Swing: 500 KC max. for 100% modulation.

Contained in single cabinet with necessary power supplied for operation from 115 volts 60 cycles—Associated relay pick-up receiver also furnished.



The first F-M relay transmitter (250 watts at 156 Mc) in the World, installed by R.E.L. for the Yankee Network in Boston, Mass., relaying to Paxton, Mass. (45 miles, airline) and in operation 16 hours daily since May, 1939.

RADIO ENGINEERING LABORATORIES, INC.

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or approximately twelve times that of the new wire.

To meet the wide variety of wire sizes and tensions employed by different manufacturers in the construction of grids for different tube types, the new wire can be produced to meet specific requirements as to yield point, breakage point, total percentage of elongation, and positioning of the knee on the elongation-load characteristic. A wire 0.005 inch in diameter, for instance, can be supplied with elongation in percentages varying from 25 per cent to 40 per cent; yield point occurring at any specified value from 650 to 850 grams, etc. The available ranges of these values for other sizes are shown

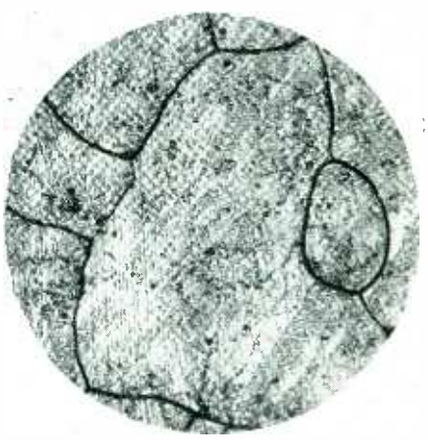

Fig. 3—Section *B* showing structure of alloy after thorough annealing

in the accompanying table of wire characteristics. Thus, the wire in its manufacture can be adapted to the requirements of the tube manufacturer and his equipment.

Different treatments can produce wide variations in the characteristics of Calmolloy. An interesting visual illustration of this is found in the photomicrographs of Figs. 2 and 3. *A* is a 200-diameter magnification of a section of cast rod before heat treatment, while *B* (equally magnified) shows the change in grain structure resulting from thorough annealing. The illustration of Fig. 4 is a photomicrograph of Calmolloy after drawing into a wire 0.005 inch in diameter, magnified 500 diameters. Here fineness of the grain structure is clearly evident, with crystals of an interlocking type that provide great strength with ready yield, characteristics which can be widely varied in heat treatment.

Demonstrating that Calmolloy is not just a laboratory curiosity, it has already been adopted by several tube manufacturers, particularly for use where tube uniformity is of the utmost importance. One instance is its use in National Union's new line of "Sound X/tra" tubes, a series of laboratory-built tubes produced to meet critical requirements for uniformity, freedom from hum and microphonics, and long

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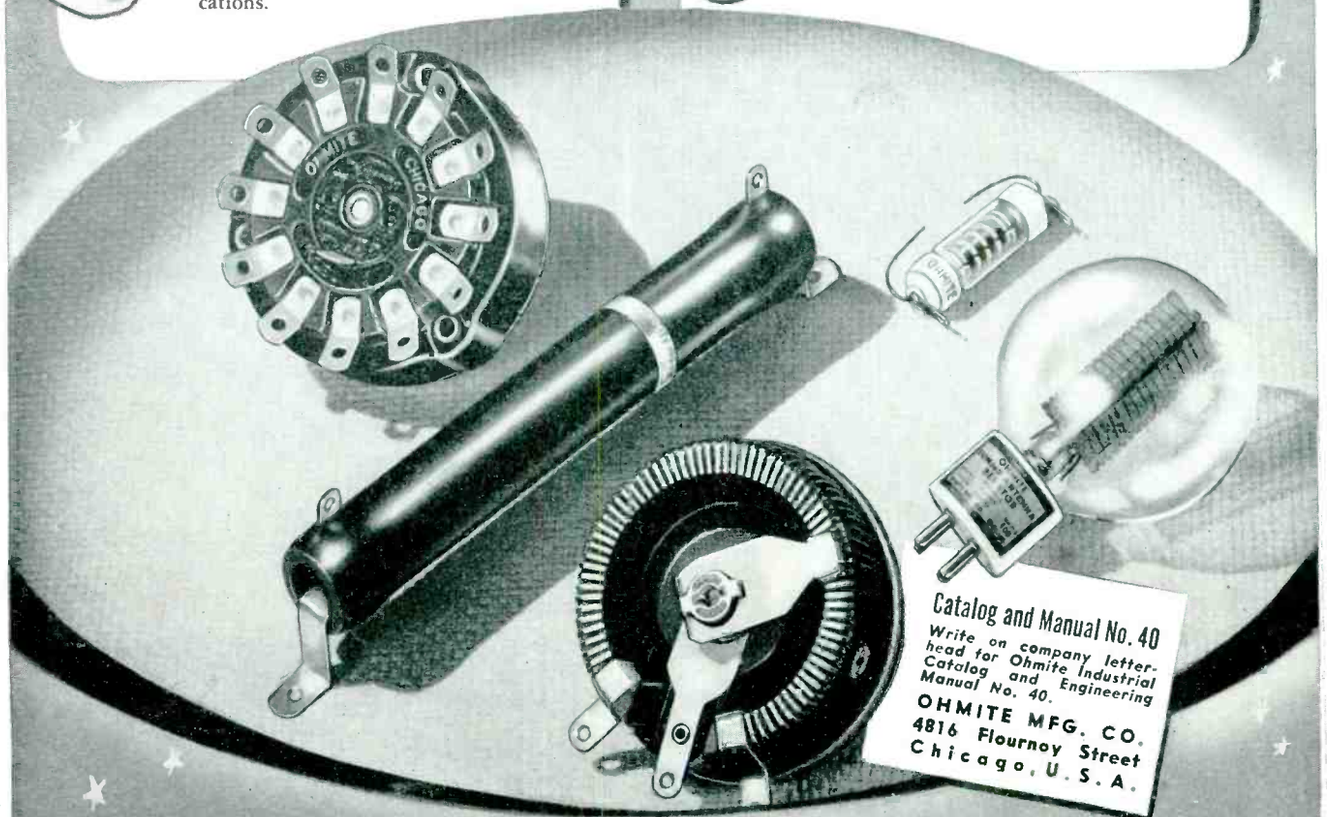

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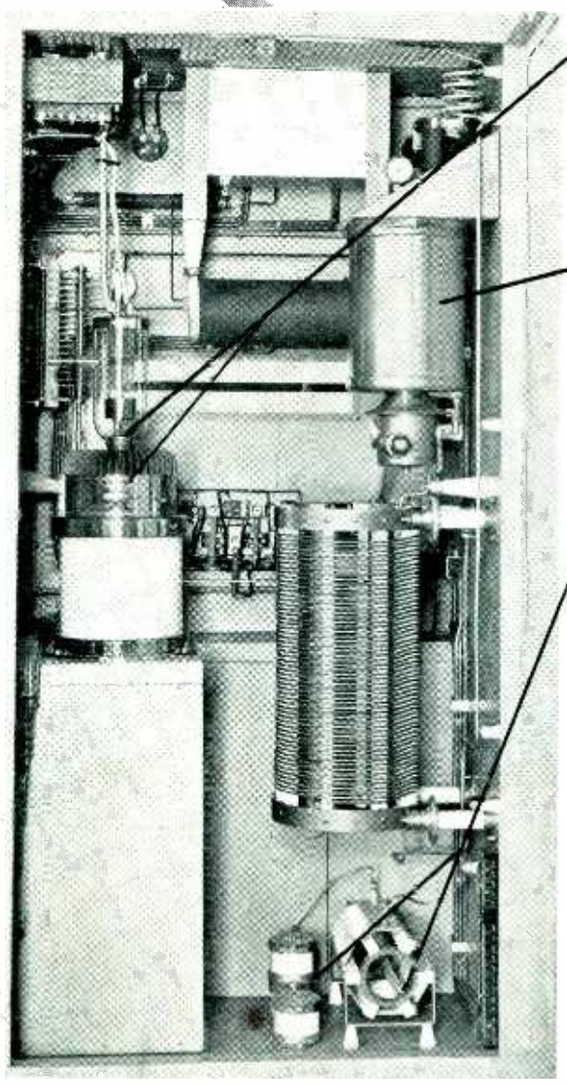

★ **THE 892-R POWER** amplifier tube, air-cooled, is easily reached when the rear door of the radio frequency power amplifier cubicle is opened.

★ **VARIABLE COMPRESSED GAS CONDENSER** used in the final radio frequency stages has short leads, low losses, complete shielding and provides a wide range of tuning.

★ **PI NETWORK** easy to adjust. R. F. harmonic reducing Pi network is preset at the factory but has convenient taps for final adjustment on the job.

Open the front and rear doors of the new Westinghouse 5-HV 5000-watt radio broadcast transmitter and you see at a glance one good reason why it is being chosen for modern, up-to-the-minute broadcasting stations. Every part is fully accessible—every part fits to make a compact unit, but with no crowding—every adjustment is within easy reach. The power amplifier cubicle, illustrated at the left, is typical of the rear door accessibility of the 5-HV.

ATTRACTIVE to look at—but its beauty is more than skin deep and goes far beyond the panel finish. Its operating advantages are attractive to men who are responsible for the operation, inspection and maintenance of a radio station—advantages built in by the same engineers who designed the Westinghouse 50-HG which aroused such widespread interest when it was installed in KDKA slightly over a year ago.

METAL RECTIFIERS used in *all* of the low voltage plate and bias power supply circuits eliminate replacement trouble and expense and insure against unpredictable rectifier tube failures.

OPERATING ADVANTAGES

- Air-cooled tubes in all stages.
- Low operating costs.
- Except for the rectifier supplying power to the amplifier and the class "B" modulator, metal rectifiers are employed throughout.
- Inductive neutralization is employed in all radio frequency stages requiring neutralization.
- Equalized feedback.
- Compressed gas condenser.
- Complete fuseless overload protection.
- Simplified circuit adjustments.
- Automatic control is realized.
- Conservative operation of all tubes.
- Current and voltage indicators are provided in all circuits where such instruments are normally desired.
- Split second switching to 1-KW reduced power.

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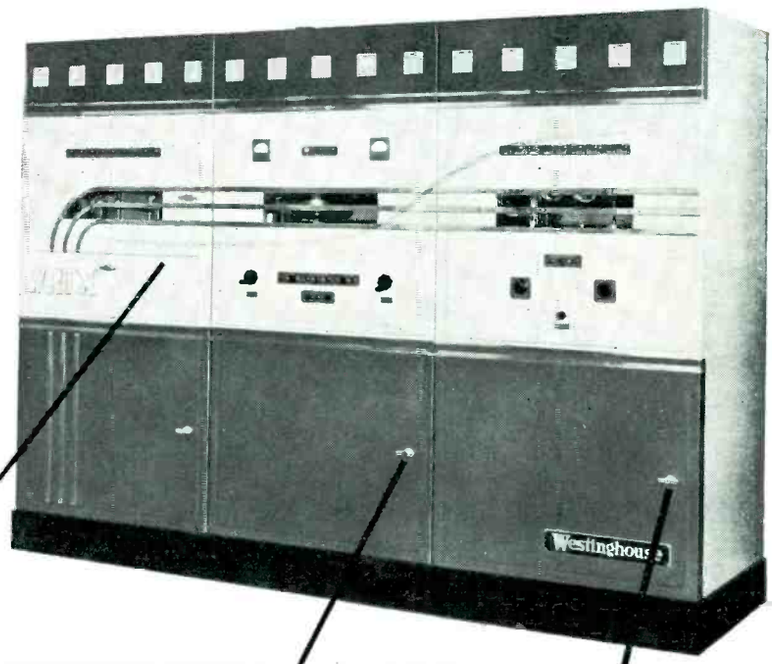
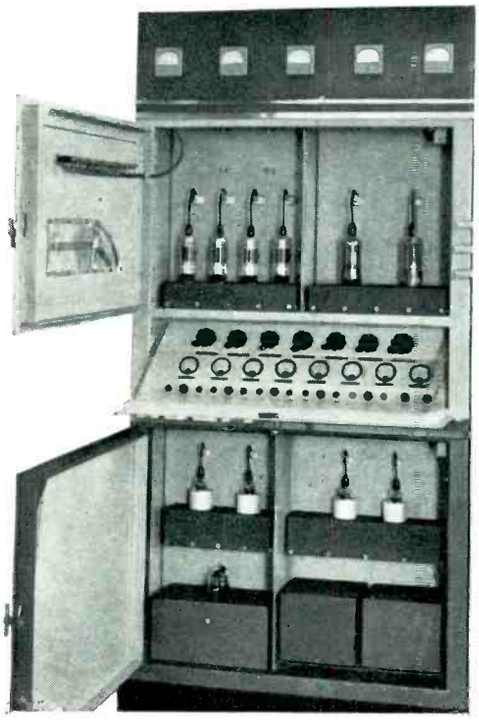
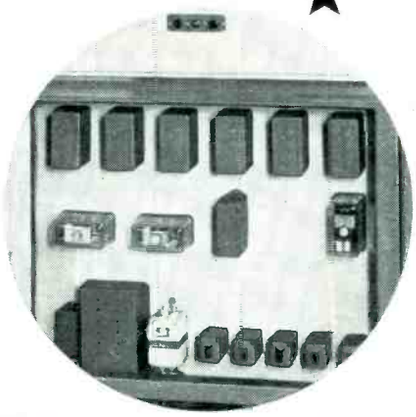
UNDIVIDED RESPONSIBILITY — In addition to complete broadcast transmitters, Westinghouse makes ALL the other equipment required for *transmitting* station operation, including tower lighting, antenna phasing and tuning, power input apparatus, switchgear, and station lighting. No matter what your problem may be, Westinghouse has the experience and the apparatus to give you exactly what you need. Call your nearest Westinghouse office.



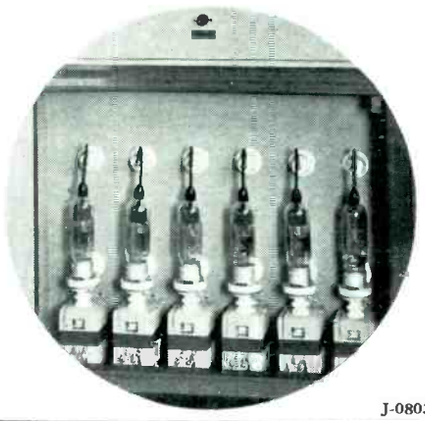
EXCITER CUBICLE—Two doors and a drop leaf give ready access to all controls, instruments, tubes—all you need to touch or see to adjust exciter for operation. Inclined panelboard makes it easy to read the instruments.



MODULATOR CUBICLE—Lower door opens to make it easy to check relay operation.



POWER AMPLIFIER CUBICLE—Tubes and their supporting sockets are instantly available through lower door.



J-08036

BROADCAST EQUIPMENT

life in high-grade sound installations. In these tubes grid accuracy is maintained within limits of 0.002 inch. Calmolloy not only making this possible, but definitely contributing to freedom from microphonics because of the increased rigidity provided by this material.

Where even slight oxidation may cause harmful effects, an added feature of this wire is that it is non-corrosive to the extent of offering active resistance even to hydrochloric acid. It oxidizes only slightly at elevated temperatures, and not at all at temperatures encountered in vacuum-tube applications.

The research laboratories of the Sonotone Corporation, in the development of tiny tubes for use in its line of pocket-type hearing aids, encountered trouble from a thin oxide coating which formed on ordinary grid wires during the sealing in process. During the exhaust process and high-frequency

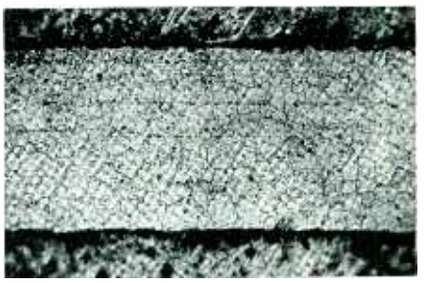


Fig. 4—Section after drawing into wire form

degassing this oxide coating would reduce, react with the filament coating and result in diminished emission and emission life.

The extent of practical applications of Calmolloy, beyond its use for grid windings and side rods, has not as yet been determined. Because it can be furnished highly tempered to maintain stiffness at elevated temperatures, can be rolled into sheets, and is weldable to materials commonly employed in vacuum-tube structures, including molybdenum, tungsten and nickel, it is probable that additional important applications will be found for it in the field of electronics.

PHYSICAL PROPERTIES OF CALMOLLOY

Density, 9.10 gms per cu cm
*Ultimate Tensile Strength, 130,000 to 157,000 lbs per sq in.
*Yield Point, 65,000 to 90,000 lbs per sq in.
Elongation .....30-35 per cent
Mean coefficient of thermal expansion per degree C.
25— 100..... 11.6 x 10^{-6}
25— 500..... 12.3 x 10^{-6}
25—1000..... 14.3 x 10^{-6}
Electrical Resistance, 635 ohms per mil foot at 25°C.
*Measured on annealed wire.

because IRC makes more types, shapes and sizes than any other manufacturer in the world

These are days when the specialized resistor service offered by IRC looms increasingly important.

For IRC *knows* resistors. It knows resistor requirements for both defense and ordinary commercial or electronic requirements. It knows how to use resistors—where to use them—what types to choose for certain applications—how to adapt them for utmost efficiency in your assembly—and a host of other things resulting from years of intense concentration on resistance research, design and manufacture exclusively.

Equally important, IRC engineers are not biased or limited to one or two types in their recommendations. IRC makes practically every type, shape and size of fixed and variable resistor. This simplifies the job of the IRC engineer in helping you select the *one right resistor for your job*—properly designed—suitably protected—economically priced—and of *tested* dependability.

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5. Attenuators: 20 or 30 step; ladder, potentiometer or bridged "T" types.

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INTERNATIONAL RESISTANCE COMPANY

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A Music-Proof Field Pickup System

By GENE RIDER
WQAM

WHEN A.S.C.A.P. MUSIC WENT OFF THE AIR, and while transcription files were being sorted and card indices rearranged, the field engineers of WQAM pondered the problem of how to keep music not available for radio off the air. The problem seemed particularly difficult with bands playing at sporting events where the broadcasting station has no control over the music to be played.

That was the question confronting the field engineers assigned to make a pickup of Ted Husing's description of the Mississippi State versus Georgetown football game in Miami's Orange Bowl stadium for a nation wide C.B.S. commercial network on January 1, 1941. It turned into a major problem because the Orange Bowl Committee, sponsor and promoter of the game, had provided 48 bands for the occasion, each band playing any music they wanted, whenever they wanted.

Obviously, the first step was to arrange for one band to be isolated from the other 47, and to provide this band with music available for radio. Through cooperation of the committee, this was done. But even though it was high in the bleachers, there was still plenty of opportunity for pickup from the other end of the stadium from the other bands.

A sound shield was built, in the first place, for the C.B.S. microphone. The shield was built of one-inch celotex, lined with one-inch airacoustic board. It was so efficient that with normal gain settings for the radio band pickup, music from the other bands down the field was unrecognizable.

The big problem was the booth. Measurements made on a General Radio noise meter showed a noise level of 85 decibels during an early December game, when tests were being made to determine a course of action. It was decided that to be absolutely safe, a new booth had to be built. In cooperation with Johns-Mansville, the C.B.S. engineers designed the booth. Since the booth was to be a permanent affair, it was decided not to skimp on size. The result was a booth 30 feet long, 10 feet high, and 8 feet wide with a glass front extending down to thirty inches above floor level. The job was built in a metal shop, completely prefabricated. The outer wall was of 26 gauge sheet metal, followed by a wall of one-inch airacoustic, held in place by another wall of 26 gauge sheet metal, the airacoustic being the filler for double metal walls spaced an inch apart. Over this inner wall of metal was fastened a filler of four-inch superfelt, held up by still another wall of 26 gauge sheet metal.

After this structure was assembled at the stadium, tests were again made, only to reveal that there were still sound leaks. With a band playing in

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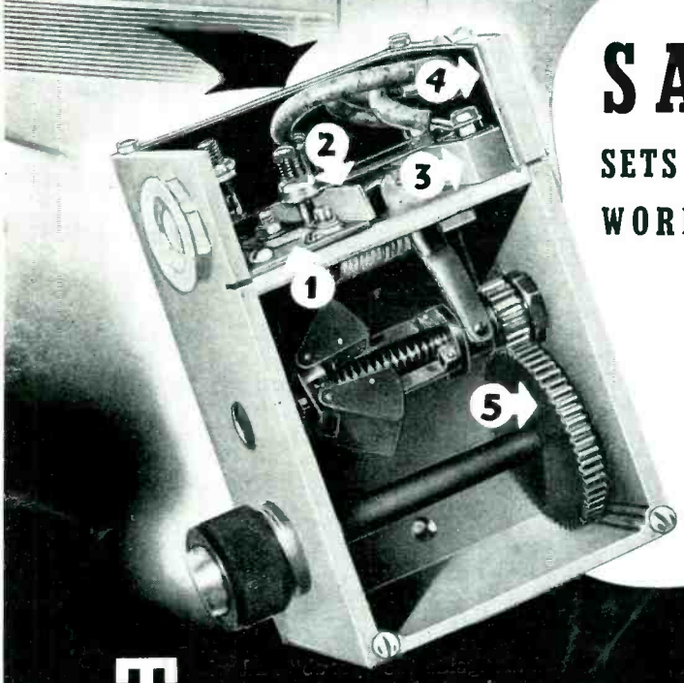

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THE Speed Control device shown above, which is readily attached to any pleasure car or truck, is manufactured by the Safety Speed Control Company of Chicago. This unit functions in a completely different manner from usual speed governors. It is operated by the speedometer cable — preserves the full power and acceleration of the car at all speeds below the set limit.

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the grandstand, the music was faintly recognizable in a monitoring speaker fed from a field amplifier setup. And in addition, the booth was too live, acoustically. Furring strips were then attached and a one inch lining of Fibercoustic was mounted. Tests were again made, this time satisfactorily, for the noise meter showed about 55 db isolation.

Since there was to be no traffic in and out of the booth during the broadcast, sound lock doors were not provided. Ordinary wooden double doors were built. They were lined with the one inch airacoustic material used as initial insulation between the outer and inner metal walls.

For ventilation, a two foot square intake duct and an identical outlet were built of sheet metal, lined with the airacoustic material, built in an L shape, extending upward from the booth's outside bottom about six feet. These ducts were very effective, as it was possible to shout in their outer ends, without being heard inside. A blower was placed in the outlet, drawing air from the booth, and fresh air in through the intake at the opposite end.

The flooring was constructed as follows. A subflooring of pine, an eight inch filler of superfelt, followed by another pine deck, covered by linoleum. The windows were of Crystallex glass, the outer pane being one half inch thick, the inner one quarter inch in thickness. These windows provided excellent sound insulation without in any way obstructing or distorting vision. It is important that different thicknesses be used, for if the two panes are the same gauge, any sound leaks through the first one, will cause the other one to pick up and transmit the sound, because they are of the same natural period of vibration. One inch spacing between panes was used.

It was then up to the control engineer not to make any mistakes. Since he would be occupied, watching a vu meter, obviously it would be impossible for him to watch the stands to see when a band was playing. Yet to keep the broadcast from sounding like a studio program, crowd noise had to be faded in at the right times.

C.B.S. shipped in a parabolic reflector. A keen eyed observer was stationed alongside the "parab" and when he saw a band about to play, he threw a switch in the low level microphone circuit, this switch flashing a warning light inside the booth, indicating that crowd noise was not available. Thus, it was impossible for the control operator to get the wrong kind of music from the parab, because the observer had opened the microphone circuit at the faintest sign of any band activity.

Whenever Ted Husing wanted music, he merely asked for it. The bandleader with his radio-music band in the bleachers wore cue phones feeding off the pickup amplifier in the booth, and at Husing's cue, gave the men the downbeat. Even though other bands were playing at the same time, the

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sound shield described previously did such a good job that no cross music was picked up.

Considering the quality of the material, the cost was surprisingly low, roughly one dollar per square foot.

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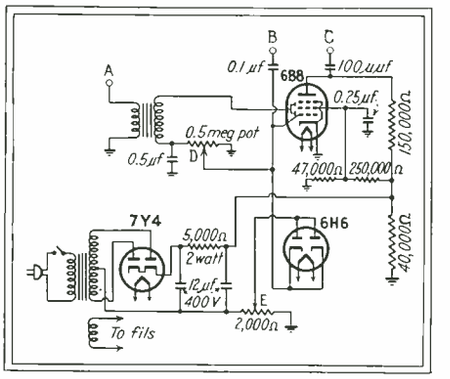
Electronic Attenuator

BY FRED A. SCHANER

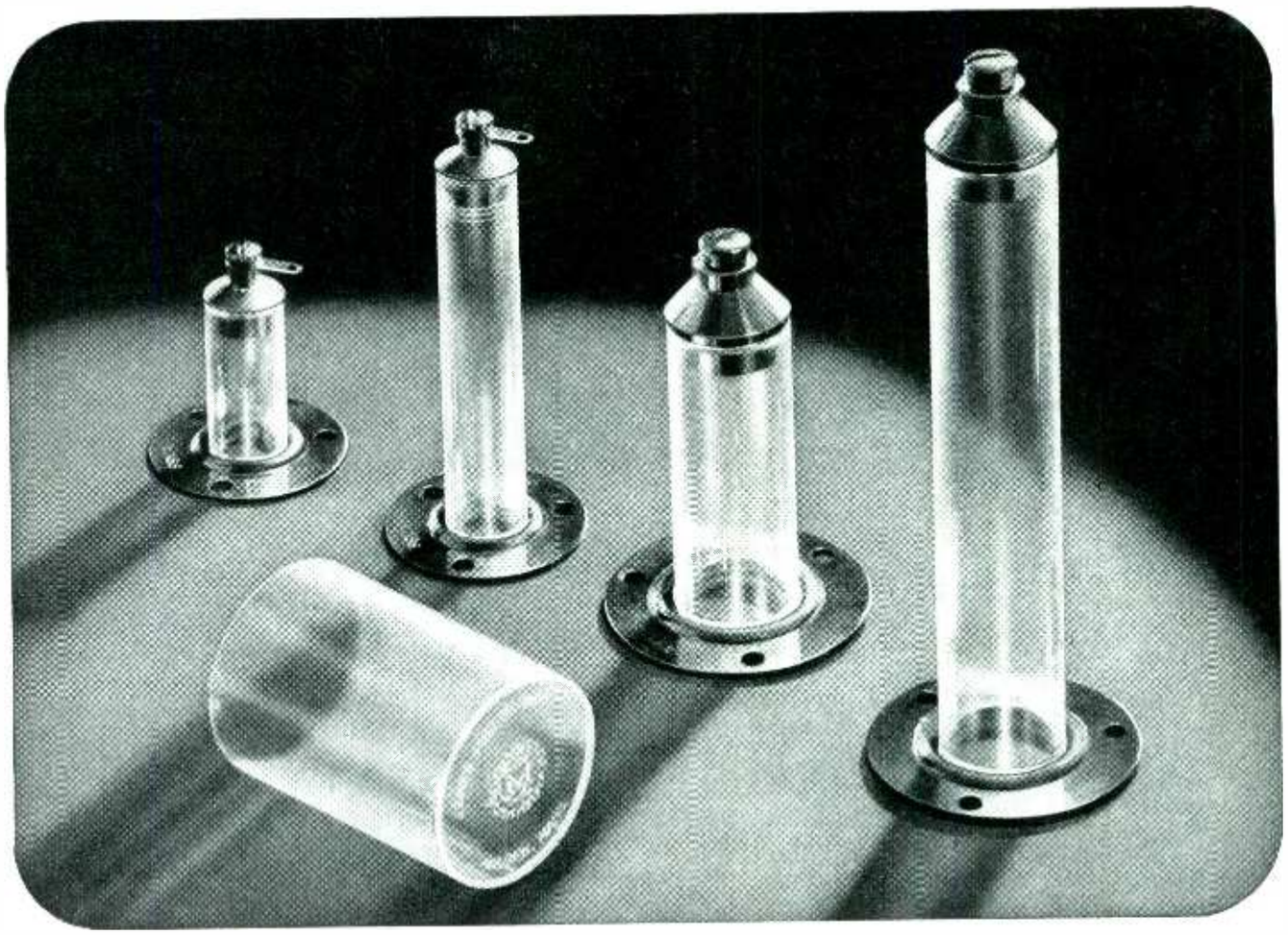
WHEN A RADIO RECEIVER is first placed under test, the various circuits are out of tune and it is necessary to use a strong input signal to obtain any indication on the output meter. As the circuits are brought into resonance the signal input voltage must be diminished to prevent overload or off-scale readings on the output meter. Usually this is accomplished by adjusting a manual attenuator, although with the electronic attenuator to be described, this operation is made automatically.

In the wiring diagram, point *A* is connected to the output of the receiver



Circuit of a simple electronic attenuator

under test, preferably by connecting it to the voice coil. Point *B* is connected to the signal source and point *C* is connected to the antenna connection of the receiver. As the circuits are brought into resonance by adjustment of the trimming condensers, the signal is rectified by the diode section of the 6B8 tube, and this rectified voltage is applied to the same tube as its bias. This controls the amplification of the tube and limits the amount of signal reaching the antenna of the receiver. The amount of bias may be controlled by an initial adjustment of the voltage divider, *D*. In order not to have too much compression of signal in the r-f section of the 6B8, and which would result in sluggish action of the output meter, a 6H6 tube is shunted across the grid of the 6B8. The response of this tube is controlled by the voltage divider, *E*. When the bias reaches a value predetermined by the setting of *D*, any further increase is shunted through the 6H6 tube. By setting up the two voltage dividers on an average set, an automatic attenuation of 10,000 to 1 is possible without any danger of overload or off-scale readings of the output meter.



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(60 to 50,000,000 cycles)
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VOLUME RESISTIVITY
Over 10^9 megohm cms.

ARC RESISTANCE
(proposed A.S.T.M. method)
120 to 140 secs.

Television Hearing

(Continued from page 19)

in all cases, and hence felt that the dissenting statements must be considered in the light of the N.T.S.C. vote in each case. The Farnsworth Company urged immediate commercialization and stated that, as manufacturers of television broadcasting and receiving equipment, they saw no difficulty in the light of the present defense production. Sufficient materials, man-power, and production facilities are available, in their opinion, to give television a start and to permit a healthy gradual expansion, which would be of the greatest value in the post-war economy of the country.

A. F. Murray, consulting engineer representing the Hughes Productions Division of Hughes Tool Company, then went on record that the minimum number of program hours should be set at three hours per day, rather than the five hours specified in the F.C.C. proposed rules, and that a better statement would be not

• • •

ELECTRONICS AIDS "MODERN HELEN KELLER"

Joan Higgins, 8 years old, born blind and with only 30 per cent normal hearing, is shown here with her nurse and teacher Mrs. Pauline Smith and the Phonotactor which enables her to "feel" words. The device was developed by Dr. Robert H. Gault, a director of the Audio-Visual Research Foundation

ELIMINATE TEMPERATURE DRIFT

Simply

CHANGES in reactance of coils, tuning condensers, tube sockets and other components that take place when a receiver warms up can affect the oscillator frequency considerably. Instead of trying to correct this condition in each of the components, it is far more simple and just as efficient to insert one Erie Ceramicon of the correct value in the oscillator circuit to compensate for the total frequency drift of all of the components.

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less than 15 hours per week, giving the broadcaster the option of allocating the time each day where it would do the most good. The Hughes Company also supported the N.T.S.C. standards in their entirety and disapproved all alternate standards. Mr. Murray also suggested that the audio transmitter (frequency modulated) of a television station be permitted to operate to give sound programs during times when the television transmitter was inactive, stating this would increase the public's use of the television receiver. E. K. Jett, chief engineer of the F.C.C. then questioned Mr. Murray closely on the advisability of the flexible standards proposed by A. B. DuMont. Mr. Murray gave technical reasons, as well as economic ones, why in his opinion the standards should be rigid, single-valued conditions of operation. He believed that even if the flicker problem were overcome by the use of retentive devices, the problems of jumpy motion and "smear" could not be cured at 15 frames per second.

N.B.C. Wants Industry to Advance as a Unit

Witnesses for the National Broadcasting Company, A. H. Morton, vice-president in charge of television and C. B. Jolliffe, chief engineer of the R.C.A. Laboratories, caused something of a sensation at the hearing, by advising caution in the commercialization of television, lest the industry get off to a bad start and then bog down. Dr. Morton, appearing as the first witness first gave complete assent to the N.T.S.C. standards and advised commercialization, but stated that Mr. Jolliffe would give testimony regarding the date at which such commercialization should begin. Dr. Morton then urged that the minimum number of program hours be set somewhere in the neighborhood of 10 hours per week, at least at the start, and that the minimum be increased from time to time as the state of art warranted. He believed that whereas stations in large cities near sources of talent might meet a more rigid schedule, stations in isolated small cities might well find it impossible to do so and hence would refrain from going into television at all. He placed the cost of programs at $1000 per hour, or over a million dollars per year on a

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30 hour per week basis. He stressed also the lack of available studio facilities and space and trained crews to operate a system on such an extensive schedule.

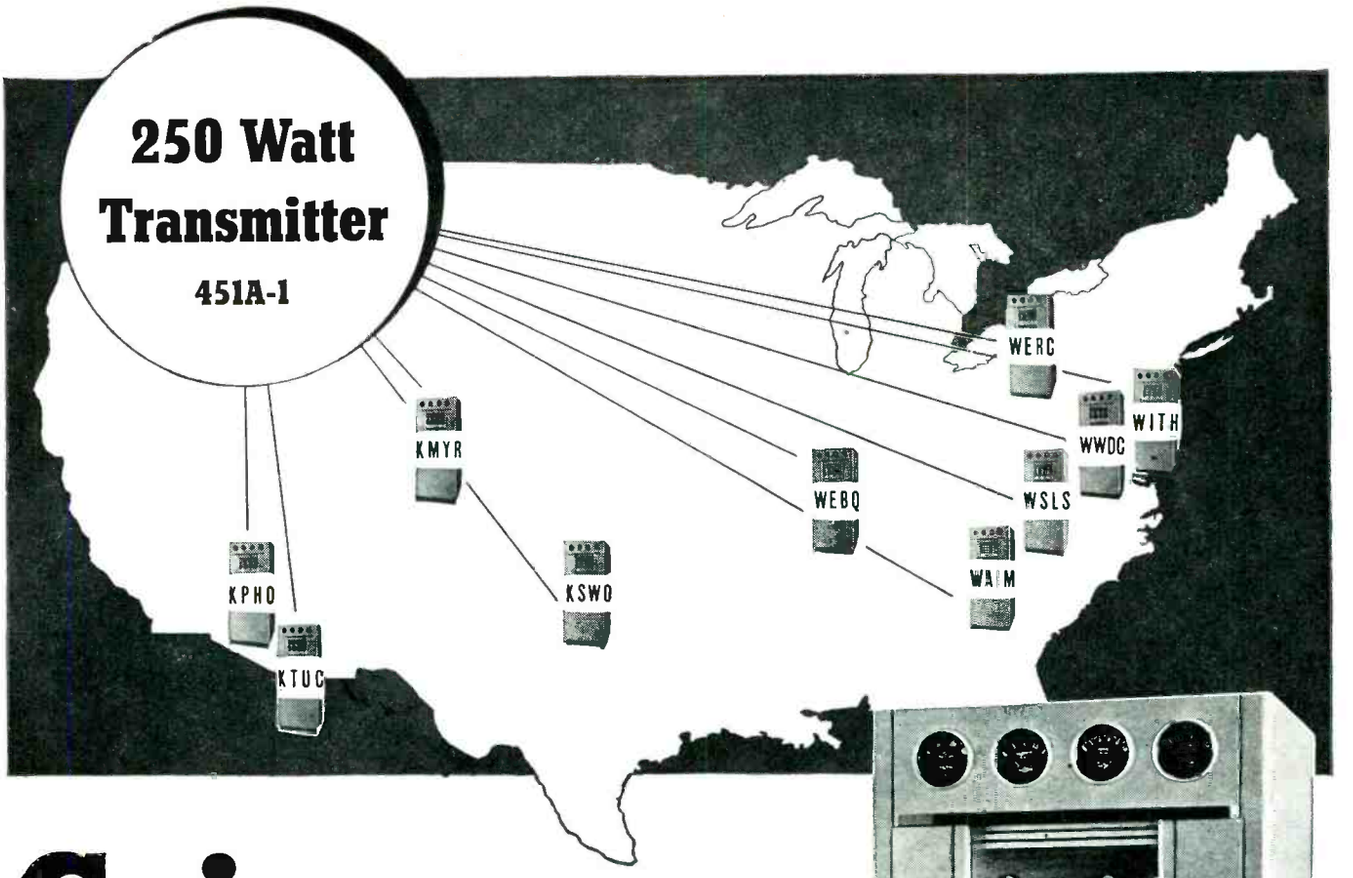
Mr. Jolliffe then took the stand and recommended that the N.T.S.C. standards be adopted immediately by the government, and that the plan to begin commercial service be announced. However, he stated that further investigation should be undertaken, before setting the date at which commercialization would begin, to determine that a substantial number of broadcasters had equipment and facilities ready for commercial programs, and that a substantial number of manufacturers of television receivers were ready to offer receivers to the public in the areas served by these broadcasters. Moreover, he stated that some branch of the government, not necessarily the F.C.C., should investigate the probable future of the defense effort, particularly as it concerns supplies of needed material, manufacturing facilities, and man-power, so that commercial television, once started, would not find itself blocked by priorities or some other form of governmental restriction. When this additional information was available, he stated, the Commission would be in a position to state the date for beginning commercial operation.

This attitude was in such sharp

• • •

AMATEUR MAINTAINS COMMUNICATION

N. C. Settle, Dallas amateur radio operator is shown at his equipment as he communicates with operators in Amarillo, which was isolated by recent sleet storm which put telephone, telegraph and power lines out of commission



Going Strong!

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They like its *performance,* which is typically Western Electric . . . 250 watts, frequency response flat within 1.5 db from 30 to 10,000 c.p.s. They like its low power consumption, low tube cost, low maintenance cost.

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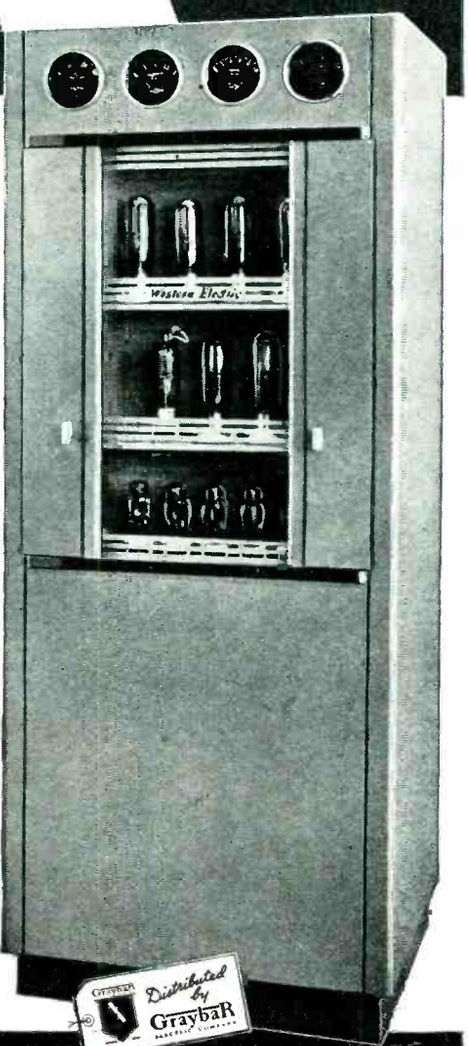

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contrast to that stated by the R.C.A. organization in the hearings last year that Chairman Fly of the F.C.C. questioned Mr. Jolliffe at some length regarding the revised policy. Mr. Jolliffe revealed that R.C.A. had no production facilities for television receivers at present, whereas a production line and trained operators were in readiness a year ago. Moreover, it was his understanding that other manufacturers were in substantially the same position. In response to questioning by the Commissioners, Mr. Jolliffe stated that all broadcasters should not only be required to meet the rules and regulations of the Commission, but should be in fact ready and willing to do so before the signal to start was given. He stated that R.C.A. and N.B.C. were ready to participate fully in such a program, but that they did not believe they should do so until others in the industry expressed their ability and willingness to go ahead also.

Scophony Requests Tighter Sync Tolerances

S. H. Dodington, appearing for Scophony Ltd., gave support to all the N.T.S.C. standards except one, that is, the standard which specifies the tolerance on the rate of recurrence of the horizontal sync pulses. The N.T.S.C. recommends a variation not more than 0.15 per cent, whereas Scophony recommends the narrower variation of not more than 0.03 per cent. This request is made because the mechanical scanning system used in the Scophony receivers can operate satisfactorily only if the sync variation is limited to an amount which the mechanical system can follow without losing synchronism. Mr. Dodington also suggested that this variation apply to all broadcasts, not specifically to studio broadcasts as the N.T.S.C. recommends. Chairman Fly then called to the stand T. T. Goldsmith, Jr., Chairman of Panel 8 of the N.T.S.C. Dr. Goldsmith stated that his panel was aware of this situation, and had made their recommendation simply because they were not sure that a more rigid tolerance could be met. Mr. Fly requested that the matter be investigated further by the N.T.S.C., inasmuch as Scophony stated that circuits are available which will permit the narrower

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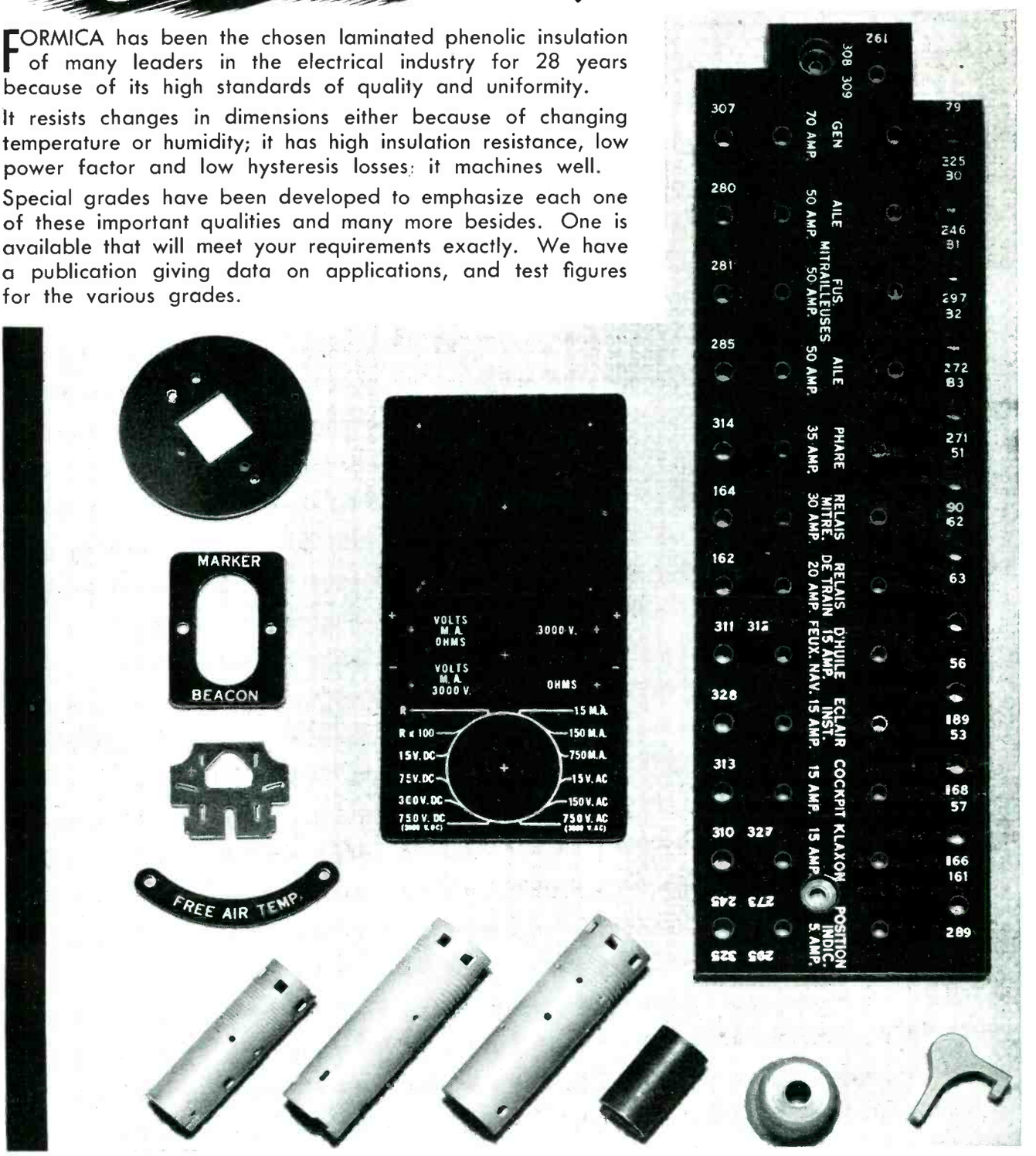

The Formica Insulation Company, 4611 Spring Grove Avenue, Cincinnati, O.

FORMICA

tolerance to be met. It was pointed out that studio transmissions from the N.B.C. in New York were very close to the 0.03 per cent figure at the present time.

The Zenith Radio Corporation of Chicago, represented by John Howland, then appeared. After stating his company's acceptance of the N.T.S.C. standards, Mr. Howland pointed out that commercialization of television depends fundamentally on the willingness of organizations to take the gamble that the money spent will eventually be returned. He stated that this gamble would be much less attractive if too large a number of program hours are specified, and recommended a minimum requirement be 10 hours per week, or preferably five hours, since the latter figure would permit many more stations to enter the field.

Metropolitan Television, Inc., of New York, licensee of station W2XMT, appeared to ask that Channel 8, 162 to 168 megacycles, be given commercial status. Inasmuch as the N.T.S.C. had removed its previous recommendation that the commercial standards apply only to the first seven channels, and inasmuch as the Commission stated that they were disposed to give Channel 8 the same consideration as the lower channels, the witness for this organization was withdrawn. It was evident that none of the channels in groups A or B (those below 294 Mc) were to be considered in the non-commercial category and that the standards would apply to any or all of these channels which might be specified for commercial operation by the Commission.

Gordon Burroughs, representing the Telechordon Laboratories, then appeared to give assent to the N.T.S.C. standards and to urge immediate commercialization stating that if it is withheld long, this action would have a very adverse effect on competition, because many of the smaller concerns would be eliminated from the field for lack of financial incentive.

Hollis Baird, representing the General Television Corporation of Boston, urged immediate commercialization on the basis of the N.T.S.C. standards, recommended against flexibility or other alternative standards, and suggested that color television might be much further from the commercial state

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WHEN You TURN FROM THE BEATEN PATH

. . . and you set out to find new ways, or improvements in present methods, the Sensitrol may prove the guide to valuable discovery for you. For Sensitrol's magnetic contacting principle provides sure, unfailing contact operation under extremely low energy conditions. Remember, too, that Sensitrol is available with indicating scales . . . a feature most desirable for many control applications. Complete information on Sensitrol, as well as on other WESTON sensitive and auxiliary relays, can be secured from the WESTON representative in your vicinity, or by writing...Weston Electrical Instrument Corporation, 618 Frelinghuysen Avenue, Newark, New Jersey.

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that the laboratory demonstrations might make it appear, inasmuch as little is known concerning the adverse effects of noise and loss of sync in a three-color system.

The final witness, U. A. Sanabria representing the American Television Laboratories, made several unique proposals. After giving support to the N.T.S.C. standards and asking immediate commercialization, he suggested that the standards be established officially for a period of eight years, and that at the end of four years new standards be adopted, after an investigation similar to that of the N.T.S.C., for the next period of eight years. During the 4-year period of overlap, each station would operate both systems on two channels, sharing time with other stations. Mr. Sanabria also recommended the licensing of television workers, to avoid the domination of the skilled workers in the field by labor unions, and finally suggested that television work was of sufficient importance to the national defense to warrant deferrment of qualified workers from the selective service draft.

The Farnsworth Company made an additional appearance to announce that their company would be ready to offer all the necessary equipment for commercial television, including receivers for the public, within 120 days after the adoption of standards. Finally the DuMont organization made an additional appearance to urge, first, that as soon as the decision was reached a public announcement be made to the effect that commercialization was an accomplished fact, and second to point out that the N.T.S.C. standards, while admitting the DuMont signal to test, do not give it a fair opportunity because the single values of lines and frames per second rob this signal of its great advantage.

At the conclusion of the hearing Chairman Fly thanked the industry for its labor in preparing the standards, and suggested that the N.T.S.C. be perpetuated in some way, though on a less active footing than that of recent months. Those present at the hearing, which ended at 12:30 Monday March 24th, were optimistic that the Commission would take action within a few weeks to approve the standards and to set up the program for commercialization.

—D.G.F.

TUBES

The operation of u-h-f circuits is discussed and data on tubes newly registered with the R.M.A. Data Bureau as well as data on older tubes are also presented for reference

Operation of Power Triodes in U-H-F Circuits

By W. G. Wagener
Heintz & Kaufman, Ltd.

The proper functioning of ultra-high-frequency circuits is dependant upon a number of factors among which the design of the tubes used and their operating conditions are important.

The Types HK-54 and HK-254 are well suited for operation in the u-h-f region from 30 to 200 megacycles as power amplifiers and frequency multipliers. Several design features are incorporated in these tubes for operation at these frequencies, as follows: 1. A totally enclosed plate and grid construction which confines all electrons to the useful space within the plate structure. 2. Short heavy plate and grid leads which keep the lead inductances low. 3. Low interelectrode capacities which simplify neutralization and further reduce the ill-effects of lead inductance. 4. The lack of internal insulation within the tube, which avoids the high losses which normally occur in such highly stressed insulating pieces at ultrahigh frequencies.

Plate conversion efficiencies as power amplifiers on the order of 70 per cent have been obtained at frequencies as high as 125 megacycles. Plate conversion efficiencies of 55 to 60 per cent have been obtained in this region as single tube frequency doubler stages. For service at these frequencies plate voltages from 1500 to 2000 volts are recommended.

In order to obtain the results noted it is essential that proper circuits be associated with the tube. At ordinary frequencies the circuits need seldom be given much consideration except to attain the proper ratios of circulating energy to dissipated energy (loaded Q), and to tune over the desired frequency range. For operation in the u-h-f region, it is necessary or desirable to observe the following additional points:

1. The circuits should be balanced to ground, as in push-pull circuits, in order to reduce radiation and magnetically coupled losses.

2. Tube leads and connecting leads should be short, with ample surface area of good conducting material. This is necessary because the reactance of the inductance per unit length of the lead is very high, and because most leads carry high charging currents. Avoid stranded leads.

3. Circuits with low resistance losses are necessary because the stored energy in the circuit is inherently higher than necessary.

4. Insulator losses rise rapidly with frequency and a minimum of good ceramic insulation should be used.

5. Because the reactances of all incidental capacities are low and the reactances of all mutual inductances are high, the proximity of metal shelves, shields, and cabinets makes it necessary to consider their possible effect on the circuit. Care must be taken to bond all such pieces or assure solid contact wherever such pieces come together. Such pieces should have good conducting surfaces also to minimize the losses incidental to carrying the induced currents. Variations of contact which may shift the path of the current in these pieces only a matter of inches may have considerable reaction on the stability of the operating circuits.

6. Possible resonant circuits in the framework and shields should be avoided.

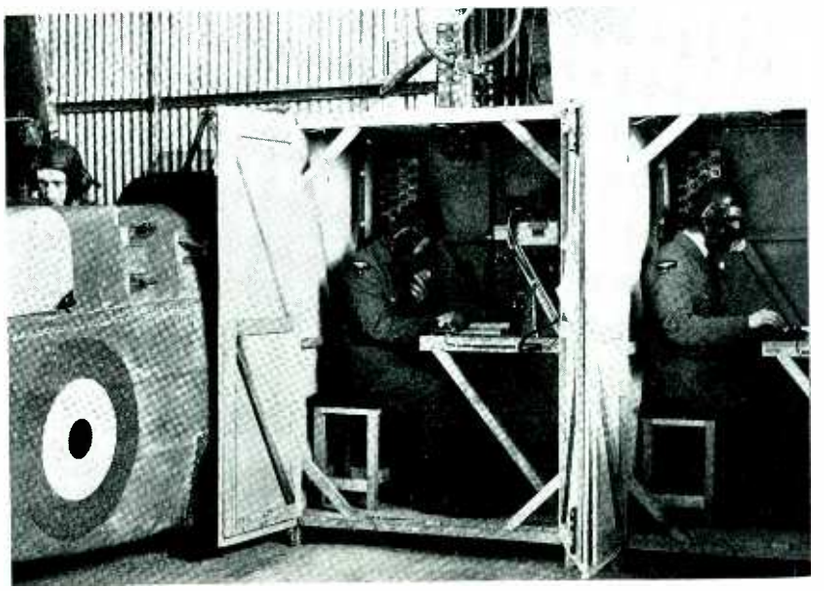
7. It is often advisable to think of the circulating energy associated with the u-h-f circuit as stored in the field near the line circuits, and of the field confined by the presence of the circuit itself and limited in extent by the stage compartment.

8. Balance excitation of power amplifier tubes can be obtained by floating the grid circuit, and making the grid leak the sole connection to the grid circuit midpoint.

Neutralization

Conventional cross-connected neutralizing circuits for the push-pull amplifiers are satisfactory. However, the circuit must usually be arranged so that the connections to the neutralizing condensers as well as to the tube are short and of low inductance. This is necessary because both the plate and grid resonant circuits, when viewed as sections of transmission lines loaded with the fixed capacities of tube and neutralizing condensers, actually extend in physical dimension out to the dielectric region of the neutralizing condensers. It is usually difficult to attain sufficient physical length of circuit away from the tubes, and for this

R.A.F. TRAINS RADIO PILOTS



The R.A.F. trains operators under conditions simulating those which they will later encounter in flight. Here are three operators receiving or giving instructions in code transmission and reception in order to qualify each as a wireless operator gunner

reason, one usually wishes to waste as little as possible of this length in the neutralizing leads.

Because of the mutual inductive coupling between plate and grid circuits by virtue of the charging currents flowing in the tube and neutralizing leads, it is usually of little value to introduce shielding between the grid and plate circuits.

The grid lead of the tube from the point of juncture of the neutralizing lead and grid circuit proper of the grid element of the tube itself represents an appreciable inductive reactance. The presence of the inductive reactance at this point in the circuit results in a regenerative feedback which is difficult to compensate for by throwing off the neutralizing condensers. It is sometimes desirable to tune out this inductance by series capacitance.

It is not necessary to tune out the inductance of the filament leads. Simple bypass condensers to the metal shelf will suffice. Tuning of the filament is not necessary because of the low tube capacities, and especially the filament to plate capacity which is unusually low in the construction of the HK-54 and HK-254.

Practical elimination of parasitic oscillations is possible using the above technique and that of the usual considerations in the elimination of parasitics in ordinary circuits. It is

• • •

ROOF WATCHER

Employed in an important asbestos plant in England, this roof watcher is equipped with a microphone through which he announces the news of the approach of enemy aircraft to his fellow workers. A telephone in his right hand keeps him in contact with the control room, whereas the microphone in the left hand is used for sounding a warning in the event of an emergency through the loudspeaker system in the factory

When SPRINGS have to STAND UP against HEAT and CORROSION...

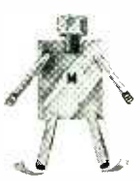
HEAT fatigue under heavy alternating stresses, aided by corrosion, soon ruins springs of ordinary materials. Yet here are three alloys that stoutly resist this type of attack and retain excellent spring properties.

Monel*, "K" Monel* and "Z" Nickel*, all completely rust proof, offer great strength and stiffness, and high endurance limit. Readily fabricated, these alloys may be used for helical, spiral, and flat springs of all shapes and sizes.

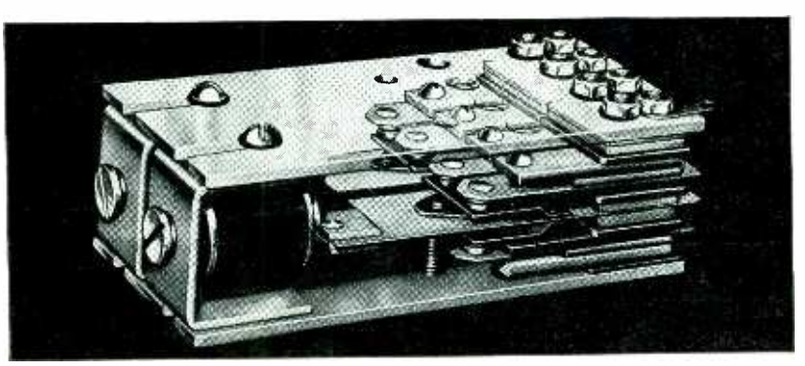
Which of these materials is *best?* They are *all* good . . . each possessing individual characteristics for specific applications.

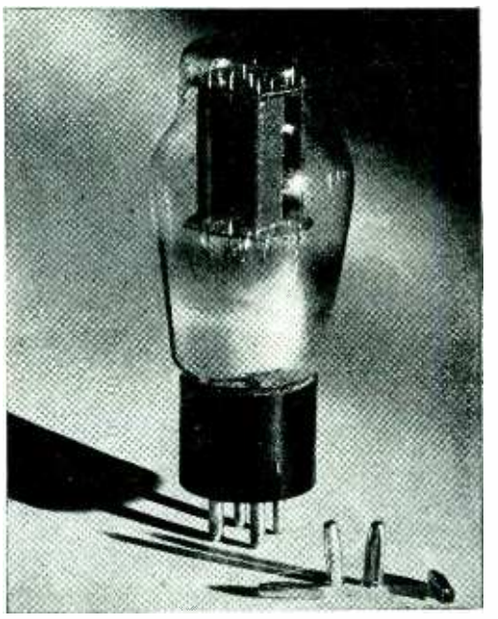
Some idea of the relative merits of Monel, "K" Monel and "Z" Nickel is given in captions below. For full information write for Bulletins T-9 "Engineering Properties of 'K' Monel," T-5 "Engineering Properties of Monel," and T-16 "Heat Treatment of 'K' Monel and 'Z' Nickel."

(Below) **COIL SPRINGS OF "K" MONEL . . .** Continual flexing as the miner works tends to frazzle or break the cable leading out of this battery case. The spring employed for protection must be strong, and resistant to both corrosion and fatigue. Because "K" Monel offers these advantages, it proves most suitable for the job. This Nickel-base alloy is also non-magnetic, heat treatable, and a strong spring material up to 500° F.



REED SPRINGS OF MONEL . . . Accuracy of this automobile radio vibrator (below) depends on fine adjustment of air gap to within .0005 inch. In spite of fatiguing vibrations and heat developed by currents up to 20 amps., Monel spring strips maintain this delicate adjustment. Highly resistant to corrosion, and completely immune to rust, Monel retains its strength and assures long, trouble-free service.





BANANA SPRINGS OF "Z" NICKEL... Tube socket springs in a portable field radio set must hold the tube prongs in a clean, tight grip. They must also be proof against jolting and exposure to weather. Rustless, a good electrical conductor, and one of the *strongest* materials available for springs, "Z" Nickel proves ideal for this application. The springs are formed from soft temper "Z" Nickel, then hardened by heat treatment for maximum strength.

• • •

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York, N. Y.

MONEL
"K" MONEL
"Z" NICKEL

sometimes possible to discover a very weak parasitic oscillation with both input and output circuits detuned considerably. Such an oscillation in a properly neutralized amplifier at these frequencies is inherent in the electronic action but seldom, if ever, will appear under normal operating conditions.

Frequency Multiplication

The use of the HK-54 and HK-254 to double or triple in the u-h-f region is governed by the same circuit considerations as noted above. It is desirable to make a balanced plate circuit even in the case of single tube operation. It is desirable in attaining good tube efficiency to neutralize very crudely the feedback of the harmonic energy from the plate to grid circuit. If this is done in the single tube case, a balanced plate circuit will inherently result also.

The essential difference between power amplifier and doubler or tripler operation is that the latter cases require very high grid leak values in order to operate at high efficiencies. Otherwise all the circuit comments made for the power amplifier apply with equal force to the frequency multiplier stages.

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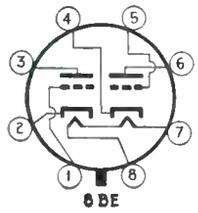
Tube Registry

Tube Types registered by R.M.A. Data Bureau During February 1941

Type 6AH7GT

TWIN TRIODE, heater type; T-9 glass envelope; seated height 2½ inches max; 8-pin bakelite octal base.

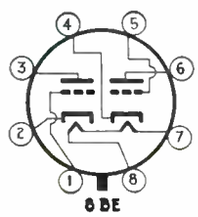
E_f = 6.3 v.
I_f = 0.3 amp
E_b = 250 v
E_c = − 9 v
I_b = 12 ma
μ = 16
r_p = 6600 ohms
g_m = 2400 μmhos
C_{in1} = 3.2 μμf
C_{in2} = 2.9 μμf
C_{out1} = 3.0 μμf
C_{out2} = 2.6 μμf
C_{gp1} = 2.2 μμf
C_{gp2} = 3.0 μμf
Basing 8BE-0-0



Type 12AH7GT

TWIN TRIODE, heater type; T-9 glass envelope; seated height 2½ inches max; 8-pin bakelite octal base.

E_f = 12.6 v
I_f = 0.15 amp
E_b = 250 v
E_c = − 9 v
I_b = 12 ma
μ = 16
r_p = 6600 ohms
g_m = 2400 μmhos
C_{in1} = 3.2 μμf
C_{in2} = 2.9 μμf
C_{out1} = 3.0 μμf
C_{out2} = 2.6 μμf
C_{gp1} = 2.2 μμf
C_{gp2} = 3.0 μμf
Basing 8BE-0-0



40 Years of Service . . . to the Electrical Industry

Younger than some of our customers, older than others, AMERTRAN takes pride in the service it has rendered, and will continue to render, to the Electrical, Industrial, Communications and Electronic fields. In design, engineering and manufacture, we have kept pace with progress. A list of customers for AmerTran Electronic Transformer Equipment constitutes a blue-ribbon group of leading American manufacturers and communication companies. It is also our privilege to serve a number of important projects connected with the United States Government and with industrial activities in defense work. We proudly accept this responsibility; and to this work, as to all industry, we pledge our fullest cooperation.

AMERICAN TRANSFORMER CO.

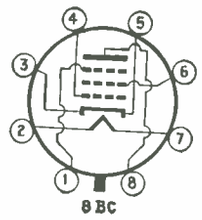
178 Emmet St. Newark, N. J.

AMERTRAN

Type 6SG7

R-F PENTODE, semi-remote cutoff; heater type; MT-8 metal envelope; seated height 2 1/16 inches max; 8-pin octal base.

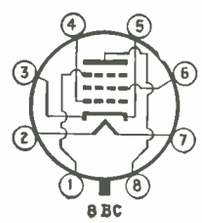
E_f = 6.3 v
I_f = 0.3 amps
E_b = 250 v
E_{c3} = 0 v
E_{c2} = 150 v
E_c = − 2.5 v
I_b = 9.2 ma
I_{c2} = 3.4 ma
g_m = 4000 μmhos
r_p = 1 (+) megohm
@E_{c1} = − 17½ v
g_m = 40 μmhos
C_{in} = 8.5 μμf
C_{out} = 7.0 μμf
C_{cp} = .003 μμf (max)
Basing 8BC–1–1



Type 12SG7

R-F PENTODE, semi-remote cutoff; heater type; MT-8 metal envelop; seated height 2 1/16 inches max; 8-pin octal base.

E_f = 12.6 v
I_f = 0.15 amp
E_b = 250 v
E_{c3} = 0 v
E_{c2} = 150 v
E_c = − 2.5 v
I_b = 9.2 ma
I_{c2} = 3.4 ma
g_m = 4000 μmhos
r_p = 1 (+) megohm
@E_c = − 17½ v
g_m = 40 μmhos
C_{in} = 8.5 μμf
C_{out} = 7.0 μμf
C_{cp} = .003 μμf (max)
Basing 8BC–1–1

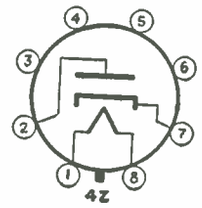


Type 35Z3 (GL)

HALF-WAVE rectifier; heater type; T-9 integral glass envelope-base; seated height 2⅝ inches max; 8-pin loktal base.

RATINGS
E_f = 35.0 v
I_f = 0.15 amp
E_p = 235 v rms (max)
E_{inv} = 700 v (max)
I_{fwd} = 600 ma (max)
E_{drop} @ 200 ma = 20 v

OPERATION
E_f = 35 v
E_f = 0.15 amp
I_p = 235 v (max)
I_b = 100 ma (max)
Minimum total effective plate supply impedance = 100 ohms
Basing 4Z–L–0

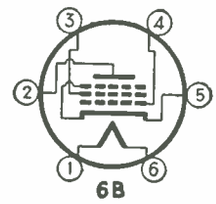


Tube Types Previously Registered with the R.M.A. Data Bureau

Type 42

POWER amplifier pentode, heater type, ST-14 glass envelope, seated height 4 1/16 inches, 6-pin base.

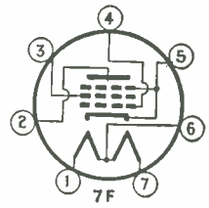
E_h = 6.3 v
I_h = 0.7 amp
E_b = 250 v
E_{c2} = 250 v
E_c = −16.5 v
I_b (zero signal) = 34 ma
I_{c2} (zero signal) = 6.5 ma
R_l = 7000 ohms
P_o = 3.2 watts (8%)
Basing 6B–0–0



Type 12A5

POWER amplifier pentode, heater type, ST-12 glass envelope, seated height 3 9/16 inches, 7-pin base.

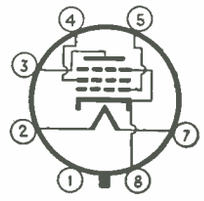
E_h = 6.3 or 12.6 v
I_h = 0.6 or 0.3 amp
E_b = 180 v (max)
E_{c2} = 180 v (max)
E_c = −25 v
I_b (zero signal) = 45 ma
I_{c2} (zero signal) = 8 ma
R_l = 3300 ohms
P_o = 3.4 watts (11%)
Basing 7F–0–0



Type 25A6G

POWER amplifier pentode, heater type, ST-14 glass envelope, seated height 4 1/16 inches, 7-pin octal base.

E_h = 25 v
I_h = 0.3 amp
E_b = 135 v
E_{c2} = 135 v
E_c = −20 v
I_b (zero signal) = 37 ma
I_{c2} (zero signal) = 8 ma
R_l = 4000 ohms
P_o = 2 watts (9%)
Basing 7S–0–0



Type 12Z3

HALF-WAVE high-vacuum rectifier, heater type, ST-12 glass envelope, seated height 3 9/16 inches, 4-pin base.

E_h = 12.6 v
I_h = 0.3 amp
CONDENSER INPUT TO FILTER
E_{ac} (rms) = 235 v (max)
I_{dc} = 55 ma (max)
Minimum total effective plate supply impedance = 75 ohms
E_{drop} (I_{dc} = 110 ma) = 17 v
Basing 4G–0–0

Type 77

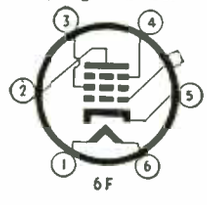
TRIPLE-GRID detector amplifier, heater type, ST-12 glass envelope, seated height 3 29/32 inches, 6-pin base.

E_h = 6.3 v
I_h = 0.3 amp
E_b = 250 v
E_{c2} = 100 v
E_c = −3.0 v
r_p = 1 + megohm
g_m = 1250 μmhos
I_b = 2.3 ma
I_{c2} = 0.5 ma
Basing 6F–0–3

Type 78

TRIPLE-GRID super-control amplifier, heater type, ST-12 glass envelope, seated height 3 29/32 inches, 6-pin base.

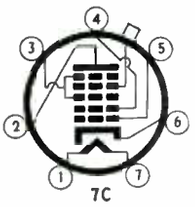
E_h = 6.3 v
I_h = 0.3 amp
E_b = 250 v
E_{c2} = 100 v
E_c = −3.0 v
I_b = 7.0 v
I_{c2} = 1.7 ma
r_p = 0.8 megohm
g_m = 1450 μmhos
Basing 6F–0–5



Type 6A7

PENTAGRID converter, heater type, ST-12 glass envelope, seated height $3\frac{29}{32}$ inches, 7-pin base.

E_h = 6.3 v
I_h = 0.3 amp
E_b = 250 v
$E_{c3,5}$ = 100 v
E_{c4} = −3 v
E_{c2} = 250 v through 20,000 ohms
I_b = 3.5 ma
$I_{c3,5}$ = 2.7 ma
I_{c2} = 4.0 ma
g_c = 550 μmhos
Basing 7C–0–0

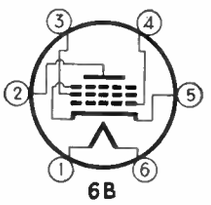


7C

Type 18

POWER amplifier pentode, heater type, ST-14 glass envelope, seated height $4\frac{1}{16}$ inches, 6-pin base.

E_h = 14.0 v
I_h = 0.3 amp
E_b = 250 v
E_{c2} = 250 v
E_c = −16.5 v
I_b (zero signal) = 34 ma
I_{c2} (zero signal) = 6.5 ma
R_l = 7000 ohms
P_o = 3.2 watts (8%)
Basing 6B–0–0



6B

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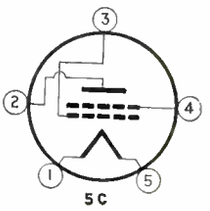
"WALKIE-TALKIE" FOR THE ARMY

Soldier carrying Walkie-Talkie radio apparatus, used by the 62nd Coast Artillery during fire practice at Fort Tilden, N. Y., in which 50-calibre guns were used. By means of this portable equipment, two-way voice conversation can be carried on between observer on the ground and a plane which tows an aerial "sleeve" target for gun fire

Type 49

DUAL-GRID power amplifier, filament type, ST-14 glass envelope, seated height $4\frac{1}{16}$ inches, 5-pin base.

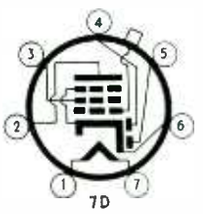
E_f = 2.0 v
I_f = 0.12 amp
E_b = 135 v (max)
E_{c1} = −20 v
Grid 2 connected to plate at socket
I_b = 6.0 ma
R_t = 11,000 ohms
P_o = 0.17 watts
Basing 5C–0–0



Type 2B7

DUPLEX-DIODE pentode, heater type, ST-12 glass envelope, seated height $3\frac{29}{32}$ inches, 7-pin base.

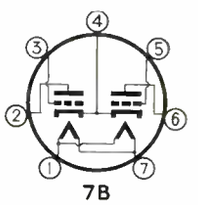
E_h = 2.5 v
I_h = 0.8 amp
E_b = 250 v
E_{c2} = 100 v
E_c = −3 v
I_b = 6.0 ma
I_{c2} = 1.5 ma
r_p = 0.8 megohm
g_m = 1000 μmhos
Basing 7D–0–6



Type 53

CLASS B twin triode amplifier, heater type, ST-14 glass envelope, seated height $4\frac{1}{16}$ inches, 7-pin base.

TRIODES CONNECTED IN PARALLEL
E_h = 2.5 v
I_h = 2.0 amps
E_b = 250 v
E_c = −5 v
I_b = 6 ma
μ = 35
r_p = 11,000 ohms
Basing 7B–0–0



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CAPTURED GERMAN RADIO EQUIPMENT

British soldier investigating the radio transmitter found in the possession of an enemy agent arrested and executed as a spy. The complete portable equipment was housed in the leather cases

New Use For X-Rays

(Continued from page 31)

wavelengths as low as 0.7 meter. The 954 has an indirectly heated cathode and is in the sharp cut-off pentode class with a filament operating on either direct or alternating current.

A few somewhat unusual features will be noted in the circuit. For one thing, the ordinary 75-250 volt plate potential has been replaced by 7.7 volts. The positive voltage of grid 1 is another. As a rule, a positive grid 1 would cause the plate to draw an excessively large current, but low voltages on the plate and grid 2 prevent damage to the tube. The screen grid voltage is obtained from the voltage divider system which is adjustable and also furnishes power to grid 1. The fixed sliders remain at that value for this particular tube.

Ordinarily, grid 1 acts as the input element, but this is much too sensitive a condition for this application, so the suppressor grid is used here as the control, since it is impractical to vary the voltage on grid 2 by means of ionization current. The compensator potentiometer determines the initial voltage on grid 3 and gives a range from 0 to 6.3 volts, which is overcome by the

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EASING THE NERVES

On the theory that soft music soothes, Dr. Tom Connor, a Dallas dentist, has provided a "juke box" arrangement for his patients. Shown here is a patient selecting a tune on a remote control selector while waiting for the dentist to start work

potential caused by ionization current flowing through the 2500-megohm resistor.

When this initial voltage is reduced slightly, or overcome to an extent where its polarity is reversed, the plate current increases in some definite proportion dependent on the tube characteristics. If the plate current increase is sufficient, the plate circuit relay closes, thus closing the relay which operates the reject mechanism.

Since the bias potentiometer controls the plate current, and the sensitivity shunt regulates the action of the galvanometer relay, either one or both of these controls may be used to affect the sensitivity of the apparatus as a whole. In short, they may be used to determine the size defect which will or will not operate the reject mechanism.

Let us return for a moment to the chamber itself. No attempt will be made here to discuss all the details of its construction, but it should be noticed in Fig. 7 that the chamber consists of a series of metal plates placed directly in the x-ray beam path. As x-rays traverse these plates, secondary x-rays and photoelectrons are ejected and thus greatly increase the total number of ionizing particles available. This particular design can be used only where it is desired to measure relatively large changes in ionization currents, say 200-400 per cent. The size and shape of the chamber also determine its saturation point and electrical field contours, so that a chamber constructed for this application might be impractical for use in other applications.

When the various parts described are assembled, they appear as shown in the photograph. The knives approach the lead inspection hood from the left on a conveyor system. Beneath the hood is the x-ray tube, normally enclosed in a lead drum, but here exposed for illustrative purposes. Resting on the shelf just in front of the hood is the electron tube amplifier with its various ground-shielded cables leading to power supply, battery box, ionization chamber and reject solenoid. At the extreme right is the x-ray machine control cabinet.

Within the hood are a fluorescent screen with its lead glass protection and x-ray filtration system, the ionization chamber, and a device for

interchanging the screen and chamber. This latter mechanism is so designed that the chamber, when moved into position for use, is adjusted correctly within a very small tolerance. To match this, each knife enters the hood and must come to a stop under the exact center of the chamber.

After the knife has remained there for 1.3 seconds, it moves on and is replaced by the next one and so on. The first knife emerges from the inspection hood and, if defective, is ejected from the chain by a solenoid-actuated finger. The apparatus is readily capable of examining 1,400 knives an hour.

In closing it should be pointed out that since the ground has now been broken for application of x-ray ionization phenomena industrially, it ought not to be too difficult to find many other fields where similar systems would be valuable. The fact that this apparatus has been operating successfully at the Oneida Ltd. plant for about a year is a good indication of its graduation from the laboratory stage.

The authors wish to acknowledge their indebtedness to L. D. Marinelli and T. R. Folsom of the Physics Staff of Memorial Hospital, New York City for construction of the ionization apparatus and R. W. Noyes of Oneida Ltd. for design of the handling equipment.

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UNION OF SCIENCES

In the new Lockheed Structures Research Laboratory, E. J. Demax is shown watching an instrument which records the reaction of a wing section to strains under hydraulic pressures

F-M Signal Generator

(Continued from page 38)

5 megacycles, the use of 45 megacycles as a test point might not be possible if the receiver's i-f rejection ratio were low. Actually, in receivers equipped with an r-f amplifier stage ahead of the first detector, no difficulty from this source has been found.

In the generator described, the oscillators are not switched to select the desired output frequency range. All of the required switching is done in the plate circuits of the mixer and amplifier tubes. In the i-f range these plate circuits are low-pass filters passing the band up to 10 megacycles, the shunt capacitances serving to attenuate higher frequencies. For the carrier band, tuned circuits arranged to pass the 41-50 megacycle band are switched into the plate circuits, the low shunt resistances serving to broaden the pass band to the required degree. Control of the output level is accomplished by means of a potentiometer voltage divider inserted into the circuit between the mixer and the amplifier tubes.

Pre-Emphasis and Audio Oscillator

One of the important features of commercial f-m transmission is the possibility of using high-fidelity reproduction. While the f-m transmission system has within itself a very considerable discrimination against noise, this inherent reduction of extraneous noise is not sufficient to satisfy the requirements of completely "noiseless" high-fidelity reproduction when the receiver is opened up to pass 10,000 or 15,000 cycles per second. Hence the introduction of high frequency pre-emphasis into the system. To permit the receiver designer to investigate the restoring or de-emphasis circuits of his receiver with either single frequency or program tests, a standard pre-emphasis circuit is included in the audio circuits of the generator. It can be included in or cut out of the circuit by a panel

control switch. The standard pre-emphasis transmission curve is shown in Fig. 3.

The generator includes other features not ordinarily found in laboratory type signal generators. For example, the frequency modulation makes possible the tracing of selectivity curves on an oscilloscope. To permit this, connections for synchronizing the sweep of the oscilloscope are provided. Also instead of the one or two audio frequencies usually provided in the internal modulating oscillator, this generator has five, covering the audio range. They are 100, 400, 1000, 4000, and 10,000 cycles per second with under 2 per cent harmonic distortion, sufficient for all but the most exacting tests. Therefore the generator does not ordinarily require the use of an external modulating oscillator.

Output Measurement

Like most other modern signal generators, this one employs a vacuum-tube voltmeter to measure the output voltage. The measurement must be made at a level sufficiently high to obtain reasonable stability of calibration, good scale distribution, and interchangeability of rectifier tubes, and a level of one volt is about the minimum that will satisfy these requirements. The rectifier circuit is of the diode type, using a 6H6 tube with the two sets of elements connected in parallel, this having been shown by experience to be the most satisfactory and stable arrangement. After establishing the one-volt level by direct measurement, the output voltage is attenuated in a conventional ladder type attenuator network of resistances, to the microvoltage level desired. The degree of attenuation is of course controllable by the operator so that all of the various microvoltage levels ordinarily used in receiver testing are available. The network includes six 10-to-1 steps of attenuation, thus giving output voltages of 100,000, 10,000, 1000, 100, 10, and 1 microvolt when the voltage at the input of the attenuator is 1 volt.

To obtain values of voltage intermediate between the levels mentioned, it is necessary to include some auxiliary means of voltage division, finely adjustable over a

10-to-1 range. This can be done by a slidewire or other type of calibrated potentiometer, but recent practice has been to avoid such elements, experience having shown them to be sources of unsatisfactory operation and maintenance difficulty. The trend is toward the use of the input voltmeter as an indicator of fine increments of output voltage. The input voltage fed to the voltmeter is made adjustable by means of a control which need not be calibrated, and the exact value of voltage is read from the meter scale. This system can of course only be used when the signal generating source is of a type whose carrier frequency and modulation characteristics are completely independent of load circuit variations, a condition which is fully met by the heterodyne generating system with its associated amplifier.

The use of the output voltmeter for obtaining the fine division of output voltage brings up certain problems which are of much less importance when it is used only at a fixed level:

1. The shape of the meter scale (distribution of scale points) must be such as to permit accurate reading over a 10-to-1 range.

2. Meter damping must be such as to permit reading soon after a change in level has been made.

3. The calibration should not change when a voltmeter tube is replaced, or at least some simple adjusting means must be provided to permit regaining the original calibration.

Requirement 1 is made somewhat difficult to meet by the fact that all diodes show a non-linearity of characteristic at low input levels, up to about 0.3 volt impressed. This tends to crowd the scale at the low values. A one-volt voltmeter, of the type used in this generator, has a meter current at one-tenth of full scale of only 3 per cent of full scale current instead of the 10 per cent it would have were the characteristic truly linear.

The third requirement is met by selection of tubes. About 60 per cent of a given lot of tubes are found to yield calibration curves falling satisfactorily close to the average, and these are selected for use in the instruments and as replacements for future requirements. It is necessary to age all of the voltmeter tubes for at least fifty hours in order to stabilize their characteristics, before running the calibration curves.

Attenuation System

Although not at first fully appreciated, it is now an accepted fact that high sensitivity is even more valuable in frequency-modulation than in amplitude-modulation receivers. This means that testing will be done at low levels and the signal generator must furnish them, if it is to be fully useful. This is the reason for the inclusion of six 10-to-1 steps of attenuation, giving a low output range from 1 down to 0.1 microvolt. Naturally the use of such low levels places severe requirements upon the design of the attenuator and on the shielding of the whole generator structure. It might seem that any f-m signal generator of the type described would get by with less shielding than is used on other generators, since the output frequency is generated at a fairly low level and there are no oscillating circuits carrying large circulating currents of output frequency, as in the case of conventional a-m generators. This is not true to the extent that first appears, however, for there are present the rather high energy levels of the two fundamental oscillators. This energy if radiated might interfere with nearby test positions in which operation in the 20 to 30 megacycle region was being carried on. When sufficient shielding is applied to bring the 20 to 30 megacycle leakage down to a low value, the result is to bring the leakage fields at the desired output frequencies to very low values, so low that the generator is capable of being operated satisfactorily without its external case, on the bench closely adjacent to a sensitive receiver, without causing stray pickup difficulties or apparent output voltage errors.

The attenuator proper departs from usual practice in that it employs a pushbutton type of gang switch instead of the usual rotary switch. This improves considerably the convenience of operation of the instrument, but brings with it a number of new problems in connection with the arrangement of parts, shielding, control of current flow and so on, all of which were well worked out and known for the old

concentric box type of attenuator structure, but which had to be re-investigated in the new arrangement. It was found necessary to isolate the current-carrying parts of the switch from the mechanical actuating parts by a shield plate, so as to keep stray currents out of the actuating mechanism. Without this precaution, there was enough coupling between input and output of the attenuator to make it impossible to obtain a correct 10-to-1 ratio from the sixth step, although a five step attenuator might have been satisfactory.

As in all signal generators, the output impedance of the instrument was made as low as possible considering the necessary compromise between power available, maximum voltage desired, and the ideal zero source impedance. The r-f source used, a 6AC7 (1852) tube, was found to be able to maintain one volt, with a little margin of safety, across 500 ohms. This is therefore the impedance level which obtains when the one volt output tap is used. The attenuator network was then designed to have a 50-ohm impedance at the output of the first 10-to-1 step, or 100,000-microvolt level, and a 5 ohm impedance on all of the succeeding steps. By using for the output transmission line a concentric cable whose impedance was 50 ohms, it was possible to use this cable on all steps of the attenuator except the highest or one volt tap, so that the advantages of the terminated transmission line output system could be realized for all output voltages up to 100,000 microvolts. Voltages between this value and the maximum of one volt must be obtained by plugging into a special jack provided on the panel. To attempt to provide one volt of output at an impedance level of 50 ohms would have meant a ten-fold increase in the power output capabilities of the amplifier system. This in turn would have resulted in a great increase in the amount of heat dissipated within the instrument, aggravating the frequency drift tendencies. Due to the use of the heterodyne method of generation, frequency drift in this generator is somewhat worse than in conventional types. In an effort to minimize temperature rise, the power pack was not included in the instrument case proper, but is assembled as a separate unit.

THE ELECTRON ART

Automatic control of airplanes by radio, a photoelectric turbidimeter, frequency modulation of quartz crystal oscillators, and stereophonic recording with standard disc records are discussed in this month's review of technical literature

Automatic Control of Aircraft

AUTOMATIC CONTROL OF AIRCRAFT is discussed by C. D. Barbulesco in the March 1941 issue of *Electrical Engineering*. Advances in the last few years in both aviation and aircraft radio have made the solution of this seemingly difficult problem quite simple. Two methods have been successfully developed. In the first method the control operator sends into space a definite number of electromagnetic impulses using an ordinary telephone dial. It is obvious that if the operator is on the ground, the radius of action of such a device is quite limited because the airplane must remain in full sight of the operator at all times. In order to increase the range of this system, it is necessary for the control operator to follow it in another airplane.

A much more useful method of automatic control makes it possible to navigate a pilotless airplane over a pre-determined course of considerable length and to land it safely at the end of its journey. This operation can be entirely automatic and can be performed in any weather conditions and without the presence of a control operator.

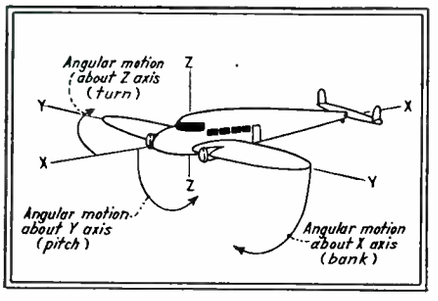

Fig. 1—An airplane has freedom of motion about three axes and is controllable by remote means in each of them

The success of this method was made possible by the development of six devices of novel design. They are: (1) the automatic pilot which maintains the airplane in proper flying attitude; (2) the radio compass which is capable of controlling the rudder of the airplane through the automatic pilot, and thus can direct the aircraft toward a desired guiding radio station on the ground; (3) the ultrahigh-frequency marker beacon which is associated with the radio guiding station. When the airplane arrives over the guiding station

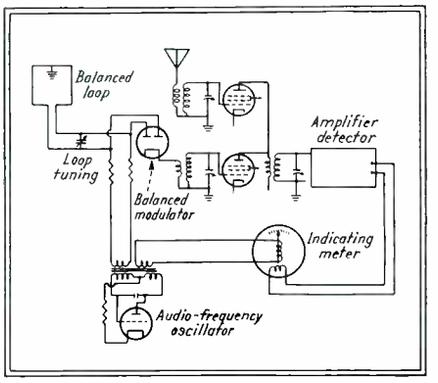

Fig. 2—Simplified circuit diagram of the radio compass

the marker beacon controls certain instruments on the airplane to automatically dispatch the airplane to the next predetermined guiding radio station; (4) An altitude control mechanism; (5) a power control device and (6) an interlocking electromechanical system to coordinate and synchronize the automatic landing operation.

The attitude of the airplane in flight is maintained by the artificial horizon through the automatic pilot. A small airplane is painted in silhouette on a dial in front of a pointer bar, which is connected to a gyroscope spinning about the vertical axis. As the airplane banks, climbs, or dives, the silhouette does likewise, but the pointer bar, being actuated by the gyroscope, remains horizontal. To maintain proper flight attitude, it is only necessary that the silhouette of the small plane be kept in line with the bar and parallel to it.

The automatic pilot also makes use of the directional gyro to keep the airplane on its course. The relative movements between the gyros and their casings are converted into movements of a hydraulic servo unit by means of air pick-offs and air relay systems. The servo unit in turn provides power for moving the proper controls.

With the aid of the radio compass the pilot can fly toward a known radio station on the ground. A simplified diagram of this compass is shown in Fig. 2. It consists of a vertical non-directional antenna, a receiving loop mounted perpendicular to the longitudinal axis of the airplane, a balance modulator, a conventional aircraft radio receiver, and a right-and-left indicator. By maintaining the needle in zero position, the pilot can head the airplane toward a control station or away from it. As long as the airplane flies toward the radio station, the plane of the loop is parallel to the magnetic lines of force of the radiated field and there is no electromotive force induced in the loop. The needle of the indicator remains at zero until the airplane is steered to the right or to the left. The electromotive forces induced in the loop, when its normal takes two symmetrical positions with the course, are 180 degrees out of phase. The balanced modulator compares these phases in the two coils of the electrodynamometric indicator. As may be seen from Fig. 2, the fixed coil is fed directly with the low-frequency current generated by the modulator, while the moving coil receives the rectified component which modulates the incoming carrier.

The Air Corps has developed a method of causing the right and left movements of the radio compass indicator to correct the directional gyro in the automatic pilot in order to maintain the true heading of the airplane toward the radio station. By means of this method the airplane can be flown to its destination merely by tuning the radio compass to a radio station located in the vicinity of the landing field.

By means of the ultrahigh frequency marker, a positive indication is given of arrival over the control radio station. Each control station is a conventional transmitter in the range of 200 to 400 kilocycles, and at ultrahigh frequency marker-beacon projectors. Each non-directional transmitter has a different frequency, while all the ultrahigh frequency markers operate at 75 megacycles.

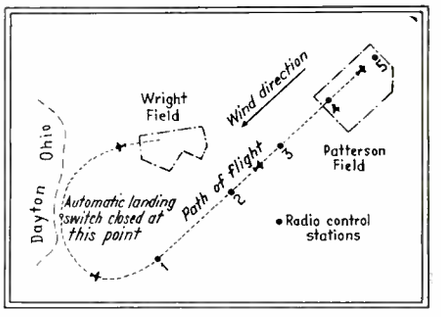

Fig. 3—Path of flight during an automatic landing

In an automatically controlled airplane the sequence of operation is somewhat as follows: Once the plane is in flight its direction is controlled by the radio compass which directs it toward a certain radio control station. As the plane flies over the station the energy received by the marker-beacon receptor actuates a relay which advances a selector switch one step. The arm of the selector closes a contact to actuate the tuning mechanism of the radio compass. The compass is then tuned to the frequency of the next control station along the flight path. The airplane then flies toward the new station where the same series of operations takes place. The sequence of tuning the radio compass to control stations along the route must of course be pre-set.

The automatic landing of the airplane is negotiated as follows: Assume that the airplane is flown at an altitude of 1,000 feet within the range of station 1. The radio compass is tuned to this station and the airplane is automatically flown toward it. Arriving over this station the plane enters the field of the marker-beacon projector associated with it. The selector switch advances one step and tunes the radio compass to the frequency of station 2. Now the planes flies automatically toward station 2, gradually directing its flight into the wind following the alignment of the stations. Arriving over the second station the selector switch advances a step further and the compass is tuned to station 3. When over station 3 the contact not only causes the tuning of the compass to station 4, but also closes another circuit actuating the throttle control. This control is identical with the automatic tuner of the radio compass using a cam preset for a position of the throttle corresponding to a glide of about 400 feet per minute. Over station 3 the airplane starts to glide into the field and if there is no wind arrives over station 4 at an altitude of about 200 feet. Passing over station 4 the compass is switched to the frequency corresponding to station 5, located on the other end of the field, and the airplane maintains the proper heading into the wind until the wheels touch the ground. The impact produces a displacement in the landing gear closing a switch which closes the throttle. After rolling over the ground a short distance, the tail drops and the airplane automatically comes to a complete stop.

If the landing glide is much steeper than normal, a phototube relay which operates in conjunction with a barometric altimeter with a small mirror attached to its hand, closes the circuit controlling the throttle, setting it in a forward position for level flight. When the airplane arrives over the control station 4, located at the boundary of the field, the selector switch again actuates the throttle control setting it for normal glide.

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Television Studio Technique

THE TECHNIQUE of operating a television camera in a studio is discussed in an article entitled "Photographic Aspects of Television Operations", by Harry R. Lubcke in the February 1941 issue of the *Journal of the Society of Motion Picture Engineers*. A comparison is drawn between the operation of a television camera and a motion picture camera, pointing out the greater difficulties in television because if mistakes occur, retakes are impossible and they must be covered over in some manner right on the spot. In this respect the television camera principle is similar to that of newsreel cinematography, where the action must be followed and composition, focus and other operative adjustments must be maintained almost subconsciously. Va-

rious methods of focusing a camera and several viewfinding methods, including those using optical means and those using a cathode-ray monitoring tube, are discussed.

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Steatite Insulation Standards

THE MECHANICAL standards of a number of Steatite electrical insulation units are presented in a booklet entitled "NEMA Steatite Electric Insulation Standards." Standard sizes are given for unglazed insulators such as posts, tubes, rods, bars, plates, cups, etc., along with standard tolerances.

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Frequency Modulation of Quartz Crystal Oscillators

"FREQUENCY MODULATION of Quartz Crystals by means of Variable Resistance Devices," an article by Isaac Koga, appears in the May 1940 issue of the *Electrotechnical Journal*. In order to minimize the effects of fading in long distance telegraph communication it is often necessary to modulate the carrier with a suitable low frequency. Under these operating conditions the sidebands occupy as much as 20 kilocycles on each side of the carrier and therefore cause interference with adjacent channels. If the degree of modu-

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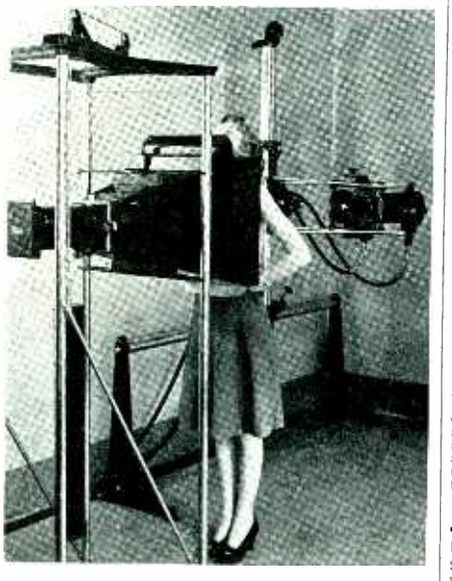
IMPROVED RADIOGRAPHIC TECHNIQUE



The newest type of rotating anode x-ray tube is used in this radiographic method of examining large areas of the body. An x-ray photograph of the girl's chest is made on a small film at the extreme right. The film need not be life size as was formerly the practice

lation is reduced to overcome this, there is danger of losing the advantages of frequency diversity.

A method previously developed utilized a rotating condenser in series with an oscillating crystal plate and another in parallel with it, the combination being driven by a single synchronous motor. The combined effect of the rotating condensers was to nullify each other in so far as amplitude of oscillation was concerned, but to act in unison with regard to frequency variation. The disadvantage of this arrangement was the electrical failure of the brush contact used on the condensers to pass the high-frequency currents.

The author describes an electrical method which eliminates rotating parts and uses instead a variable resistance device to obtain the desired results. The circuit is shown in Fig. 1. It consists of a source of modulation and two rectifiers arranged with the point "*a*" connected to the modulating condenser and neutral point "*b*" connected to the

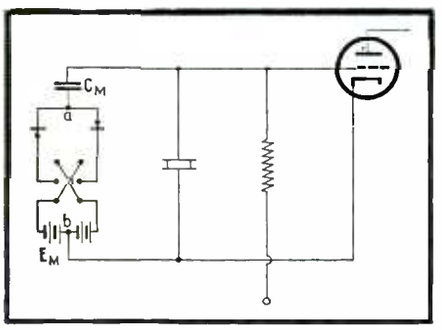


Fig. 1—Diagram of the basic circuit of the variable resistance crystal oscillator

cathode. With suitable voltage from E_m in the direction of conduction for the rectifiers, the high frequency components of current will flow from *a* to *b* and from *b* to *a* so that C_m is effectively in parallel with the crystal. When E_m takes a high value in the opposite direction, the high frequency current no longer flows through the rectifiers and C_m is disconnected. This will cause the frequency of the oscillator to vary with the alternate connection and disconnection of C_m to the quartz crystal. If the source of modulation is a low frequency a-c current, the carrier frequency can be modulated at that frequency.

In practical application the rectifier must be carefully selected. If selenium or cuprous-oxide rectifiers are used they will act as capacitances rather than variable resistance and therefore cannot be used. This difficulty can be overcome by utilizing a vacuum tube for the purpose.

The author discusses the characteristics of the modulating device at high frequencies and also presents curves which show the variation of oscillation frequency against modulating voltage E_m.

Sensitization of Photoelectric Surfaces

"PHOTOELECTRIC SENSITIZATION of Alkali Surfaces by Means of Electric Discharges in Water Vapor," by J. Tykocinski Tykociner, Jakob Kunz and Lloyd P. Garner, is presented in Bulletin Series No. 325, of the University of Illinois Engineering Experiment Station. The subject matter describes research work which was undertaken by the authors to develop an efficient method of sensitization of surfaces of alkali metals by means of electric discharges in water vapor. Atomic hydrogen as a factor in sensitization, sensitization by means of beams resulting from the dissociation of water vapor and sensitization by means of electric discharges in pure water vapor form the main chapter heads of this booklet. A new method of sensitizing alkali surfaces is discussed which makes possible an increase of about fifty times the photosensitivity of the untreated alkali surface.

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Photoelectric Turbidimeter

A SIMPLE PHOTOELECTRIC turbidimeter is described by Shirleigh Silverman in the February 1941 issue of the *Review of Scientific Instruments.* This instrument is used for determining the turbidity of almost clear solutions and with proper filters may also be used with colored solutions. In practice a difference of several microamperes on the indicating meter is indicated between distilled and tapped water, accurate to about 0.5 microamperes. It has been used successfully at the upper end of 200 to 300 times the turbidity of water in such materials as nitrocellulose lacquers.

A schematic diagram of this photoelectric turbidimeter is shown in the accompanying illustration. S is a light source which is a 32-candlepower automobile headlight lamp with a prefocused base. This lamp is operated from a voltage regulator to give a constant light intensity. C is a condenser made up of two plane convex elements 6 cm in diameter. G_1 and G_2 are two grids consisting of alternate bars and open spaces which are equal in size. There are four bars in each grid, each

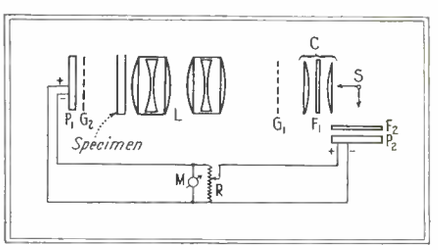

Diagram of the circuit and optical system of the photoelectric turbidimeter

ground to a fine feather edge and the entire grid blackened to reduce diffraction and reflection to a minimum. L is a pair of 4-inch objective lenses sliding in a tube for focusing adjustment. G_1 is fastened rigidly to the base plate and G_2 is set in a holder which will permit motion in any direction, including rotation at a few degrees on either side of the vertical. P_1 and P_2 are photocells of the dry-disk type. F_1 and F_2 are heat filters. Each heat filter is 2 mm thick. M is a 50 microampere meter.

The operation of this instrument is as follows: The condenser C is placed so as to completely illuminate grid G_1 which is set with its feather edge away from the light source. The lens system L is adjusted to form an image of unit magnification on G_2. The latter is then adjusted also with a feather edge away from the light so that the image of the first grid is exactly out of phase and no light passes through to the photocell. In general there will be some stray light escaping through to the photocell due to insufficient optical correction of the lens system. This is balanced out by a second photocell and by proper setting of the rheostat R, whose resistance is several hundred ohms.

The sample to be tested is placed in an ordinary 1-cm absorption cell and placed in the light beam. Any suspended material will scatter light so that the image of G_1 will no longer be sharp and the light will be scattered into the shadows cast by the bars of G_2. This scattering is very nearly a linear function of the concentration of scattering particles for solution in which the intensity of light remains much greater than the total scattered light. For extremely sensitive work a galvonometer, such as the Rubicon 3403 HH 1100-ohm galvanometer of 0.005 microamperes per millimeter, replaces the microammeter.

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Stereophonic Recording with Conventional Disk Records

A METHOD OF STEREOPHONICALLY recording sound on conventional disk records is discussed in an article entitled "Experiments with Stereophonic Records," by K. de Boer in the June 1940 issue of *Philips Technical Review*. Two grooves modulated with the sound are cut on the record, one in the outer portion of the record and the other in the inner portion of the record with a smaller diameter. A number of difficulties arise from the use of the grooves at different radii on the record. The author analyzes these problems and offers solutions to them so that the system will perform in a satisfactory manner.

In recording, two cutter heads mounted on a shaft on the radius of the recording disk move in a straight line along a radius of the disk. In reproduction, on the other hand, the two pickup heads are fastened to the end of a rotating arm and thus describe an arc of a circle on the disk. Due

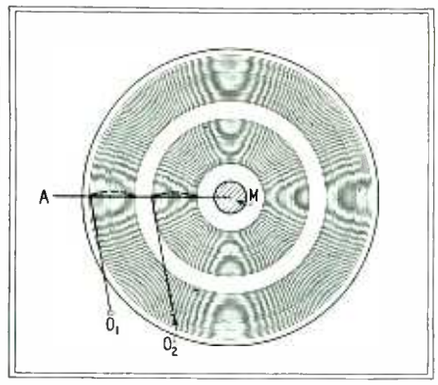

Fig. 1—Stereophonic record showing two sound-tracks

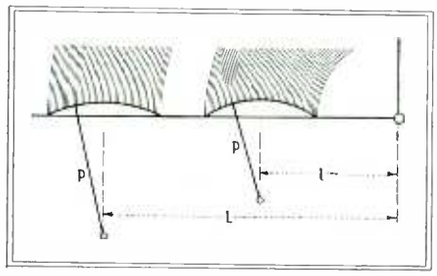

Fig. 2—The pickup arm of the inside sound track is shorter than the other

to the fact that in reproduction the needle describes a different path on the disk than in recording, time differences occur. The arms of the pickup are therefore adjusted so that the needles stand exactly on the same straight line of recording at the beginning and end of the sound track, as shown in Fig. 1. It may be seen that during the playing of the record the two sound tracks experience first a gradually increasing and then a decreasing retardation. This would cause no shift in the sound image if the deflection from the recording straight line were equal for both sound tracks. This, however, is not the case although the deviation of the needle is the same on both sides. Due to the difference in speed of the disk at different distances from the center, the same differences do not correspond to these equal deviations. If the lengths of the pickup arms are of unequal lengths such that the product of the arm length and the distances from the center line of the record are equal as shown in Fig. 2. Problems of placing the pickup needles in the proper places on the sound track and the effect of eccentricity of the phonograph axis are also considered.

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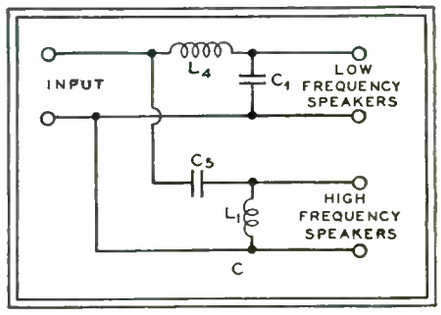
A Correction

"Loudspeaker Dividing Networks" by John K. Hilliard which appeared on page 26 of the January 1941 issue contained an error in Fig. 1C. The correct diagram is published herewith.



MEASURING BRAIN REACTION

An electrical device which makes it possible to measure reactions of the brain so as to enable the facilitation of brain disease diagnosis is being used successfully at the Grace Hospital's Outpatient Department, at Detroit, Mich. The instrument records electrical potentials generated by the brain and picked up by means of electrodes applied to the head. Cases dealing with various brain and spinal diseases have been diagnosed

Television Signal Boosting

(*Continued from page* 41)

sistors were used, one in series with each lead, to improve the impedance matching. These same resistors were connected to the microvolter output posts when the instrument was connected to the input of the preamplifier and the booster fed through them.

Two curves were taken on the receiver with the a-v-c action switched off. The first was plotted showing microvolts input against volts output as measured at the speaker voice coil with a rectifier type voltmeter. The receiver r-f gain and a-f gain were set at convenient values and maintained constant. The input was varied from 0 to 500 microvolts. It was found that the receiver response was linear over this range. The second curve was taken to show volts output (at voice coil) vs frequency over the range 48 to 58 megacycles. The input was held at 400 microvolts.

Calibrating the Preamplifier

The microvolter was set to deliver 50 microvolts and connected through the series resistors to the preampli-

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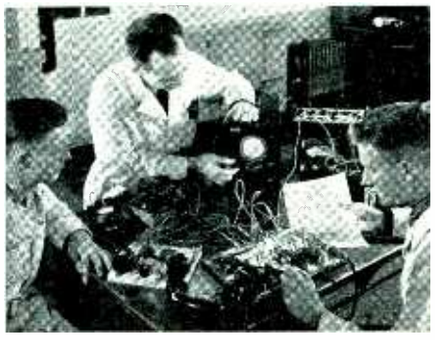
AVIATION STUDENT STUDIES RADIO



Radio has become such an essential part of airplane operation that it is required that students understand the principles involved in the transmitting and receiving of messages. Also, they are required to be familiar with the construction and maintenance of various types of apparatus. To be sure that its personnel is well trained, Boeing has inaugurated an aviation school in which radio is taught as a required subject

fier input. The receiver was connected through the 8-foot cable to the preamplifier output. The booster was aligned at 54.75 megacycles (picture carrier for station W2XBS). The frequency was then varied over the range 48 to 58 megacycles and readings of the voltage across the voice coil (with receiver adjustments undisturbed) were taken at various values of frequency. The correction factor was computed from the receiver curve. The response curve of the preamplifier was thereby obtained. It will be noted that this curve has a flattened hump in the vicinity of the picture carrier frequency, that it falls off rapidly towards the adjacent channel (towards 60 megacycles) but more slowly towards the sound carrier.

The booster was also tested in various locations in Philadelphia. Reception without the preamplifier was so weak that synchronization was impossible. With it, clear steady pictures were obtained.

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AMERICAN GIFT FOR AIR RAID SHELTER

An attendant places a record on a newly installed loudspeaker phonograph in the Holborn Subway air raid shelter of the London subway. This is the first of five similar sets to be installed in the shelters for entertainment of those forced underground in air raids. These units are shipped from the American Committee for Relief of Air Raids

Resistors For U-H-F

(*Continued from page* 28)

A suitable probe voltmeter was employed to explore the voltage distribution along this transmission line. Figure 7 shown the results at four frequencies: 57, 66, 81, and 125 megacycles. We see that at frequencies as high as 81 megacycles, the termination is very good, while at 125 megacycles the termination is good enough for many applications, since the reflection is still less than six per cent.

The authors wish to make acknowledgement to the International Resistance Company, Philadelphia, which furnished special sample resistors used in this development.

Theoretical Treatment

In order to determine the proper design constants for the resistor shown in Fig. 4, we treat the unit as a transmission line which has high resistance per unit of length and which is short-circuited at the far end. Because of the extreme thinness of the carbon film, we are safe in assuming that the high-frequency resistance per unit length is the same as the d-c resistance per unit length.

Let L = inductance per unit length
C = capacitance per unit length
b = inner diameter of the metallic outer conductor of the high-resistance transmission line
a = outer diameter of the resistor
$Z_o = 60 \log_e \frac{b}{a} = \sqrt{L/C}$ = the characteristic impedance which the high-resistance line would have if the resistance per unit length were zero
f = operating frequency
$\omega = 2\pi f$ angular velocity
λ = free-space wavelength of the operating frequency
h = length of the resistance tube
R = resistance per unit length along the tube
R_u = total d-c resistance of the unit

We define a parameter, k, such that

$$R = k\omega L = k2\pi Z_o/\lambda \qquad (1)$$

The characteristic impedance of the high-resistance line is

$$Z_c = \sqrt{\frac{R + j\omega L}{j\omega C}} = Z_o \sqrt{1 - jk} \qquad (2)$$

The propagation and attenuation constant is

$$\alpha = \sqrt{(R + j\omega L)(j\omega C)} = \frac{2\pi}{\lambda} j \sqrt{1 - jk} \qquad (3)$$

Figure 8 shows some of the relations as a function of the parameter, k. We have shown the absolute value, $|Z_c/Z_o|$. On the same curve sheet is shown the phase angle of the characteristic impedance, $\overline{Z}_c$. Another curve in this figure also shows v/c, where $c = 3 \times 10^{10}$ centimeter per second = velocity of light in free space, and v = the velocity of waves traveling along the high resistance transmission line. Note that the characteristic impedance always has a negative phase angle, which approaches 45 degrees as the parameter k becomes large. The input impedance of the short-circuited transmission line is

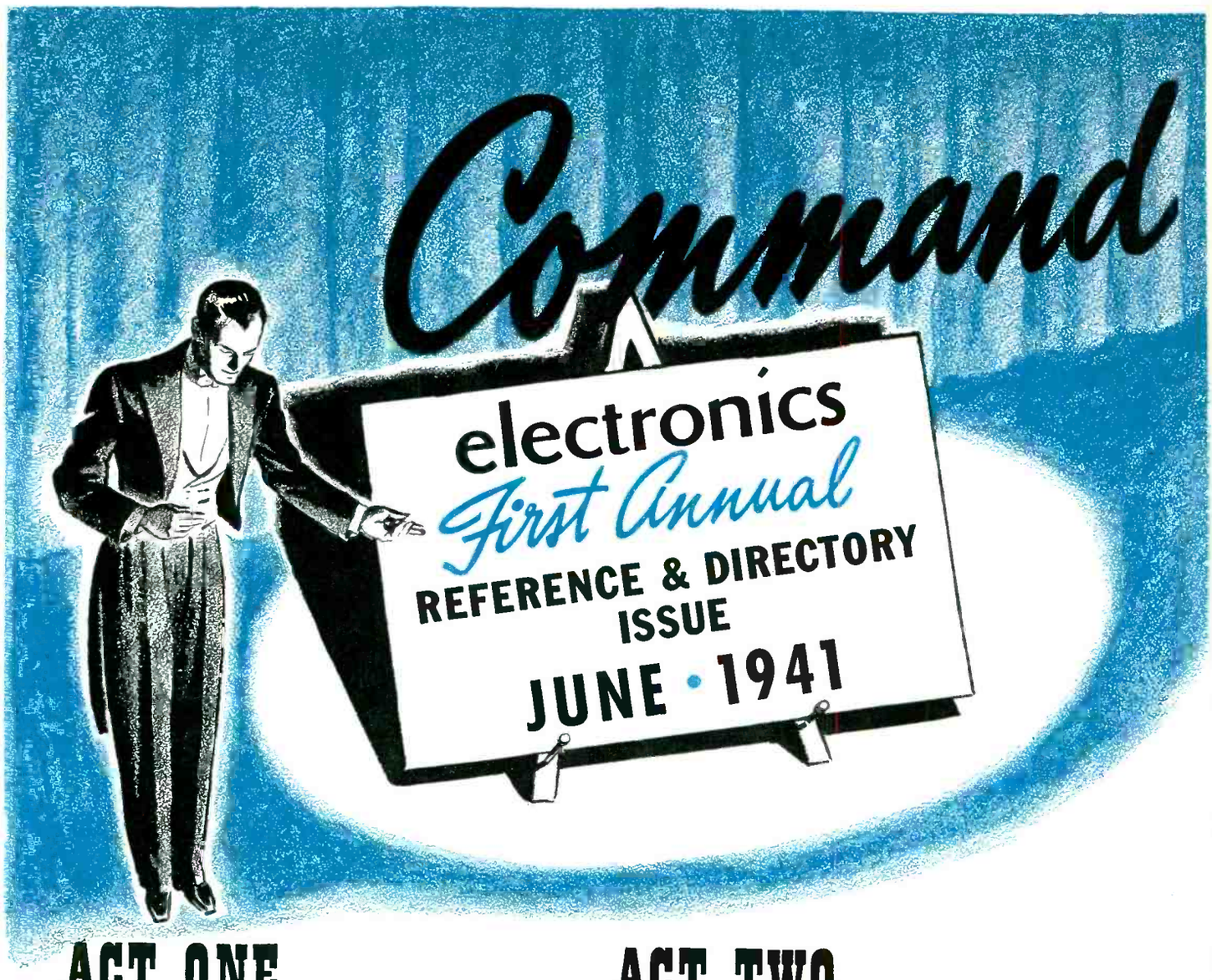
$$\overline{Z}_{in} = \overline{Z}_c \tanh(\alpha h) \qquad (4)$$

The input impedance may be expressed in terms of Z_o, since Z_c is given in terms of Z_o. We may also write

$$\overline{Z}_{in} = |\overline{Z}_{in}| < \phi \qquad (5)$$

Figure 9 gives the magnitude of the input impedance, in terms of Z_o, as a function of resistor length for a variety of values of the parameter k. Figure 10 shows the phase angle ϕ as a function of resistor length, with k as a parameter[3]. It is seen that for a given value of k, there is a definite value of h/λ for which the phase angle becomes zero, that is, the input impedance becomes a pure resistance. As k increases, this critical value of h/λ becomes smaller. Because of our interest in zero reactance resistors, Fig. 11 was built up from Figs. 9 and 10. The abscissa is $1/k$. The value of h/λ which yields zero input reactance for a given value of k is shown on this curve sheet. The corresponding values of Z_{in}/Z_o are shown, as well as R_h/Z_o, and R_h/Z_{in}. The term Z_{in}/Z_o is taken from Fig. 9 while R_h/Z_o is obtained quickly from the relation $R_h/Z_o = k2\pi h/\lambda$. It was

[3] The quantity α is a complex number. This would make the hyperbolic tangent determination rather laborious were it not for the tables, "Chart Atlas of Complex Hyperbolic and Circular Functions," by A. E. Kennelly, Harvard University Press, 1914.



ACT ONE

THE COMPLETE DIRECTORY— There has never been anything as useful under one cover before. A COMPLETE directory of *all* manufacturers of: Receiving, Transmitting and Industrial Components, Circuit Elements and Sub Assemblies . . . Raw and Fabricated Materials . . . Tubes . . . Electrical Measuring Equipment . . . Broadcast and Radio Equipment . . . Industrial Electronic Control Equipment, and Machinery . . . Public Address and Sound Equipment . . . Electronic Medical Apparatus . . . Services, Schools, Etc., Etc.

The ELECTRONICS subscriber will have at his elbow a *complete* source index for a year.

ACT TWO

THE REFERENCE COMPENDIUM— An up-to-the-second Electronic-Electrical Engineers library of Formulary and Data.

Charts, tables, listings, formulas and equations which will answer current engineering problems in the following fields: Industrial Measurement and Control . . . Manufacture of Radio Transmitters and Receivers . . . Frequency Modulation and Television . . . Broadcast, Police, Aircraft, UHF, etc., Communication . . . Research and Development . . . Tube Manufacture and Use . . . Antennas.

Invaluable, *new* working material for the all-important business of electronic engineering progress.

Added Attraction — *For advertisers interested in the radio industry* — The First Annual Reference and Directory Issue of ELECTRONICS will be on hand in our booth at the Radio Parts National Trade Show, Hotel Stevens, Chicago, June 10-13 . . . It will be placed in the hands of the key men of the industry at that show. *ONE MORE PLUS VALUE OF THIS GREAT ISSUE.*

Performance

A CONTRIBUTION TO THE NATIONAL EMERGENCY

OKAYED BY ELECTRONICS READERS

This new, dual-purpose issue was inspired by the acceleration of need for product-source information and latest engineering data brought about by the National Emergency.

To check our idea of the need for a complete directory we questionnaired a generous cross section of ELECTRONICS circulation for the reaction. More than a quarter responded, and the demand for such a directory was 89.5% of the total. In this questionnaire we did not mention the Reference Compendium. Had we done so the demand would probably have been near 100%. This is our added contribution to subscribers.

We are bringing the issue out in June because:

1. This is mid-season for the radio engineers and, we believe, for a majority of the others who subscribe.

2. Traditionally the June issue of ELECTRONICS renders an extended editorial service.

3. It dovetails into the parts show, attended by all types of engineers interested in electronic components.

The Time is Right for Best Results

A Twelve Months' Run

Whenever ELECTRONICS puts out an augmented issue, it is done primarily as an added service for the subscribers.

In the same light, we believe it to be an added service for the subscribers to have the greatest possible representation of advertisers.

Consequently, we will list all advertisers in BOLD FACE in the directory section with a reference line showing the page upon which the advertisement appears. This gives the advertiser a chance to present his first sales argument right in the issue, at the time a prospect is looking for names of companies from whom to purchase.

This Dual-Purpose Issue will LIVE — will be used repeatedly throughout the year. We do not believe ELECTRONICS has EVER presented such an advertising value at regular space rates.

from Fig. 11 that Fig. 5 was obtained.

In Figs. 9 and 10, the value h/λ varies because of an actual physical variation in the length of the resistor as the frequency remains constant. The curves of these two figures, together with those of Fig. 5, are useful for design purposes, but for a better picture of what is happening we must construct curves which show the impedance variation as a function of frequency for a fixed resistor. As a first example, let us choose a resistor of such a length that at a specific frequency f_o, h/λ is 0.228 and k is 0.5. From Eq. (1), the d-c resistance, R_h, is $0.716Z_o$. Now as the frequency departs from f_o, k and h/λ change in value. If we compute these new values and apply them to Figs. 9 and 10 we may then compute the frequency characteristic of the resistor. This was done to obtain the curves of Fig. 12. We see from Fig. 12 that the resistor characteristic is very critical in the neighborhood of f_o, so that the resistor might be used to terminate a line at this frequency, but would not be useful at other frequencies.

Figure 13 shows a frequency characteristic of a resistor which has the properties that k is 1.0 and h/λ is 0.188 at f_o. This characteristic is much flatter with frequency and less reactance is present. Figures 14 and 15 show the characteristics as we proceed still further along the line of shortening the resistor. In Fig. 15, where at f_o, h/λ is 0.535, we see a characteristic which is ideal for matching a transmission line. If we choose f_o as the highest frequency at which we wish to operate, we will be sure of a good characteristic at all of our operating frequencies.

From Fig. 5 we see that the total d-c resistance is very nearly equal to the input resistance for short values of the resistor. It is relatively easy to make the d-c resistance have this value. However, it is not always convenient (because of a limited number of diameters of the ceramic tube) to make Z_o equal to the value specified on the curve.

However for h/λ less than 0.03, the input impedance is rather insensitive to changes in the value of the characteristic impedance Z_o, where Z_o does not depart more than 25 per cent from the best value.

Power Supply Charts

(Continued from page 44)

sented herein is shown by the following widely different applications:

Illustrative Example 1

Consider a half-wave choke-input rectifier for a receiving tube power supply.

$C = 8$ microfarads
$L = 10$ henries
$\omega = 377$ (60 cycles per second)
$\omega^1 = 111.5$
$\rho = 0.296$
$i = 20$ milliamperes
$S = 6.95$ per cent
$R = 400$ ohms
$E_0 = 600$ volts

From Fig. 4, we find $\sin \alpha = .59$, $\alpha = 36°$. From Fig. 5, $\theta = 162°$. $iR\pi/\theta = 8.9$ volts, P is less than 1 per cent and therefore neglected, and hence the d-c output voltage is: $E_{dc} = 600 \times 0.59 - 8.9 + 600 \times .069(\frac{1}{2} - 162/360) = 348$ volts.

Illustrative Example 2

Consider a voltage-doubling x-ray power supply intended for high current experimental work at 100 kilovolts:

$E_0 = 67.9$ kilovolts
$C = 0.2$ microfarad
$n^2L\rho = 70$ henries
$L^1 = 0$
$\omega = 377$ (60 cycles per second)
$\omega^1 = 277$
$\rho = 0.735$
$i = 100$ milliamperes
$R = 13{,}500$ ohms
$S = 0.12$

From Fig. 4, we find $\sin \alpha = 0.78$, and from Fig. 5, $\theta = 112°$. From Fig. 6, $P = 4$ per cent. From Eq. (12), we have:

$$E_{dc} = 67.9\,(0.12\,(\tfrac{1}{2} - 1/3.2) + 1.04 \times 0.78) - 0.1 \times 13{,}500 \times 180/112$$
$$= 56.5 - 2.17$$
$$= 53.33 \text{ kilovolts per section.}$$

The authors express their thanks to Professor J. W. M. DuMond for suggesting the simplification of the solution of equations (5) and (7) as outlined above.

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[2] C. M. Wallis, ELECTRONICS, March, 1940.
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THE INDUSTRY IN REVIEW

News

✦ To further the application of radio tubes and test equipment in industry, the first of a series of educational meetings was given by the RCA Tube and Equipment Division recently at Pittsburgh, Pa., to more than 100 research, industrial and design engineers. Subjects discussed were the applications of electronic measuring equipment such as the RCA ultra-sensitive d-c meter, noise meters, etc.

✦ Polyphase transmission in broadcasting is to be tested by station WHO, Des Moines, Ia., under an F.C.C. authorization, permitting it to use a power of 150,000 watts betweeen midnight and 6 AM. The purpose of the new method is to increase effective power and to over-ride fading. The system consists of the regular antenna tower and four auxiliary antennas suspended away from the main tower. The main tower transmits the carrier signal only and the auxiliary antennas transmit the side-bands . . . S. J. McDowell has joined the engineering staff of the American Lava Corporation, Chattanooga, Tenn. He will be in charge of production . . . The production level of the Kester Solder Company is at the highest in its history. The site occupied by its Newark, N. J. plant has been purchased and is being made ready for further expansion and improvement. Its Canadian subsidiary, Kester Solder Co. of Canada, Ltd., located in Brentford, Ont., is installing new equipment to keep up with the increasing demands of armament for defense . . . The broadcast of Standard Frequency Signals by the National Bureau of Standards has been extended although still with temporary equipment. It is on the air continuously at all times, day and night . . . The Rubicon Company announces the removal of its entire facilities to a new location of 3751 Ridge Ave., Philadelphia, Pa. . . . Earl Sloan, formerly an engineer with the Illinois State Police and Bendix Radio Corporation, has joined the Engineering Staff of Gates Radio & Supply Co. . . . Thirty-four construction permits have been granted for f-m stations by the F.C.C. A total of 56 applications still await official action . . . Philco Corp has declared a dividend of 25 cents per share to stockholders of record on March 14, 1941 . . . Dr. Frederick A. Kolster has been appointed chief consultant of the Finch Telecommunications, Inc., Passaic, N. J.

✦ Average annual earnings for General Electric employees were $2,011 for 1940 compared with $1,913 for 1939. The number of employees was 88,600 at the close of 1940 with an average of 76,314 for the year . . . The annual report of the Stewart-Warner Corp. indicates a net profit of $1,470,804 for 1940 . . . Western Electric Co. has declared a dividend of 75 cents per share on its common stock. Net earnings for the year were $32,787,030 in 1940 compared with $16,476,086 in 1939 . . . J. I. Cornell, chief engineer of the Solar Manufacturing Corporation, Bayonne, N. J., has been elected a director of that company . . . William H. Wells Productions, 545 Fifth Ave., New York, has been organized for the production of consumer and commercial films. David H. Lion will be general manager . . . General Electric Co. has awarded Charles A. Coffin Foundation awards to 25 employees for 21 distinct accomplishments, four of them joint awards to two employees. Outstanding in the developments was a 1,400,000 volt d-c generator for the National Bureau of Standards by Horace S. Hubbard of the company's Pittsfield works. This generator has five times the capacity of any equipment previously built . . . Brazilian radio amateurs were recently elected to membership in the International Amateur Radio Union. This is the ninth country in the Western Hemisphere to be affiliated with the I.A.R.U. The others are Argentina, Canada, Colombia, Cuba, Mexico, Newfoundland, United States and Venezuela . . . Stephen Nester announces the organization of a new company to manufacture and sell recording and playback needles . . . Clinton B. Allsopp, vice-president of Postal Telegraph, Inc., has been appointed a Major in the United States Army Reserve Corps and assigned to the Advisory Council of communications officials recently formed by Major-General J. O. Mauborgne, Chief Signal Officer, to act as consultant in problems of communications development for National defense.

Literature

Precision Electrical Instruments. Catalog 21 available from DeJur-Amsco Corporation, Shelton, Conn., illustrates all instruments in full size and describes precision products available from them. These instruments include d-c voltmeters, ammeters, ammeter shunts, galvanometers, microammeters, milliammeters, a-c three-inch rectifier type instruments, and decibel meters.

Condenser Catalog. 1941 general catalog covering electrolytic, paper, oil, replacements, transmitting and other condensers, together with descriptions of an L-C checker, capacity-resistance bridge, and motor-starting capacitor selector available from Aerovox Corp., New Bedford, Mass.

Stand-by Power Unit. Diesel power electric generators are described in form 6537 for broadcasting stations, industrial plants and other places which need a dependable source of emergency power. Caterpillar Tractor Co., Peoria, Ill.

Photoelectric Relay. Bulletin GEA-3533 available from General Electric Company, Schenectady, N. Y., describes type CR7505-K100, a new inexpensive photoelectric relay.

Condensed Catalog. A number of indicating and controlling instruments are included in the condensed catalog and the principal items of equipment manufactured by Wheelco Instrument Co., 1929–33 S. Halsted St., Chicago.

Short Wave. A 12-page illustrated booklet entitled "A Short Story on Shortwave Radio Receivers" discusses the advantages of communication receivers in short-wave reception in non-technical language. It is published by Hallicrafters, 2611 Indiana Ave., Chicago.

Varnished Fiberglas. A booklet describing the characteristics of varnished fiberglas, a glass cloth woven from continuous fiber, soda-free yarn and coated with high heat resisting black or clear insulating varnish. Irvington Varnish & Insulator Co., 40 Argyle Terrace, Irvington, N. J.

Solderless Lugs and Connectors. Solderless lugs and connectors in which the end of the cable is held by pressure applied by turning a set screw are described in a circular by the Trumbull Electric Manufacturing Co., Plainville, Conn.

Resistors and Rheostats. A variety of vitreous, wire wound resistors and rheostats are described in Catalog No. 538 of Hardwick, Hindle, Inc., Newark, N. J.

House Organ. *The Ohmite News* for January 1941 contains definitions of standard names to aid in specifying resistance units. It is available from Ohmite Mfg. Co., 4835–41 Flournoy St., Chicago.

Vibrator Manual. Catalog 1-41 contains information on the vibrator requirements of a wide variety of radio sets. The Turner Co., Cedar Rapids, Iowa.

Transformers. A wide variety of audio and power transformers, testing plugs and cords and panels are described in a catalog available from Audio Development Co., 123 Bryant Ave., No., Minneapolis, Minn.

New Products

Three Pole Relay

G-M LABORATORIES, Inc., of Chicago, announce the addition of a three pole relay to their line of Type C Relays. One of the features of the Type C Relays is the self-cleaning wiping action of the contacts. Each time the contacts in the relays close, one contact is drawn a small distance across the other, thereby operating to displace dust particles and to wear through any films of corrosion. The economical production of machine assembly parts, long mechanical and electrical life, and reliable operation are other features. These relays are available for a large variety of operating voltages for either alternating or direct currents, or may be had with any number of contacts to suit a particular job.

Compact Radio Compass and Receiver

THE HALLICRAFTERS (CHICAGO) model S-30 radio compass provides for the small boat a means for taking accurate bearings and also facilitates the reception of broadcast entertainment and marine information. For direction finding it utilizes signals from regular beacon stations, broadcast or other stations within its 3-band tuning range of 220–540 kilocycles (beacon band), 535–1340 kilocycles (broadcast band) and 1200-300 kilocycles (marine band). Accurate null indications are provided both visually by a tuning eye and

aurally by headphones. The receiver is inclosed in a welded aluminum cabinet 11 inches wide, 10⅝ inches deep and 7½ inches high. The loop, mounted in an aluminum casting, brings the overall height to 23½ inches. All operating power is drawn from a 6-volt battery. This and the loudspeaker are external units for remote installation to avoid introduction of magnetic error in compass operation. The 6-tube superheterodyne circuit includes a tuned radio frequency stage on all bands. High gain and selectivity are provided by a 175 kilocycle intermediate amplifier.

Ceramic Dielectric Trimmer Condensers

ERIE RESISTOR CORP., ERIE, PA., announces ceramic dielectric trimmer condensers known as Ceramicon Trimmers which are designed primarily for use in aircraft and mobile transmitters. These units utilize silver electrodes in intimate contact with the dielectric. Made in four styles (three single units and one double unit) they are available in temperature coefficients of 0, -300×10^{-6}/°C., and -500×10^{-6}/°C. with a range of from 1.5 to 45 $\mu\mu$f in the smaller trimmers, and from 4 to 110 $\mu\mu$f in the largest unit. Change in capacity from minimum to maximum is practically constant per degree of rotor

rotation. The mounting base of the trimmers is made of a low dielectric-constant steatite and may be mounted flat against a metal chassis with little increase in minimum capacity. All internal connections are soldered, with the exception of the wiping contact with the rotor shaft. Metal parts are of non-ferrous material and are silver-plated to guard against corrosion. The rotor completely covers the entire track on the stator. Contacting surfaces of the rotor and stator are lapped optically flat to prevent dust and other foreign matter from coming in contact with the electrodes and affecting the characteristics of the condenser. The rotor was specially designed with a high torque averaging 1 inch pound and due to its circular shape is statically balanced so that vibration will not alter the adjustment.

Turntable

PRESTO RECORDING CORPORATION, 242 West 55th St., New York City, has released as a separate unit the dual-speed 12 inch turntable (Model 11-A) formerly sold as part of the model K commercial recorder. The recorder uses a cast aluminum turntable precision machined to dynamic balance. The table revolves on a single ball bearing at the base of a bronze shaft well. A heavy, live rubber tire is fitted to the rim of the table. A metal pulley on the motor shaft drives directly against the tire eliminating idler wheels, rubber tired pulleys, etc. A slip-over pulley is removed to change speed from 78 to 33⅓ rpm. The motor and turntable are mounted on a steel base ready for installation in portable or console phonograph record and 16 inch transcription players. Performance characteristics are: speed accuracy, 4 per cent; speed regulation, .2 per cent; noise due to mechanical vibrations 45 db below zero (0.006 watts).

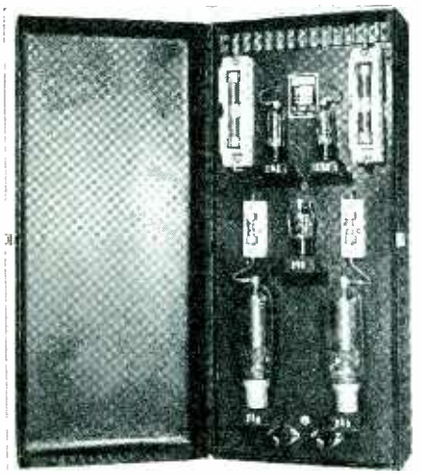
Varnished Fiberglas

GLASS CLOTH, IMPREGNATED and coated with heat resisting varnishes is available for use as insulation by manufacturers of electric motors, generators and similar equipment. This new insulation material, known as Varnished Fiberglas, is furnished in full-width rolls and tape of various widths and thicknesses by the Irvington Varnish & Insulator Company, 24 Argyle Terrace, Irvington, N. J. The material consists of a woven glass cloth base (Owens-Corning Fiberglas) impregnated and coated with a special varnish which increases its resistance to abrasion, impact, and increases its overall mechanical strength. Standard thicknesses range from .005 inches to .012 inches, with widths up to 36 inches, in black or yellow. Special combination of various Fiberglas base cloths, varying in thickness, coating, etc., are available on special order.

Electronic Welding Synchronizer

AN ELECTRONIC SYNCHRONIZER designed to avoid transient current in welding transformers is announced by the Weltronic Corporation, 3080 East Outer Drive, Detroit, Mich. The transients are eliminated by starting the

flow of current at the zero point on the current wave, provided the wave form is approximately sinusoidal. The elimination of transient currents and the resulting stresses and strains give much longer transformer life and in some instances allows the use of smaller



sizes. The synchronizer is housed in a dustproof steel cabinet approximately 30 inches high by 12 inches wide by 12 inches deep for wall mounting and is easily wired to any existing non-synchronous timer. An adjustment for any value of power factor in the welding transformer is provided.

Photoelectric Volt-ohmmeter

A NEW PHOTOELECTRIC volt-ohmmeter known as model 661 has been introduced by the Radio City Products Company, 88 Park Place, New York City. The instrument was designed for flexibility. The input resistance is 16 megohms (low) to 160 megohms; alternating or direct current voltage ranges are from 0.1 to 6000 volts; the resistance range is from 0.1 ohms to 1000 megohms; and the capacity test range is .00005 to 600 microfarads.

Impedance Matching Bridge

AN IMPEDANCE MATCHING BRIDGE developed to provide a fast and accurate method for adjusting and checking coil inductances in production work is announced by Radex Corporation, 1733 Milwaukee Avenue, Chicago. The bridge setup as supplied consists of an oscillator, an amplifier, a cathode ray indicator and the bridge proper. The setup is complete and requires no auxiliary equipment, except for fixtures that the user may find advisable to add to simplify connecting different types of coils to the test terminals. Coils having inductances between less than 1 microhenry and more than 10 millihenries may be compared to a standard with an accuracy of 1/100 of 1 per cent, if desired. Any other electrical elements, such as condensers, having impedances between ½ ohm and 5000 ohms at 100 kilocycles, may be similarly compared.

Portable Radio Equipment

A LIGHT COMPACT, rigid and easily portable radio communication system free of power supply lines and gasoline-engine generators is available from Heintz and Kaufman, Ltd., South San Francisco, Calif. The equipment is divided into three units of approximately equal weight so that it may be comfortably carried by one man. The transmitter-receiver is housed in an aluminum alloy box measuring approximately 12 inches x 12 inches x 6½ inches, the cover of which is removable and can be used as an operating table when it is desired. The transmitter circuit consists of a master oscillator and power amplifier. Tuning is by a single condenser. The power output is 50 watts of CW telegraph power into the antenna or 7 watts of telephone power. The normal frequency range is in two bands from 2½ to 7½ megacycles. The receiver is a 5-tube superheterodyne which has a sensitivity of better than 5 microvolts for 50 milliwatts output. It also covers a frequency range from 2½ to 7½ megacycles and is tuned by a single control. The antenna consists of two 8-foot sectional masts, each with a spike at the bottom to steady it and a large disc to prevent it sinking into the ground. One man can readily direct the antenna in 3 to 5 minutes. Power to operate the equipment is provided by a foot-powered generator cranked in a manner similar to riding a bicycle.

Also available from Heintz and Kaufman are the Types 931 and 933 radio telephone transmitters having six crystal control frequencies and quickly available with a single switch. It has a power output of 50 watts of 100 per cent modulated telephone power and 125 watts of telegraph power on each band.

Package Unit

A FORWARD STEP to simplify the application of electronics to industry is a package unit developed by R-B-M Manufacturing Co., a division of Essex Wire Corporation, Logansport, Indiana. A package unit may contain all electrical and mechanical parts for performing a control or other industrial function. The exact contents of the unit are worked out in consultation between the users engineering department and the R-B-M Company. Typical examples are automatic counting, weighing and dispensing machines, automatic control of production equipment, etc. When specifications are complete all of the necessary installation parts are packed in individual boxes and distributed to the production line where the complete unit may be installed with simple tools.

Ignitron Tube

A NEW IGNITRON TUBE, type GL-415, for resistance-welder control, utilizing a unique water-cooling system, has been announced by the General Electric Company, Schenectady, N. Y. The new tube depends for its cooling upon a special clamp into which it is fitted, rather than upon the built-in water-jacket construction formerly used. Consisting of a brass block with water passages, the clamp not only serves as a cooling medium but also as the cathode connection. There are no water connections to the tube itself, and removal and replacement of tubes may be made easily and quickly. Ability to pass high-peak currents makes the ignitron tubes particularly suited for controlling the current of resistance-welding machines. A pair of the tubes is capable of controlling 265 kva of resistance-welding load on a 5½ per cent duty cycle.

Electronic Remote Controller

THE WHEELCO REMOTE CONTROLLER, recently announced by Wheelco Instruments Co., 1929–1933 S. Halsted St., Chicago, is a vacuum tube oscillator relay, sensitive to the detuning of a pick-up unit by the approach of such objects as liquid columns, small metal vanes, wheel spokes, instrument pointers, etc. The oscillator, which consists of a vacuum tube, a transformer, relays, pilot light and terminal plate, is housed in a dust-proof cabinet. A concentric cable connects the oscillator with the pick-up unit which may be either of the capacitive or inductive type. The cable and pick-up units are easily detachable. The Wheelco Instruments Co. is conducting a contest with cash prizes for the best suggested applications of this remote controller.

Coaxial Loudspeaker System

A LOUDSPEAKER SYSTEM known as the Cin-axial dual speaker system using a 12-inch woofer and a 5-inch tweeter and a complete cross-over network is available from Cinaudagraph Speakers, Inc., 2 Selleck St., Stamford,

Conn. The system is intended for use in high fidelity phonograph and radio equipment. The frequency response is flat from 30 to 12,000 cycles per second, and the useful range is considerably in excess of 12,000 cycles per second.

Light Weight Relays

TWO NEW RELAYS light in weight, vibration-proof and designed primarily for aviation service for control of air flaps and similar applications where utmost dependability is required, are announced by Struthers-Dunn, Inc., 1335 Cherry St., Philadelphia, Pa. Non-welding contacts make them suitable for use with lamps, motors and other devices where high inrush loads are likely to be encountered. Modified relays are available making them suitable for keying and other purposes. Type C3007 is a single pole, single throw relay with normally open contacts rated 50 amperes at 12 or 24 volts direct current. It will stand an inrush current of 100 amperes. Contact pressure is 10 pounds. Coils are rated 8 watts continuous operation and are for use only on direct current. Its dimensions are 2⅜ inches high by 1⅞ inches wide by 2 inches deep and its weight is 8 ounces. Type CX3008 is a larger relay rated at 100 amperes at 12 volts direct current or 80 amperes at 24 volts and will stand an inrush of 300 amperes. The coil is rated at 10 watts for continuous operation, contact pressure is 15 pounds. Its dimensions are 3¾ inches high x 2½ inches wide x 2⅜ inches deep and it weighs 1 pound 5 ounces.

F-M Station Monitor

A NEW FM STATION MONITOR has been announced by General Electric Co., Schenectady, N. Y. This unit includes a center frequency monitor for use both with and without modulation, a required percentage modulation monitor, a modulation limit flasher and a high fidelity audio channel for an audio monitor. Two crystals are used, one for calibration and the other for normal operation. To check the adjustment of the monitoring circuits it is only necessary to flip a single switch. A front panel control provides an instant means of resetting the center-frequency deviation instrument to zero if required. The percentage modulation indicator, the modulation limit flasher, and the necessary controls are easily extended to the operator's desk if desired. The monitor is completely self-contained, with voltage-regulated power supply and a steel cabinet. It is quickly adaptable to use with any f-m transmitter in the 42–50 megacycle range.

Aeropressure Microphone

A NEW AEROPRESSURE microphone whose directional characteristics may be changed at will by the use of a new paracoustic reflector baffle attachment, has been announced by the Commercial Sound Division of the RCA Manufacturing Company, Camden, N. J. The microphone is for use with all types of public address applications, as well as for amateur radio telephone transmitters. The microphone is designed primarily to withstand the wind

and weather conditions found in outdoor applications, but can also be used for indoor use, especially under conditions demanding low cost and ability to withstand rough usage. Frequency response covers the full usable range of from 60 to 10,000 cycles per second, with high sensitivity.

The paracoustic baffle changes the directional characteristics of the microphone. With the concave face of the circular, dish-shaped baffle toward the grille, the directional characteristics become sharpened, and feedback is reduced. When the baffle is reversed, so that the convex face is toward the grille, the opposite directional effect is

obtained. Without the baffle, the microphone becomes a normal pressure microphone. The paracoustic reflector fits over the live end of the microphone and is held in place by a thumb screw.

Finishing Kit

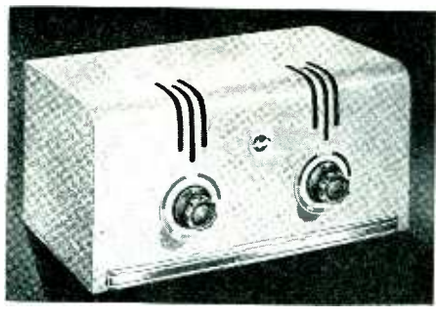
A SURFACE FINISHING KIT for finishing phonograph turntables, cabinets, testers, tool chests, compartments, etc., which gives a soft felt finish without the use of expensive spray equipment is available from the General Cement Manufacturing Co., 919 Taylor Ave., Rockford, Ill. The kit consists of flock, undercoat, undercoat thinner, brush and a sifter-top can for sifting flock over the undercoat. The colors available are brown, taupe and blue. The list price is $2.

Tracing Paper Patch

A PATCH WHICH CAN BE used to mend torn tracing paper or cloth without the patch showing through on the finished blueprint is available from Seal, Inc., Shelton, Conn. It is a dry transparent film which is placed directly over the tear. After placing the patch it is ironed onto the torn sheet with a miniature flatiron called the patch welder. Vanishing patch does not wrinkle or buckle a tracing to which it has been applied, nor does it deteriorate with age.

Public Address Amplifier

A LOW-POWERED PUBLIC ADDRESS amplifier intended for use in restaurant order systems, call systems and the like, has been announced by Lafayette Radio Corp., 100 Sixth Ave., New York. Its power output is 6 watts of continuous rating, or 8 watts on peaks. One microphone and one phonograph channel are provided with a gain of 105 and 62 db, respectively. Frequency



response is 50 to 8000 cycles per second, but a tone control is provided to adapt the output to the acoustic requirements of each location. It is enclosed in a gray wrinkle-finish metal cabinet, 6½ inches high, 9 inches wide, 7 inches deep. It is also available as a part of a completely coordinated indoor system or of a portable sytem in a compact carrying case with built-in speaker, crystal microphone and banquet stand.

Visual Curve Tracer

RADEX CORPORATION, 1733 Milwaukee Avenue, Chicago, have available a visual curve tracer which produces on the screen of a cathode ray tube a frequency-amplitude function for visual observation. A proper screen will enable an immediate appraisal of the correctness or error of the observed curve. The instrument will test intermediate frequency transformers, wave traps, discriminator circuits, and high-, low- or band-pass filters. The frequency limits are 10 cycles per second to 30 megacycles. Bandwidths of 200 kilocycles up to 5 megacycles may be shown on the large cathode ray tube.

Carbonyl Iron Powder

ADVANCE SOLVENTS & CHEMICAL Corporation, 245 Fifth Avenue, New York, will be the distributors for various types of carbonyl iron powder. The powder will be produced from iron carbonyl by patents and processes acquired from their German owners by the General Aniline & Film Corporation. Up to now the powder had to be imported from Germany. Because of its extremely fine particle size and unique spherical form, the powder has been of interest to radio and telephone equipment manufacturers. It is used in magnetic devices and in intermediate frequency transformer construction in the form of iron cores.

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NEW ADVERTISEMENTS received by 10 A. M. April 25th will appear in the May issue, subject to limitations of space available.

POSITION VACANT

LARGE MIDWESTERN radio receiver manufacturer has openings for experienced automotive and household radio receiver design engineers. Applicants should state education, experience and give references. Our own employees know of this ad. P-270, Electronics, 520 N. Michigan Ave., Chicago, Ill.

RADIO PARTS MANUFACTURER wants young man with mechanical, electrical and radio engineering experience for research engineering. Man with inventive ability preferred. P-276, Electronics, 330 W. 42nd St., New York, N. Y.

X-RAY ENGINEER or MECHANIC familiar with Gaiffe-Gallot and Pilon Equipment wanted to repair one Radiographic-Fluoroscopic apparatus and mechanical rectifier. P-277, Electronics, 520 N. Michigan Ave., Chicago, Ill.

RADIO ENGINEER, design, build, service Radio and Intercommunicating systems. Attractive proposition for capable man. Established Chicago manufacturer. P-278, Electronics, 520 N. Michigan Ave., Chicago, Ill.

POSITIONS WANTED
(See also "Selling Opportunity Wanted")

PHYSICIST, five years Government research-development experience, electronics expert, effective writer. Creative instrument and circuit designer. Desires stable technical or administrative position. Reply PW-269, Electronics 330 W. 42nd St., New York, N. Y.

ELECTRICAL ENGINEER desires opportunity to work into factory management. 7 years experience in development, design and production of electrical equipment with large electrical manufacturing concern. B.S. degree in Electrical engineering also M.S. degree. Married and employed at present. Age 29. Medium size reliable firm of good standing desired. PW-275, Electronics, 520 N. Michigan Ave., Chicago, Ill.

OPPORTUNITY WANTED

ELECTRONIC-RADIO-SOUND Engineer desires to represent manufacturers of quality products in Chicago territory. Give full information. RA-272, Electronics, 520 N. Michigan Ave., Chicago, Ill.

Inductive Tuning

(Continued from page 35)

total turns at any required number up to the maximum of 14 for which the unit has been designed.

The units as just described are mounted to a sturdy channel plate when employed in multiple gang construction. A four gang tuner with its insulated couplings is shown in Fig. 5.

Design Factors

Several considerations determine the choice of the number of turns for a given frequency range:

1. The maximum usable frequency to which any inductively tuned circuit of the type under discussion may be tuned is determined by the natural period of the unused part of the variable coil. Due to the mutual coupling between the unused part of the coil and the part in use, absorption effects will occur if tuning is attempted past the natural period of the unused section. This natural period is raised considerably due to the fact that the unused portion is short circuited on itself.

2. The choice of desirable circuit constants at both the low and high frequency limits of the range is another factor in determining the maximum turns or rather the maximum inductance. At the high frequency limit, it is important that a finite series end inductance external to the Inductuner be employed. The role of this inductor will be covered in greater detail later. For the present it may be considered as the inductive tuning equivalent of the high frequency trimming adjustment and must be of such physical dimensions as to be capable of adjustment in inductance value.

At the low frequency limit, the maximum inductance of the variable tuner and the fixed capacitance determine tune, since the series end inductor is a negligible part of the total inductance. Neglecting possible natural period limitations it would appear that for optimum L/C ratio and circuit Q the maximum number

of turns consistent with a usable circuit minimum capacitance should be employed. The tuning ratio in frequency can be shown to be equal to the square root of the ratio of the inductance of the whole variable coil plus the inductance of the fixed end coil to the inductance of the fixed end coil alone.

In the case of the present unit it appeared desirable to design for maximum coverage a unit which would allow reception of the 2½, 5 and 10 meter amateur bands in one continuous range. This required a signal frequency coverage of 27 to 120 megacycles. Figures 6A and 6B show curves of turns versus frequency employed in the entire 14 turns of the unit. In curve *A* no other series end inductor was used than that present in the shortest possible strap between the high potential circuit terminals. Curve *B* employs a two turn end inductor of soft copper wire which was adjusted to determine the desired maximum frequency when used with the correct circuit capacitance to obtain the desired low frequency limit.

The reactance-to-resistance ratio *Q* of a tuning system is a factor of primary interest in circuit design. Mr. Ware in his original paper[1] describing this tuning system discussed the role of the series end inductor in improving the circuit *Q* at the high frequency end of the tuning range. It is always simpler to make a fixed coil of lower resistance than an equal inductive portion of the variable coil, due to the absence of mechanical parts and the improvement in coil form factor. Hence, with a suitably designed series coil it is possible to produce circuits in which the resistance decreases as the tuning is carried toward the high frequency end and becomes a minimum at the high frequency limit. This is a desirable condition since in a fixed capacitance parallel resonant circuit constant impedance occurs if the high frequency resistance varies inversely as the square of the frequency.

The *Q* of the Inductuner alone is shown in Fig. 7 plotted against turns. This measurement was made on the Boonton (type 160A) *Q* meter whose top frequency is 75 megacycles and for this reason the curves extend only to that frequency. It will be noted that since the entire tuning motion was used in this

curve an increase in Q occurs as the final short circuited turn is removed from the circuit between turns numbers 13 and 14. If the tuning motion had not included this turn the Q variation would be less than 10 per cent over the range.

Of primary importance in the consideration of ultra high frequency tuning systems is the problem of frequency stability. This problem involves many factors other than the temperature variation. To determine the temperature coefficient, an oscillator was constructed in which all parts of the circuit except the tuner were mounted on the lid of a chamber whose interior temperature could be controlled over the range desired. The short interconnecting leads were of silvered "Nilvar" and were supported by ceramic blocks. The measurements were made at 31 megacycles by a multiple beat method in which the third harmonic of a 10-megacycle crystal oscillator was caused to beat with the oscillator under test with a nominal difference frequency of 1 megacycle. A signal generator was used to determine the change of difference frequency by zero beat.

The tuning unit is compared with a coil of like inductance and form factor wound on the same type of ceramic as is employed in the tuner construction. The curves in Fig. 8 are the average of several runs. The approximate temperature coefficient of frequency is 2.5 parts per million per degree Centigrade.

Circuit Considerations

The technique of tracking superheterodyne oscillator circuits utilizing inductive tuning has been described by Ware[1] and it has been shown that the series padding condenser is replaced by a parallel inductance while the high frequency tracking adjustment is provided by variation of the value of the series end inductor as compared with the shunt trimmer in condenser tuning.

Figure 9 illustrates a typical receiver circuit in which the oscillator is operating on the high frequency side of the signal. L_s is the shunt inductor which decreases the oscillator range. The value of the oscillator end inductor L_{e3} differs from the r-f circuit end inductors L_{e1} and L_{e2} for high frequency tracking.

It is obvious that the tracking

INDEX TO ADVERTISERS

shunt coil may be employed in the r-f circuits rather than the oscillator if it is desired that the oscillator operate on the low frequency side of the signal. Such a mode of operation offers a number of advantages at high frequencies. It allows the shunt tracking inductors to be employed for coupling purposes and it removes circuit elements from the oscillator, thus simplifying the problems of oscillator stabilization.

Two basic types of oscillator circuits are shown in Figure 10. The Colpitts circuit (Fig. 10A) is ideally adapted to inductive tuning since it is essentially a two terminal oscillator. The feed-back ratio depends only upon the capacitance ratio which can be readily changed in experimental setups. The tickler feed-back circuit of Figure 10B employs a shunt inductor which may also serve as the parallel tracking coil.

An interesting circuit arrangement which allows expanded band spread tuning with complete coverage of the intervening gaps is shown in Fig. 11. In this case a shunt inductor is connected across the tuner only. It is evident that if the shunt inductor is substantially lower in inductance than the maximum value of the variable, very little change of total effective circuit inductance will occur for a large portion of the variable range. As the minimum inductance of the variable is approached the change of circuit inductance will become increasingly rapid. In the illustration, circuit constants have been chosen in such a manner that a number of transatlantic short wave broadcast bands are covered employing half of the tuning motion for the desired band and using the remaining half for overlap tuning to the next band. Band switching is extremely simple since only a single pole switch without shorting function is required. An additional advantage of this type of circuit is that the *Q* progressively increases with frequency tending to offset increased tube loading.

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(2) Paul Ware, A New Inductance Tuning System *Proc. Radio Club of America,* Vol. 15, No. 1, pp. 3-7; February (1938).
(3) O. J. Morelock, Inductive Tuning—Theory and Application. *Communications* Vol. 19, Nos. 2 and 3; February and March (1939).
(4) The Inductuner is covered by U. S. Letters Patent Nos. 2,163,644-654-646 and 647.